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Collaborative Design Workshop

for VR and Tablet

A Master's Thesis by

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Abstract:

Virtual Reality (VR) is becoming an increasingly popular tool for designing and reviewing physical spaces. The pharmaceutical company *Novo Nordisk* has adopted this technology and is currently conducting VR workshops with a high degree of asymmetry to design their future factories. The sense of participation between the participants have not been found to be equal due to the high degree of asymmetry. We propose an alternative where the VR users can collaborate with multiple tablet users in a setting with a low degree of asymmetry, and mirrored directional dependency. A within group study with six groups of four participants was conducted, where the participants would get two tasks and switch interfaces in between tasks. After each task the participants would answer a questionnaire about collaboration. After the second task a focus group interview with each group was conducted. During the tasks data about the users' interactions were gathered. The results signified that the participants were able to collaborate and that their self perceived sense of participation was equal, except for the users' awareness of others in the virtual environment, where tablet users were more aware of others. Further research is needed to conclude whether this application is preferred to the current state of VR workshops at *Novo Nordisk*.

Contents

1 Introduction

Virtual Reality (VR) is becoming increasingly popular as a tool to be used in different industries for design and review of physical locations [26]. VR allows designers to review spaces in a life sized scale which allows for evaluating them as if you were there. Being able to design and review in VR can save costs and time when companies want to build new structures as you can evaluate during the building process instead of after (see Section 2.5 and Appendix F).

At *Novo Nordisk*[1], VR is currently being used in workshops to design spaces and physical locations. Due to limited physical space in meeting rooms at their offices, not everyone who participates in these workshops can be in VR (see Section 2.5 and Appendix F). Typically, there is only space for 2 people in VR, and the workshop usually has more than two participants. The participants outside of VR can spectate the virtual environment via a stream from the headset to a television (see Figure 3 in Section 2.5, and Appendix F). As a result, the non-VR participants do not have the possibility to interact with the virtual environment (VE) and acts as spectators instead of active participants of the workshop. The participants in VR in turn acts as "camera operators" who has to provide the rest of the participants with their desired viewpoints (see Appendix F.1). The non-VR participants are only able to interact with the VE with the VR participants as a proxy, which is defined as a high degree of asymmetry [32] [14]. This results in the non-VR participants having a lower sense of participation in the workshops leading to a less efficient collaboration (see Appendix F.1.1).

Reducing this asymmetry could be done by having all the participants in VR. This is not always feasible as it requires large amounts of space for each participant [21]. Therefore, it could be beneficial to use another interface than VR. There are also other limitations such as the risk of cybersickness, which can induce various levels of discomfort, such as eye strain, nausea, disorientation or headache [28] [31] [18]. It can also be complicated to take notes in VR as it is difficult to produce text efficiently [7].

A tablet interface would allow the participants to participate needing a limited amount of space as it can be handheld. Additionally, all employees at Novo Nordisk are familiar with touch interfaces, as they all have a work smartphone.

In this paper, we propose a networked multiplayer cross platform prototype for VR and tablet, with the goal of ensuring that all participants at a workshop can participate and collaborate with the VR users in the design workshop.

2 State of The Art

This section will explore the state of the art of VR workshops, asymmetric VR, and how VR designn workshops are conducted at Novo Nordisk.

2.1 Workshops

The VR workshops at Novo Nordisk have the goal of providing a spatial context to design decisions for future factories. Previously, the spatial context was given by acquiring a large empty hall where boundaries for the interior of the factory was marked on the ground with tape (See Appendix K). This process gave good results, but it was tedious and time consuming. The VR workshops allows for the same spatial understanding without wasting unnecessary time, effort and space (See Appendix F).

Brooks-Harris & Stock-Ward describes an outline for a successful workshop [5]. First of all, a workshop must have an overarching theme which is based upon the participants' needs and goals. The theme of the workshops at Novo Nordisk is to gain insight in spatial considerations for designing factories. The workshop should then be separated into three distinct parts: 1) A beginning which makes sure all

[1] https://www.novonordisk.dk/

participants are aligned on the goals of the workshop and are aware of the workshop's structure. 2) A middle consisting of learning activities. 3) An end which concludes the workshop by summarising the findings. The workshop must also have a facilitator which creates a learning environment. They should ensure the participants are cooperating and following the structure of the workshop.

According to Brooks-Harris & Stock-Ward, the format of conducting a workshop has changed throughout the years, from something resembling lectures to a more collaborative learning experience [4]. One of the defining characteristics of modern workshops is that they are a short-term learning experience which encourages active learning [4]. A workshop includes learning activities which supports the learning goal of the workshop. These learning activities are classified into four different categories [6]:

- **Reflecting-on-experience**: The learning activity is based on the prior knowledge of the participants.
- **Assimilating and Conceptualizing**: The participants assimilate what they have learned throughout the workshop.
- **Experimenting and Practicing**: The participants act out scenarios related to the theme of the workshop.
- **Planning-for-Application**: The participants plan for how to apply the knowledge gathered in the workshop in their future work.

The learning activities in the VR design workshops at Novo Nordisk belong to the category *experimenting and practicing*, as they design by simulating being in a factory before it is built (see Appendix K).

2.2 Computer Supported Cooperative Work and Computer Supported Collaborative Learning

Computer supported cooperative work (CSCW) is a multi-disciplinary research field that focuses on computer based techniques, often referred to as *groupware*, that supports multiple people working on related tasks [9]. Groupware can be categorized using the time-place matrix (see Table 1). The first dimension describes the time where the task takes place, either synchronously or asynchronously. The second dimension describes where the task is performed geographically, which can be either co-located or remote [25]. Computer Supported Collaborative Learning (CSCL) is focused on the participants learning in a group setting [19]. Collaboration and cooperation are central themes in research on CSCW and CSCL. Cooperative work can be defined as the distribution of labour [19]. Collaboration, in contrast, can be defined as the mutual engagement from participants in solving a problem and finding one solution in coordination [19]. Studies in collaborative writing have found that information sharing, knowledge of group and individual activity, and coordination are crucial for successful collaboration [8]. It should also be explicit in the groupware what other users are capable of, and what other users are currently doing [8]. Immersive technologies such as VR brings new tools to CSCW and CSCL, especially for synchronous collaborative work as it can provide a higher level of immersion compared to traditional communication tools [25]. It can support collaborative work via object manipulation, knowledge sharing using gestures, voice, and visual information. These capabilities can support activities such as meetings, product development, design and review of products, brainstorming, and training of employees in a fast and efficient way [25].
The VR workshops at Novo Nordisk are synchronous and co-located, but can also support remote participants (see Appendix F). Not all participants in the workshop have the same goals. While some attend the workshop to design, some participants are there evaluate and gather information on the VR system in order to develop and improve this (see Appendix F). The whole process of VR workshops at Novo Nordisk can be categorized as a cooperative process as different teams work on different parts.

This project focuses only on the collaborative design process happening at these workshops. In this process the participants are working toward the same goal, being improving the current design of the factories.

	Same Time (synchronous)	**Different Times (asynchronous)**
Same Place (co-located)	Face-to-face interaction	Asynchronous interaction
Different Places (remote)	Synchronous distributed interaction	Asynchronous distributed interaction

Table 1: Table showing the time-place matrix. The VR design workshops at Novo Nordisk falls into the category face-to-face interaction.[19][25].

2.3 Virtual Reality Workshops

This section will explore the use of VR as a collaborative design tool, and how VR applications enable users to design and review spaces.

VR is an immersive interface that uses a head mounted display to place the user inside a virtual environment [29]. This can be used as a tool to design real life environments by interacting with life sized models. Using VR can give the user a sense of the spatial properties of a room as if they were there [29]. VR also enables the user to act out and evaluate interactions in the space e.g. whether objects can fit through doors or whether certain actions can be performed This is especially useful when designing buildings or factories where workers need to be able to perform specific actions (see Appendix F). Reviewing these spaces in VR allows the designers to make decisions before the spaces are built and it can increase the efficiency of designing these spaces (see Appendix K). Design reviews are used to verify designs and plan actions to be taken by a design team. A design review usually consists of three phases: preparation, execution, and post-processing [15].
In a review study by Horvat *et al.* some general requirements present in most VR design review tools were explored. The VR design tools reviewed in the study includes the following features [15]:

1. *Navigation* allowing the user to move in the environment.
2. *Manipulation options* allowing the user to interact with the environment, e.g. moving or scaling objects.
3. *System control* allowing further interaction with the application e.g. settings or other functionalities.

Commercially available tools for collaborative design in VR include applications such as Gravity Sketch[2] which is a cross platform 3D sketching application. It allows users to sketch in a virtual environment, either alone, together in realtime (synchronously), or together asynchronously. It can be used either in VR or from a desktop computer. In a study by Van Goethem *et al.* 13 master students used Gravity Sketch in order to design a backpack in 3D [34]. The study evaluated the process using the NASA RAW Task Load Index (TLX), in order to compare the design process in VR to other methods, such as classical sketching, and found no significant differences. It was reported that designing 3D objects in a 3D space made more sense than on a 2D screen and that it was easy for the participants with no prior VR experience to learn how to model in 3D [34].

2.4 Asymmetric Virtual Reality

This section will explore asymmetry in collaboration and how it affects VR workshops. When having workshops where some participants are in VR, there can be different degrees and types of asymmetry. Asymmetry refers to how different participants can interact with the same virtual environment through different interfaces [32]. Asymmetrical VR always include VR and another non-VR interface.

[2]https://www.gravitysketch.com/

An asymmetric VR experience can either have a low, medium or high degree of asymmetry (see Figure 1) [32]. In a low asymmetry context, the non-VR users have direct control of the virtual environment and have a direct view of the environment. At a medium degree of asymmetry, the non-VR participants have indirect control over the environment, e.g. by having a handheld user interface they can use to indirectly interact with the environment. At a high degree of asymmetry, the non-VR participants rely on verbal communication with the VR participants to interact with the virtual environment by proxy. The non-VR participant might have a document or manual with information relevant to the virtual environment. An example of this is the co-op VR game *Keep Talking and Nobody Explodes*[3] where a player outside VR uses a manual to help a player inside VR. The asymmetry can be present in different aspects of collaboration. In terms of workshops, the asymmetry might occur in the *interface* where users use different hardware, *information* where users have access to different pieces of information, or *ability* where users have different capabilities in terms of manipulating the VE [14]. Several aspects of asymmetry can occur at the same time.

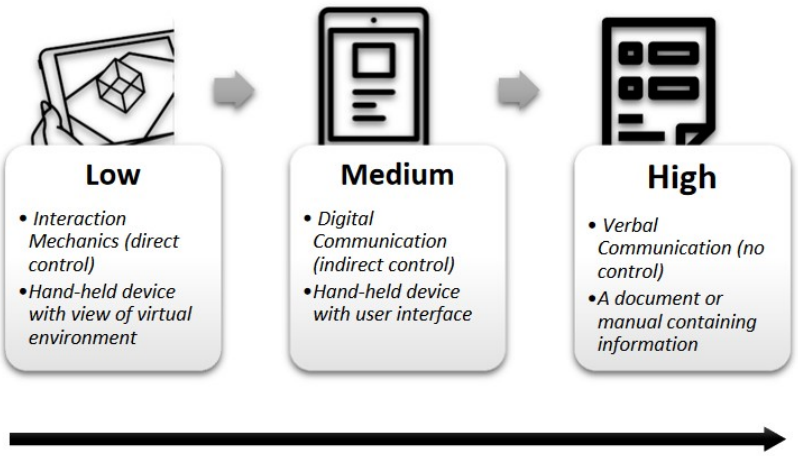


Figure 1: Three degrees of asymmetry from left to right: low, medium and high [32].

2.4.1 Directional Dependence

The participants in an asymmetric VR setting can have different directional dependencies. This term refers to how a participant's actions affect the other participants and their possible actions [14]. Harris *et al.* defines three types of directional dependence: *mirrored*, *unidirectional*, and *bidirectional*.

Mirrored dependence refers to all participants relying on each other's actions equally. An example of mirrored dependence can be found in the collaborative virtual environment for VR and AR created by Grandi *et al.* [12]. In this application, both users are able to transform and manipulate shared objects at the same time. The efficiency of the asymmetrical collaboration was then measured and compared with symmetrical VR collaboration and symmetrical AR collaboration. The asymmetrical collaboration were found to be more efficient than both VR-VR and AR-AR [12].

Unidirectional dependence is where one participant relies the actions of another user but not the other way around. An example of this is a remote collaboration tool with augmented reality drawings and virtual navigation by Gauglitz *et al.* [10]. This tool allows for a remote user to interact with a live video feed from a local user (see Figure 2). When interacting, the remote user has the capability to pause the video and annotate instructions directly onto the video feed. These annotations are anchored to specific locations on the objects within the video, ensuring they remain correctly positioned even as

[3] https://keeptalkinggame.com/

the video resumes and the objects move. The remote user is also able to zoom and move the camera themselves if needed. These drawing are then reflected to the local user, which they can then act upon in the real world. In this application, the remote user is unable to interact with the environment unless the local user operates a camera to provide a video feed, which the remote user can then utilize for interaction. A similar approach of using a local video feed as a unidirectional dependence is also found in VR. *TransceiVR* is an application where an external user can see the view of the VR user on a tablet device. They can then detach and freeze the view to annotate information which would be rendered in the VE [33].

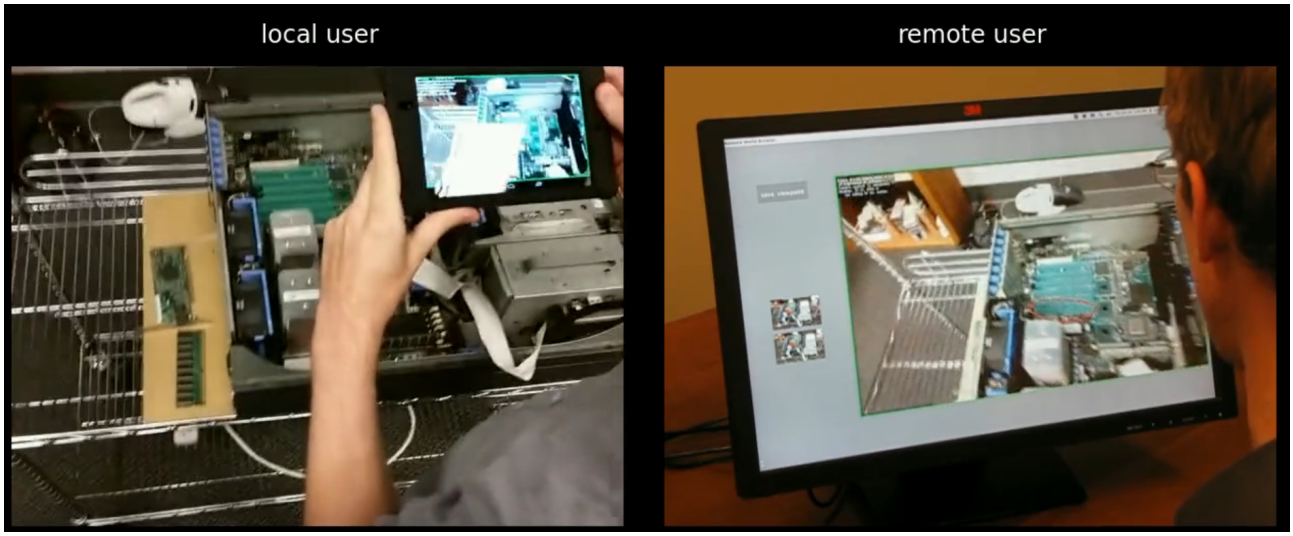


Figure 2: Figure showing a screenshot of a remote user drawing on top of live video feed from local user [10].

Bidirectional dependence is where both or all participants rely on each other's actions to perform their own, but they have different actions available [14]. This form of dependency can be found in high asymmetrical VR applications [32], such as the game *BirdQuestVR* by Smilovitch & Lachman [30]. In this game, a tablet and a VR user have to collaborate to control a spaceship where each user have their own distinct way of influencing the spaceship. The deciding factor of success in this game was the communication between the players. This is an example of bidirectional dependency, since no player knows the correct course of action without the context provided from the other player.

2.5 Workshop Deconstruction

To gain insight on how the VR design workshops at Novo Nordisk can be improved, we have made a deconstruction of a VR workshop from interviews with facilitators and observations from a Novo Nordisk VR design workshop (see Appendix K and F). Three people were interviewed:

- A CAD specialist who works in the XR department in Novo Nordisk who is in charge of acquiring 3D assets and making sure that they are implemented correctly into VR before they can be used for a VR workshop.
- Two operational readiness professionals who work in a team focusing on standardization of procedures and processes. They are both in charge of facilitating the VR design workshops currently being held at Novo Nordisk.

The room used for the workshops contains two 2.5m x 2.5m VR playspaces, two televisions, and some extra seating for non-VR participants (see Figure 3).
The participants in the workshops are typically:
There are three main roles in the workshop: facilitators, observers, and participants. The facilitator's job is to make sure that the technical aspects of the workshop runs smoothly. The observers observe

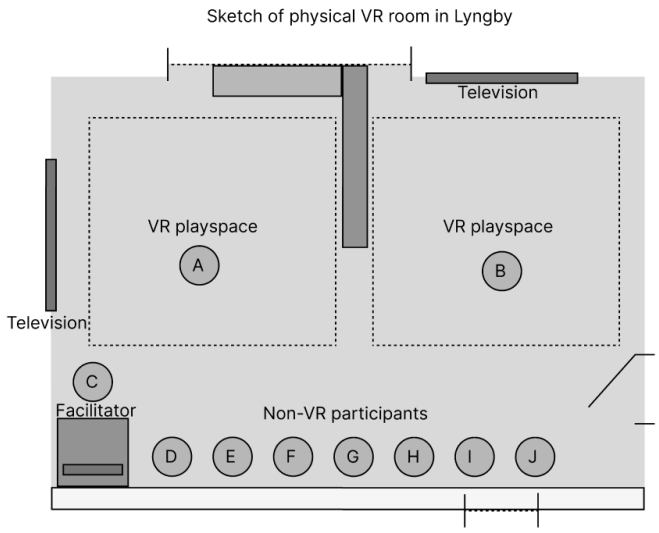


Figure 3: Figure showing the layout of the observed VR workshop from Appendix K. It contains two televisions, two 2.5m x 2.5m VR playspaces and extra seating for non-VR participants. Participant A and B are using VR, while participants D through J can watch participant A and B's viewports on the two televisions. Participant C is acting as the facilitator of the workshop.

the workshop to gather feedback from the application. They are very familiar with VR, but will not partake in the workshop unless some technical difficulties or bugs appear. They can observe in VR, via a TV or a web application either co-located or remotely. The participants will partake in the workshop either through VR or as spectators of a livestream to a TV from the VR headsets. The participants are either Subject Matter Experts (SME), who have an expertise in the matter being designed, or are other relevant people, whose professions are relevant for the topic discussed. The participants' prior knowledge and experience with VR varies from no experience at all to experts.

The timeline of the workshops are as follows:

1. Before the workshop the facilitators and VR developers make sure the current VR build is up to date with the current design decisions, and that the current undecided design topics are implemented to a degree, which makes it possible to use for further discussion.
2. The two facilitators set up the HMDs in the workshop room in advance and make sure that all necessary applications are installed and working.
3. When the participants arrive, they are given a short introduction to VR, and they are told what kind of application is available for them to use as a discussion tool.
4. One or two of the participants are invited to join in VR, while the rest can watch on the TV screens. They are at any time allowed to switch who is in VR or spectating.
5. The relevant matter is discussed between the VR participants and the onlookers. This takes approximately 1 hour.
6. Notes for relevant decisions are taken, and the next steps are discussed. This changes depending on the participants. Some will not take notes during the workshop, but wait until they get back to their office before noting decisions.

The format of this workshop has not been designed, but has emerged through trial and error. The interviewed employees believe the workshops would be improved upon if all the participants could control their own view of the VE: " (...) giving them more ownership and more feeling of participation

in the workshop because they are taking the lead in what they can see and what they can discuss." (see Appendix F.1.1).

The workshops would be categorized as having a high degree of asymmetry where the asymmetry occurs both in the interface and available actions (see Section 2.4). The directional dependence in these workshops is unidirectional where the non-VR participants rely on the VR participants to perform actions, but the VR participant does not rely on the non-VR participants since they do not have access to manipulate the environment.
If the goal of these workshops is to allow all participants to have equal sense of participation over the environment, the asymmetry should strive to be as low as possible. The lowest form of asymmetry is no asymmetry at all, which would be achieved if all participants were present in VR. This provides another challenge, which is the physical space requirements for VR. It is recommended to have access to a 2m x 2m physical play space when being in VR [21], which is not feasible for a workshop of 6+ people in smaller workshop areas. Another challenge with creating an exclusively VR workshop is that some participants might be prone to cybersickness or might have other reasons for not being comfortable with VR. Adding a non-VR option would accommodate both needs, while also adding the possibility to enhance the workshop with another media which could add other dimensions to the workshop, such as the ability to easily use a keyboard, or be able to see the VE from different viewpoints. Therefore, a degree of asymmetry which does not require an excessive amount of physical space is required.

2.6 Requirements for The Application

Based upon the analysis from the state of the art, requirements for the asymmetric VR application should be:

- The application should have a low degree of asymmetry, so that all users can interact directly with the environment (see Section 2.4).
- The directional dependency should be mirrored, so that both users are able to collaborate equally (see Section 2.4.1).
- All users should be able to navigate the environment (see Section 2.3).
- All users should be able manipulate relevant objects in the environment (see Section 2.3).
- All users should be aware of other users' actions (see Section 2.2).

3 Method

The aim of this project was to find out how to activate and enable non-VR participants in a design workshop to participate and collaborate in the workshop by decreasing the degree of asymmetry in the experience.

To research this, an application was developed for VR and tablet with a mirrored directional dependence (see Section 2.4.1) and a low degree of asymmetry enabling all users to interact with the virtual environment. This platform was developed in two phases. A networked multiplayer cross media platform and a cross media design tool utilizing the initial platform. The networked multiplayer cross media platform was developed in collaboration with group 7, also from 10th semester Medialogy while the cross media design tool was built as an extension of the initial platform by the authors of this paper.
To evaluate whether the platform was successful in enabling non-VR users to engage in the workshop, tests were conducted exploring the collaboration between VR users and tablet users. The evaluation method was inspired by the paper *Designing and evaluating collaboration in a virtual game environment*

for vocational learning by Hamalainen, where five groups of four participants collaborated on designing hotel rooms in an edugame for vocational learning, where the focus of the test was to explore collaborative learning [13]. Four participants was given tasks to complete using the platform while using the two different interfaces: 2 tablets and 2 HMDs. All participants tried both interfaces to be able to compare the experience. The evaluation used a mixed-methods approach. The data collected was a combination of quantitative data from questionnaires inquiring about collaboration and qualitative data from focus group interviews. It was analysed to see whether the tablet users felt that they could collaborate and participate as much as the VR participants.

4 Design

This section will describe the reasoning and design considerations for the application developed to evaluate the collaborative aspects of asymmetric VR.

The application aims to follow the official design guidelines from Novo Nordisk, as this would make it more recognizable for the workshop participants at Novo Nordisk.
Novo Nordisk has also released several prototypes for VR, which all have a common baseline for canonical interactions and locomotion. This prototype will strive to mimic the already established design considerations. These guidelines and considerations are:

1. The colors used must be official Novo Nordisk colors [24].
2. The UI should consist of simple drawings.
3. The user locomotes in VR by using the left thumb stick to teleport, and the right thumb stick to snap rotate.
4. The user can grab objects in VR by either grabbing with their virtual hand using the "select" button on the controller, or by pointing a ray on an object and grabbing with the "select" button (see Figure 7).

The rest of the design chapter will describe the design approach for the collaborative features of the application, the tablet version of the application, and the VR version of the application.

4.1 Cross Media Collaboration

To support cross media collaboration, both the tablet and VR users needs some tools to facilitate collaborative design in a VE.

According to Germani *et al.*, to foster collaboration among participants, all users should be able to easily manipulate the positions and rotations of objects in the VE [11].
In the case of design workshops at NN, the participants should not be able to topple over objects. Therefore it should not be possible to rotate objects on other axes than the y-axis (see Figure 4). Since the environment mimics reality objects should always be on the floor and adhere to rules of gravity. As everything will be situated on the floor, the participants will only need to translate objects along the x and z-axis (see Figure 4), unless they want to put something on top of another object.

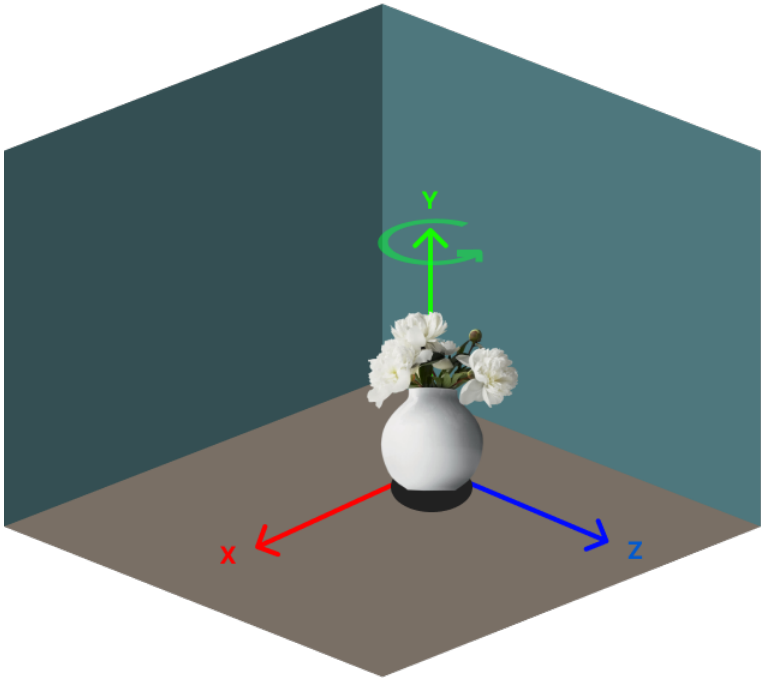
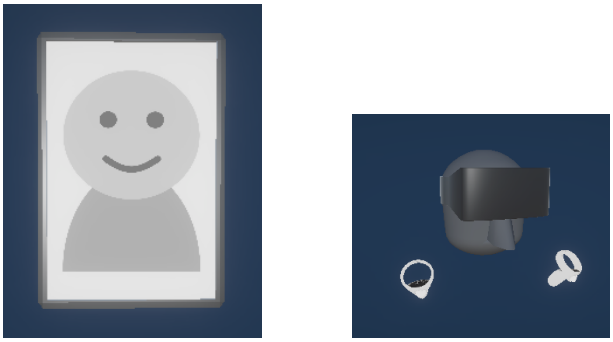


Figure 4: Figure showing which axes the users are able to translate and rotate objects on.

It is essential that all users are aware of the current actions of other users, and the current location of other users [8]. The users should also be able to communicate points of interests to other users in the VE to enhance their ability to have a fluent and efficient communication [16].
The location of all users can be represented by having an avatar for each user in the scene. These avatars should match the device type of the user, to make it clear to others how they can interact with the environment (see Figure 5). Each avatar should also have a distinct color which makes them easily recognisable from the others.



(a) *(b)*

Figure 5: Figure showing the tablet avatar (a) and the VR avatar (b). The avatars were 3D modelled for this project.

To convey information of the current interaction of the users and to create a common point of interest, a highlight system was created. All users are able to select objects in the VE, which is then highlighted in accordance with the flowchart in Figure 6. The highlight color for each user is matched to the color of their avatar, to create clarity of who is currently selecting an object. Every user is only able to manipulate with objects which they have already selected. Since objects could only be selected by one participant at a time, this ensured that no objects could be manipulated by several participants at the same time.

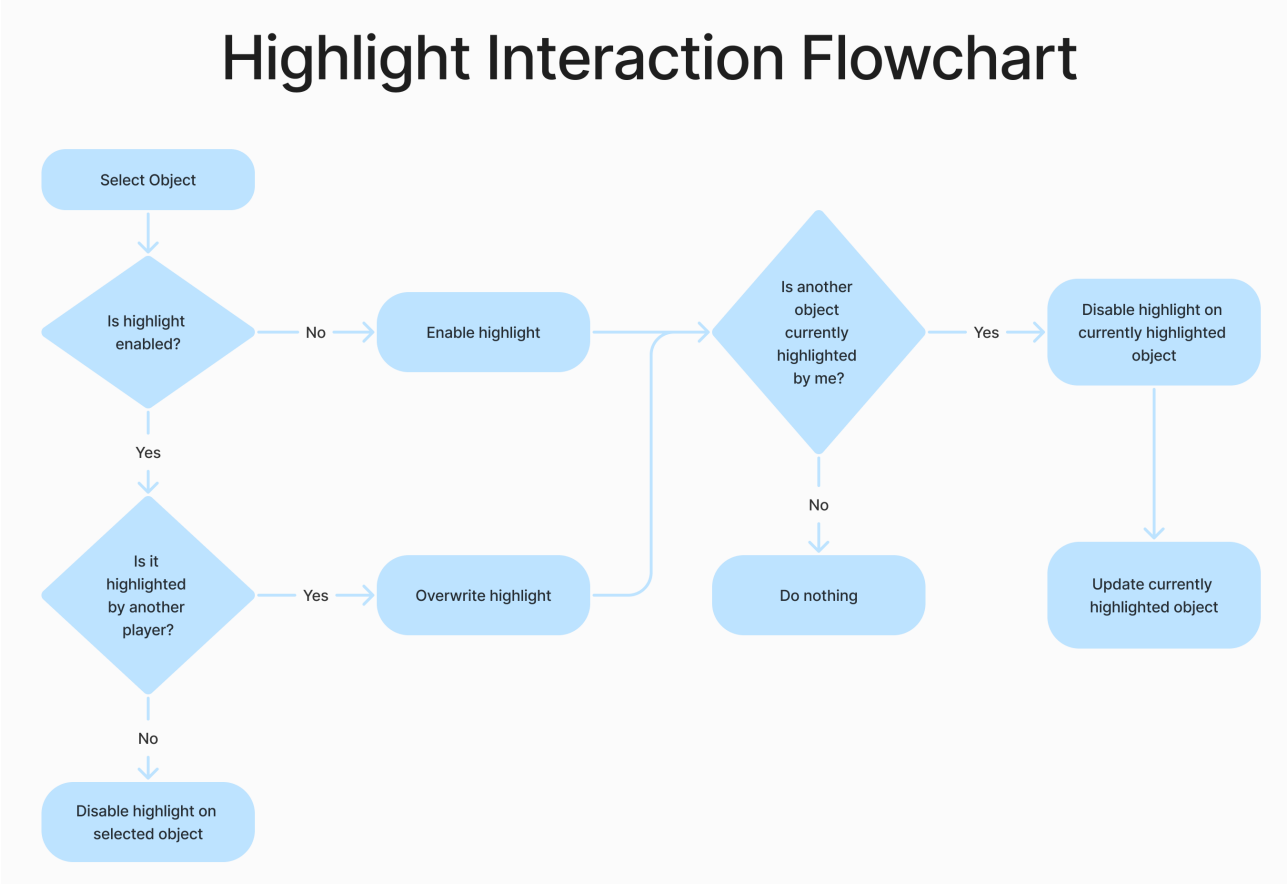


Figure 6: Figure showing a flowchart over the highlight interaction for both VR and tablet.

4.2 Virtual Reality Interface

This section will describe the design decisions made for the VR interface. The VR interface was designed for the Meta Quest 2 HMD.

In the application the user's hands are represented as 3D models of the Meta Quest 2 controllers (see Figure 5a). Having controllers as hand representations allows the user to see the buttons on the controller while in the virtual environment, making it easier for users to use the buttons. The controller buttons used in the application are *select* used to grab objects, *activate* used for highlighting object and the joystick is used for locomotion and manipulation of the objects (see Figure 7).

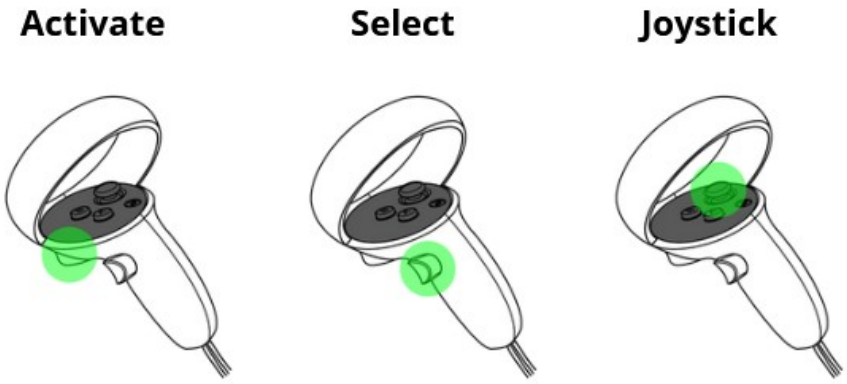


Figure 7: The controllers and the buttons used for interaction in the VR application. From left to right: activate button, select button and joystick button.

4.2.1 Locomotion

The locomotion type for this platform was chosen based on these factors: 1) The existing platform used at Novo Nordisk which uses teleportation and 2) minimizing the risk of cybersickness. The teleportation locomotion method is defined as an artificial non-continuous locomotion type as the user is moving by making instant visual 'jumps' [2]. This locomotion type has been found to be one of the lesser cybersickness inducing locomotion types and it is easy to learn [2] [17]. In this implementation of the method the user can teleport by pushing either controller's joystick forward which reveals a curved ray indicating where the user will land when releasing the joystick again. The user can rotate themselves by increments of 45 degrees by pushing either joystick to the left or to the right.

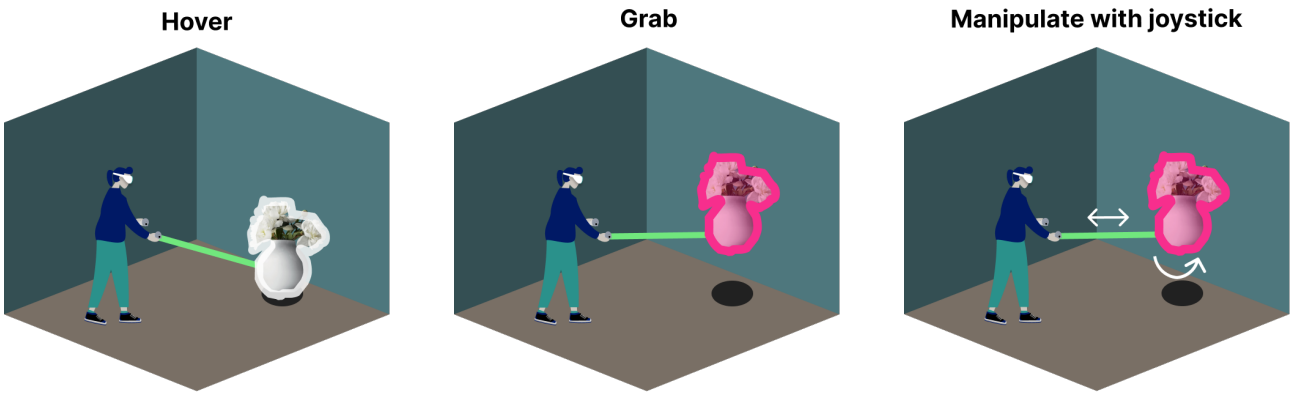
4.2.2 Interaction Techniques

When designing in the VE, the VR users are able to use the following three interaction techniques: selection, translation, and rotation of objects.

In VR there are two common ways of selecting objects: using ray casting where the user can select things from a distance or using the hand metaphor where the user physically moves their hand to the object to select it. The hand metaphor can be useful when using hand models as the representation for the controllers to mimic real life. Since this platform uses controllers as hand representation, ray casting was chosen as the selection type.
From each controller a ray is pointing out (as seen in Figure 8). The user can point this ray towards objects that will then go into a hover state (see Figure 8a). When hovered the user can either highlight the object using the activate button or grab it by holding down the select button (see Figure 7). The user can ungrab objects by releasing the select button. When the user has grabbed the object, the object's transform will follow the transform of the controller that was used to grab it, but while keeping the offset to the user (see Figure 8b). When an object is in a grabbed state the user can perform a move action or a rotation action on the object. The move action is performed by moving the joystick either forwards or backwards, this will move the object either closer to or further away from the user along the ray. The user can move the joystick left or right to rotate the object. If the user taps the joystick it will move to the nearest 45 degree increment and if the user holds down the joystick it will continuously rotate until the joystick is released.

4.3 Tablet Interface

The following section will describe the design decisions made for the tablet interface. The tablet interface was designed for the Lenovo Tab P12.



(a) The user can point to an object and it will be highlighted in white indicating that it is hovered.

(b) The user can press the grab button on the controller while pointing to an object to make its transform follow the transform of the ray and controller. This action will highlight the object as well.

(c) When an object is grabbed the user can either move it closer to or further away from them along the ray by pushing the joystick up or down. The user can rotate the object by pushing the joystick left or right.

Figure 8: Visualization of the three interactions: hover, grab and manipulation.

4.3.1 View Options

When designing how the tablet user should view the VE, it is important to consider what kind of information the tablet user will need when using the application. The participants at the VR design workshops at Novo Nordisk already have some knowledge of the rooms before attending the workshops. When not being part of the VR design workshops, they use the floor plans and CAD files of the factories when discussing design considerations (see Appendix K). Therefore, the tablet should include similar information. The tablet should also have some information on how the VE feels from a first person point of view, since the learning activities in the workshop is experimenting and practicing (see Section 2.1).

The view options for tablet were inspired by the smartphone and tablet design application *Room Planner* [4], where the user is provided with three different options for viewing the environment: (1) a 2D top down view of the floor plan, (2) a 3D view where the user can zoom and tilt with a pivot point in the center of a room and (3) a first person view option where the user's viewpoint is places at head height move around on the x-axis and z-axis (y-axis is up).

In this application, the three view options are an isometric top down 2D view, a non-isometric 3D view and a first person view. These views can be switched between using the buttons seen in Figure 9. The 2D view was chosen to give tablet users an overview of the environment, and to resemble floor plans. The 3D view was chosen to give the user a spatial understanding of the environment, and to be able to view things from different angles. The first person view was chosen to try giving the user an experience similar to the VR user's point of view, where the user can see the environment from a human perspective. The different views and possible interactions for movement in each view can be seen in Table 2.

[4] roomplannerapp.com

4.3.2 Movement Gestures

To navigate the first person view the *Drag'n Go* approach was chosen, which was developed by Moerman *et al.* [22]. The approach is inspired by the point-of-interest approach where the user selects a target (object or location) and the user is then moved to this target. With Drag'n Go the user keeps control of their position while moving to the target, as the movement is not instant but instead their position is interpolated towards their chosen point of interest. The design of the technique is based on screen space where the movement of the touch should be the same direction as the on-screen optical flow [22]. The interaction is composed of three phases:

1. Activation: Touch (in screen space) on point of interest, raycast to find location in world space and calculate path from current position to desired position.
2. Interaction: Move the user towards target when user moves finger, and calculate and apply rotation.
3. Termination: Lift finger and movement is ended.

For the zoom interaction in both 2D and 3D view the pinch gesture was used, as this is the preferred gesture for this interaction [23]. The rest of the gestures to move, rotate and tilt the camera were swipe gestures in either the x or y direction, with either one or two fingers.

It was prioritized for the user to have to use the least amount of fingers as possible to avoid screen occlusion and to keep the other hand free for holding the tablet [20]. This is necessary if the tablet is to be used in the workshop room at Novo Nordisk, since it does not have a sufficient amount of tables (see Figure 3 in Section 2.5). One finger gestures were used for the primary form of view manipulation for each view, and two finger gestures for secondary forms of view manipulation. For drag'n go, moving towards objects is the primary form of movement, while rotating and tilting while standing still will be the secondary form of movement. For 2D view, moving the camera would also be the primary form of movement, while no secondary form exists besides zooming. 3D view differentiates from the others in that the primary form of view manipulation would be rotating the camera around a pivot point, while moving the pivot point (thus also moving the camera) is the secondary form.

A full overview of the gestures used in the three views can be seen in Appendix A, Figure 17b.

View Type	Movement Interactions
2D	Zoom, translate
3D	Zoom, rotate around pivot point, tilt around pivot point, move pivot point
First person	Drag'n go [22], rotate, tilt

Table 2: The three different view types, 2D, 3D and first person and their movement gestures.

To find out whether the view options provide the user with the desired information and whether the movement interactions are intuitive an evaluation was conducted (see Appendix B). It was found that the buttons for switching view types were understood. The 3D view was the most preferred type for looking at and finding objects and was deemed good at getting a spatial understanding of the environment. The 2D view was good for getting an overview of the environment. First person view did not feel as useful, which might be due to the participants not having a relation to the test environment (see Appendix B).

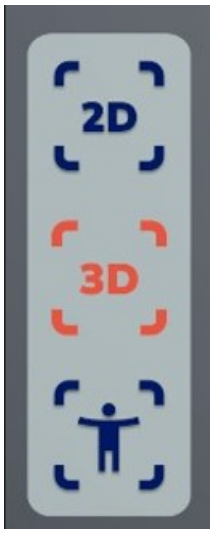
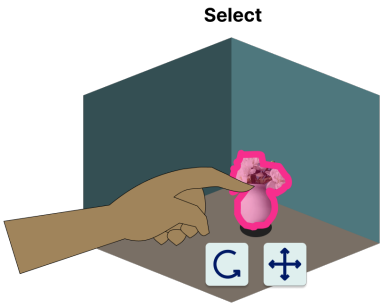
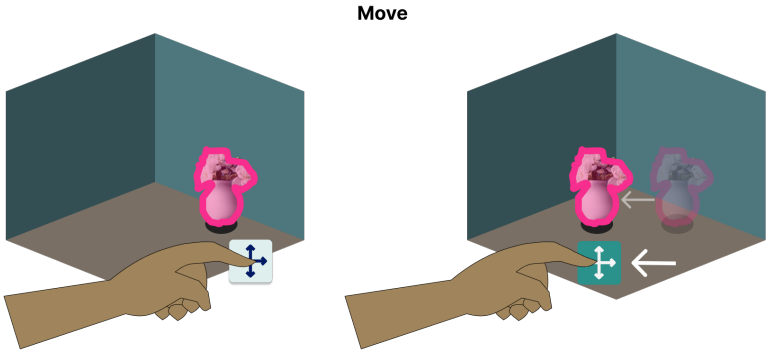


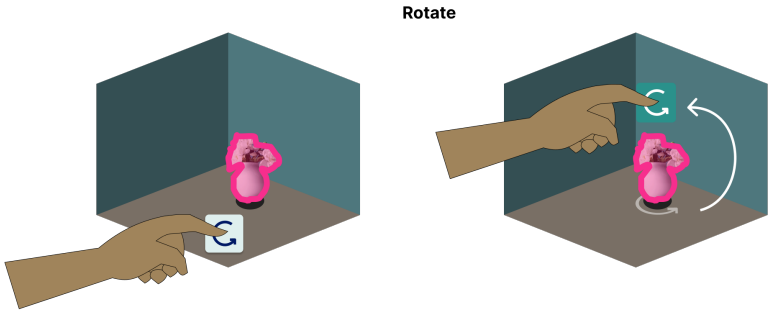
Figure 9: The interface for switching between the three views from top to bottom: 2D, 3D and first person. The orange icon indicates which view has been selected.



(a) A user can select an item by tapping it resulting in it being highlighted and two interactable icons will appear.



(b) The user can move an object by dragging on the move icon. The icon not in use will be hidden during the interaction.



(c) The user can rotate an object by dragging the rotate icon in a circle around the object. The icon not in use will be hidden during the interaction.

Figure 10: Storyboard of the interaction techniques for the tablet.

4.3.3 Interaction Techniques

To ensure that the consistency between the VR and tablet interactions is as high as possible, tablet should have the same capabilities in terms of manipulating the environment as the VR users have. Methods for selecting, moving and rotating objects were implemented for the tablet. To select an object the user can click on it. To move the object, two approaches were considered: (1) press an object an drag to move it, (2) press an icon placed beside the object and drag the icon to move the object. Both approaches uses the common short press and drag interaction [3][1], but if the objects are small, the object and the desired location for it might get occluded by the user's finger if the first method was used. For the rotation interaction the same concerns were applicable. Therefore, the icon based approach was chosen. When selecting an object, that object is highlighted and two icons appear, one for moving the object and one for rotating the object, as seen in Figure 10a. The UI icons were designed to be at least 44x44 epx, based on Microsoft's recommendation for a touch-optimized UI element size [3]. To move an object the user has to hold down the move icon and then drag the object to their desired location (see Figure 10b). If an object collides with a another object it is moved on top of that object. To rotate an object the user holds down the rotate icon and moves it in a circle around the object to rotate the object around its own y-axis (see Figure 10c). When either of the icons are interacted with they change color to indicate this, and all movement is disabled so the user does not move by accident.

5 Implementation

The hardware used for the prototype were Meta Quest 2 and Lenovo Tab P12, which are both Android devices. The prototype was developed in the game engine Unity 2023.2.10f1[5] and was built for Android. For the networking Unity Netcode for Gameobjects[6] was used. The interactions in VR were developed with the Unity XR Interaction Toolkit[7]. The test environment made for the tablet locomotion test used various furniture assets and textures from Poly haven[8]. The assets used for the final test environment used a 3D model of a 4-room apartment, scanned by Ali Adjorlu, and various furniture assets from Poly haven and Unity Asset Store[9] (see Appendix G for the full list of 3D assets).

6 Evaluation

This section will describe the method for evaluating the prototype from this report, as well as conveying the results derived from the evaluation.

6.1 Motivation

The current format of workshops at Novo Nordisk have VR and TVs as platforms. Participants in VR can interact with the virtual environment and participants outside VR can spectate a stream from the VR headset to the TV. With the proposed platform in this project, the non-VR participants was given the chance to also interact with the virtual environment through a tablet.
The motivation for this evaluation is to explore whether a multiplayer, cross-platform application for tablet and VR can be used as a tool to improve participation and collaboration in asymmetric design workshops between the VR and non-VR participants.

[5] https://unity.com/
[6] https://unity.com/products/netcode
[7] https://docs.unity3d.com/Packages/com.unity.xr.interaction.toolkit@3.0/manual/index.html
[8] https://polyhaven.com/models
[9] https://assetstore.unity.com/

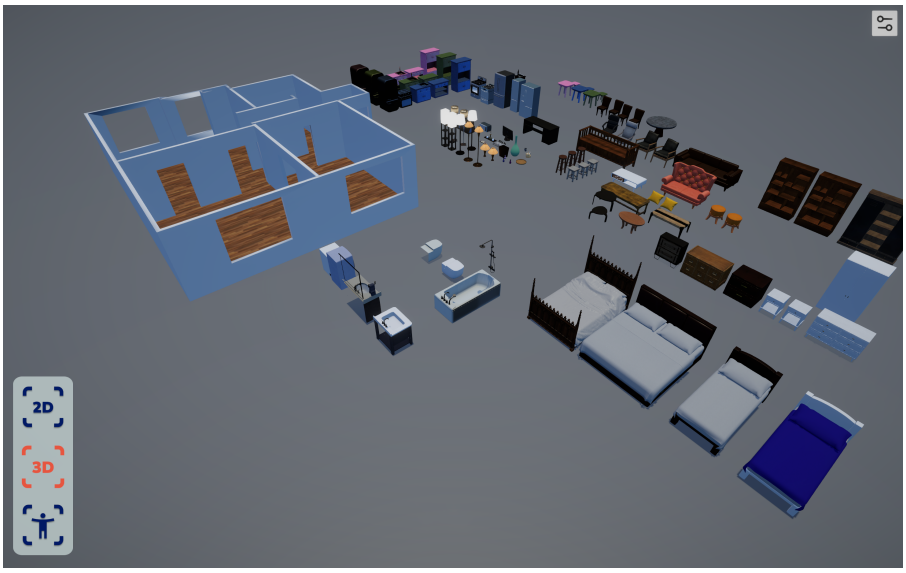


Figure 11: The virtual test environment with an empty apartment and furniture outside used for the evaluation.

6.2 Evaluation Method

The evaluation was a within group study with participants found by convenience sampling. It was not possible to test on Novo Nordisk employees due to scheduling difficulties and time limitations.

The test explored the participants' behaviour in a workshop setting while using the application. All participants tried using both tablet and VR, and then self-evaluated their perceived collaboration and sense of participation through a questionnaire and a focus group interview. During the test, user data derived from interactions in the VE, was gathered to provide insight in the users behavior when collaborating. Before the test, every participant read through and agreed to a consent form describing how their data would be gathered and used (see Appendix C).

6.2.1 Environment and Tasks

The virtual environment used was 3D model of an empty apartment with four rooms, and a space outside the apartment filled with furniture that could be moved into the apartment (see Figure 11). Since everyone had to use both interfaces two tasks were designed. In the first task, the participants had to collaborate on designing two of the four rooms, the participants had to decide and agree on which rooms. The room types they could choose to design was a bathroom, a living room, a kitchen, and a bedroom. In the second task the participants had to design the remaining two rooms, which had to be the remaining two types of room options given in the first task. The tasks were chosen to be universally relatable and understandable, unlike more specialized tasks such as designing a Novo Nordisk factory. Additionally, these tasks were intended to foster collaboration by encouraging participants to work together, rather than dividing the work and cooperating independently.

6.2.2 Test Procedure

For the evaluation the following equipment was used: 4 computers for questionnaires, 2 Meta Quest 2 headsets, and 2 Lenovo Tab P12 tablets. One researcher acted as a facilitator and interviewer, and another researcher acted as an observer. The physical setup for the test can be seen in Figure 12.
The evaluation was composed of the following steps:

1. The four participants were assigned a random number from 1-4.

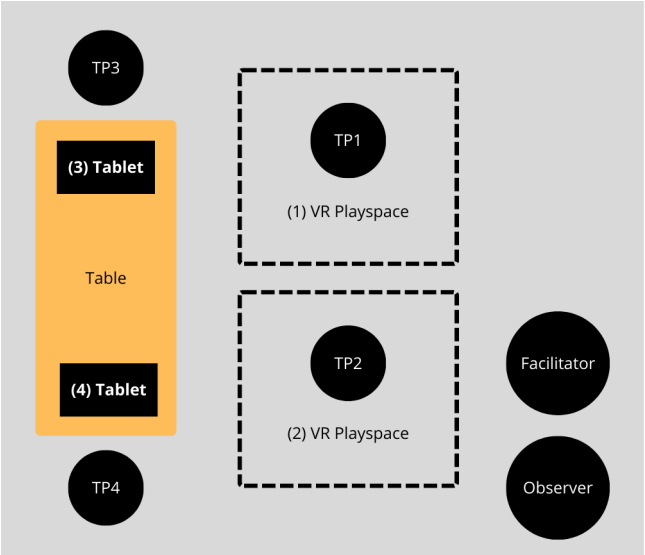


Figure 12: The test setup and placement of the two tablet users, the two VR users, the facilitator, and the observer. TP = test participant. After the first task TP1 and TP3 would switch and TP2 and TP4 would switch.

2. The participants were asked to fill out the consent form and demographic information (age, gender, level of education, experience with VR, and whether or not they knew the other participants).
3. Participant 1 and 2 started with VR and participant 3 and 4 started with tablets.
4. The controls for both platforms were explained to the participants.
5. The first task was explained and a timer was set for 10 minutes.
6. After 10 minutes the participants filled out the Spatio-Temporal Collaboration Questionnaire (see Section 6.2.3).
7. The test participants were asked to switch platforms and the infaces' controls were explained again.
8. The second task was explained and a timer was set for 10 minutes. An example of the environment after both tasks were completed can be seen in Figure 13.
9. After 10 minutes the participants filled out the Spatio-Temporal Collaboration Questionnaire again.
10. A focus group interview was conducted.

A document for the test facilitator with a full description of the test and a manuscript can be seen in Appendix N.

6.2.3 Spatio-Temporal Collaboration Questionnaire

The questionnaire used for this study was inspired by the Spatio-Temporal Collaboration Questionnaire which was developed in a study by Reski *et al.* [27]. The questionnaire focuses on four aspects of collaboration: (1) transitions between shared and individual activities, (2) negotiation and communication, (3) sharing context, and (4) awareness of others. The original questionnaire can be seen in Appendix C. The questionnaire answer options for scale L3 (see Table 4) were edited for readability to (1) mostly others, (2) mostly others, sometimes me, (3) everyone equally, (4) mostly me, sometimes others, (5) mostly me. The final 6 questions in the category *awareness of others*, were combined into 3

Figure 13: Figure showing an example of the VE after a group was finished with both tasks.

questions (questions 11-13 in Table 3) since both tasks given in this study were group tasks and there were no individual tasks. The final questions used for the evaluation can be seen in Table 3.

Question	Scale
1. How many of your efforts during this task would you consider to have been individual efforts?	L1
2. How many of your efforts during this task would you consider to have been group efforts?	L1
3. According to your impression, who was more in a leading/directing role during the group efforts?	L2
4. According to your impression, how often did you communicate verbally to your group members?	L3
5. According to your impression, how often did you communicate non-verbally with your group?	L3
6. How often would you consider dialogue to have taken place?	L3
7. How often would you consider negotiation to have taken place?	L3
8. Who would you say mostly initiated negotiations?	L2
9. The collaborated features of the system allowed me to focus on the same subject as my group members.	L4
10. The collaborative features of the system allowed me to establish dialogue with my group members.	L4
11. The collaborative features of the system distracted me from my individual efforts.	L4
12. During the task, how much were you aware of your group members' activities?	L5
13. During the task, how much were you aware of group members' location in space?	L5

Table 3: Table showing the questions used for the evaluation based on the Spatio-Temporal Collaboration Questionnaire. The four categories each question belongs to, in order, are symbolized with the following colors: purple = transitions between shared and individual activities, blue = negotiation and communication, green = sharing context, yellow = awareness of others. The scale options can be seen in Table 4.

Scale	Format				
L1	None	A few	Some	A lot	Every
L2	Mostly others	Mostly others, sometimes me	Both equally	Mostly me, sometimes others	Mostly me
L3	Never	Rarely	Sometimes	Often	Constantly
L4	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
L4	Not at all	A bit	Some	A lot	Always

Table 4: The 5-point scale options for the questions.

6.2.4 User Data from the Application

During the test of the application, user data was gathered as context for the qualitative data. This data provided insight in the amount all users interacted with the application. The data gathered for

VR was teleport action, highlight action and grab action. The interaction for rotation was not tracked, since the way VR users rotate objects cannot be correlated with a single action. The data gathered for tablets was highlight action, translation action, rotation action, change of view action, and time spent moving.

6.2.5 Focus Group Interview

After the participants tried the application as both tablet and VR, a focus group interview was conducted for each group. The goal of the interview was to gain insight in how the group collaborated as a whole. The focus group interview followed a semi-structured form, where the participants were allowed to discuss freely with the questions as the base.
The questions for the focus group interview was as follows:

1. What was your initial reaction to the prototype?
2. Can you describe how you interacted with other players during the session?
3. Did you find yourself contributing equally to the design process, regardless of whether you were using VR or a tablet?
4. Did you work individually, in pairs or all together?
5. Were there any features or functionalities you would like to see added or improved in future versions of the application?
6. Are there anything more you would like to add?
7. Did you at any point experience any kind of physical discomfort, such as nausea or dizziness, while using the devices?

7 Results

The following section will present the results from the questionnaires, interviews and user data.

7.1 Participants

The design prototype was evaluated on 6 groups of 4 people (24 in total), who designed an apartment in collaboration. The participants were found through convenience sampling and consisted of 18 male, and 6 female participants aged 19 to 31 years old. The majority of participants were university students. 13 out of the 24 participants knew all other test participants from their group beforehand. 5 participants had never tried VR before while 5 participants had tried VR 1-5 times and 14 participants had tried VR more than 5 times. The full demographic data can be seen in Appendix O

All participants will be referred to as "PX.Y (device type)", where X = test group number, and Y = participant number. Example: Participant 2 from test group 3 using VR would be: "P3.2 (VR)".

7.2 Observation Results

This section will describe the key findings from the observations. The key findings can be seen in Table 5. The entire observations can be seen in Appendix J.

	Key findings from Task 1	Key findings from Task 2
Group 1	One tablet user took the leading role. One tablet user did not participate much in the discussions. The rest communicated and coordinated a lot verbally Unsure who the different highlight colors belonged to. Spent a lot of time playing in the environment.	Everyone participated more in the discussions than they did in task 1 All users sought validation on design choices from other users.
Group 2	Tablet users move furniture into the rooms, and VR places them inside the room. They all communicate a lot verbally. They joke a lot.	Tablet users move furniture into the rooms, and VR places them inside the room. VR players act out interactions with furniture. They ask each other for help in either fetching furniture or fine tuning the placement of it. All users sought validation on design choices from other users.
Group 3	Discussed placement of objects before placing them. All users participated in the discussions. Discussed collaboration strategies, and proposed the task to be split up.	Started to work together instead of splitting up the task. Was confused as to who did what in the environment. Tablet moved furniture into the room, and VR fine tuned the placement.
Group 4	Started by discussing furniture before taking it into the room. Did not communicate a lot when making design decisions. Discussed when furniture was placed to evaluate the design.	They all participate in designing the room while communicating. Tablet moved furniture into the room, and VR fine tuned the placement. They are confused over the differences between other users selecting an object or manipulating it.
Group 5	They are communicating a lot with each other in pairs. VR talks with VR, and tablet talks with tablet. Tablet is used for overview, and VR is used for moving furniture.	They are all discussing together. All interfaces are actively designing together. Both interfaces are finding furniture and placing furniture.
Group 6	Tablet users move furniture into the rooms, and VR places them inside the room. They are not communicating a lot verbally while designing.	All interfaces start by discussing the overall design vision. They are not communicating a lot verbally while designing.

Table 5: Table showing the key findings from the observation data.

7.3 User Data Results

The user data for the amount of interactions for both tablet and VR users can be seen in Table 10 and 7. The interactions were visualized as a timeline, and can be seen in Appendix I and H. An example of a snippet of a timeline for tablet interactions can be seen in Figure 15, and an example for VR interactions can be seen in Figure 14. The time spent moving in each viewpoint for tablets can be seen in Figure 16.

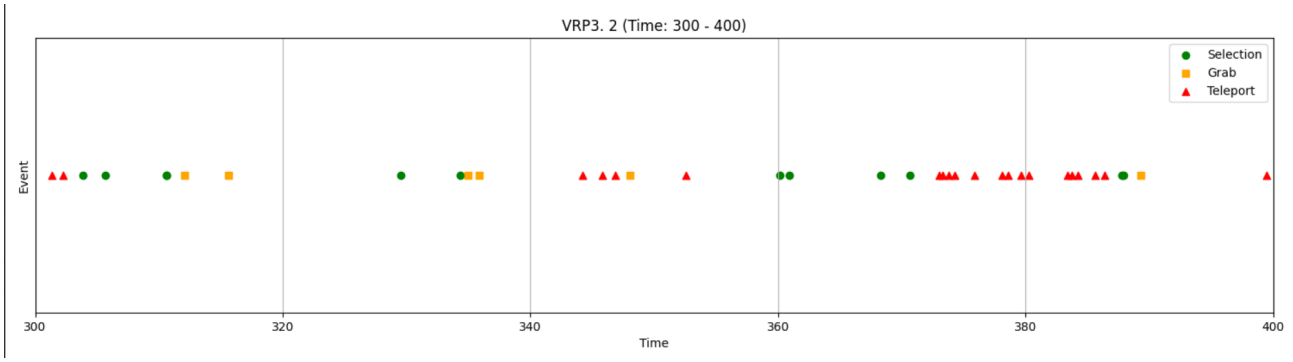


Figure 14: Figure showing an example of 100 seconds of an interaction timeline for a VR user.

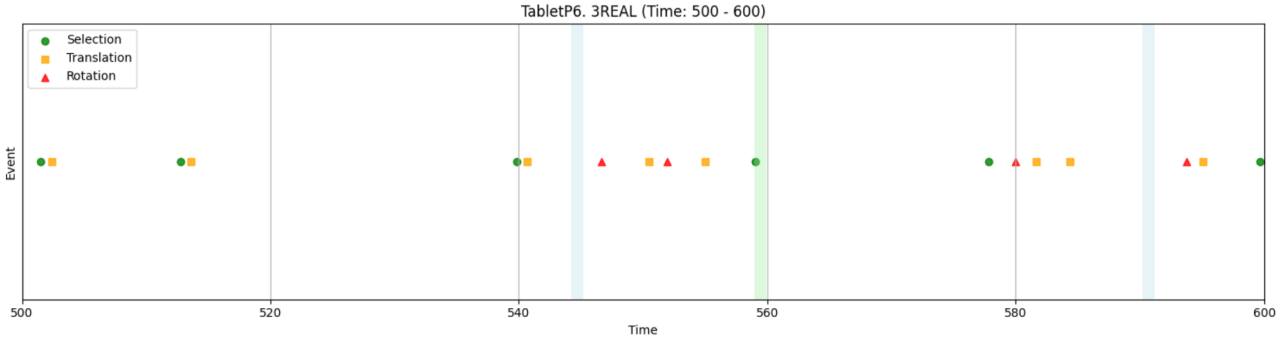


Figure 15: Figure showing an example of 100 seconds of an interaction timeline for a tablet user. Blue line = change view to "2D", green line = change view to "3D".

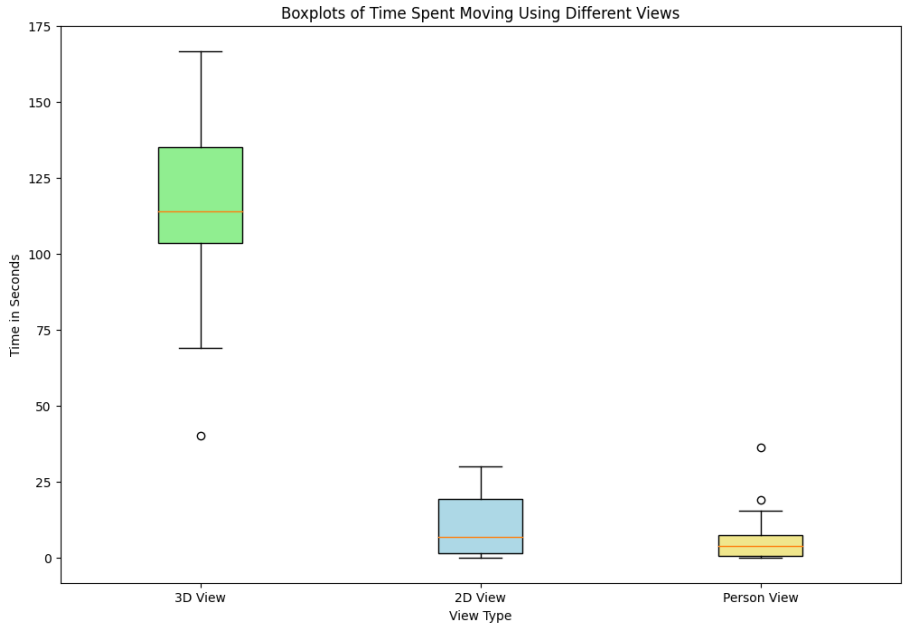


Figure 16: Figure showing the amount of time spent moving on a tablet for each viewpoint. On the x-axis the view type is represented and on the y-axis time in seconds is represented.

Test	Participant	Rotation	Translate	Selection	Total Interactions	Average of Total Interactions per Group
1	2	29	48	66	143	120.5
	4	3	51	44	98	
2	2	16	39	43	100	120.5
	4	15	74	48	141	
3	1	16	65	69	151	119.5
	2	14	45	57	118	
	3	24	46	33	106	
	4	16	49	34	103	
4	1	12	33	36	82	81.5
	2	14	38	45	99	
	3	17	37	35	92	
	4	6	29	14	53	
5	1	16	47	54	118	87.5
	2	2	15	21	40	
	3	5	22	24	54	
	4	27	65	42	138	
6	1	1	43	25	70	85
	2	9	17	14	42	
	3	23	64	53	143	
	4	11	37	33	85	

Table 6: Table showing the amount of interactions for tablet users. The tablet used by participant 1 and 3 in test 1 and 2 had a technical issue which led to the data being unusable.

Test	Participant	Selection	Grab	Teleport	Total Interactions	Average of Total Interactions per Group
1	1	73	34	132	241	278.25
	2	95	50	316	463	
	3	56	23	108	190	
	4	83	41	91	219	
2	1	152	74	103	332	383
	2	160	68	76	306	
	3	257	120	112	492	
	4	97	39	262	402	
3	1	24	103	94	225	203.75
	2	98	71	116	287	
	3	6	91	93	193	
	4	0	64	42	110	
4	1	8	43	139	195	228.75
	2	1	55	173	231	
	3	1	125	79	208	
	4	7	63	207	281	
5	1	24	87	97	214	241.5
	2	25	23	115	165	
	3	8	55	154	220	
	4	12	46	305	367	
6	1	3	43	175	228	187.5
	2	13	22	84	121	
	3	25	50	159	237	
	4	0	64	96	164	

Table 7: Table showing the amount of interactions for VR users.

7.4 Focus Group Interview Results

This section will present the key findings from the focus group interviews. The key findings can be seen in Table 8. The entirety of the focus group interviews can be seen in Appendix L.

Key Finding	Applicable For Group:
Designed both as a team and individually	2 - 3 - 5 - 6
Designed mostly in pairs	1
Designed mostly individual	4
Used tablet for overview tasks and moving furniture inside the rooms	All
Used VR to fine tune the placement of furniture	All
Thought that the application was fun and easy to use	All
Had better awareness of other players when using tablet	All
Had litlle awareness of tablet users when using VR	1 - 4 - 5
Found collaboration easier in task two, due to switching devices.	All
Physical discomfort:	**Amount of participants**
Headache	2
Eye-related discomfort	3
Dizzyness	1
Sore neck	1
Sweating	1

Table 8: Table showing the key findings from the focus group interviews.

7.5 Questionnaire Results

The results for each question in the questionnaire are presented in Appendix E. The means and standard deviation (std) for VR users and tablet users, along with the outcomes of an independent t-test comparing the responses of these two groups, are detailed in Table 9.

Question	VR Mean	VR std	Tablet Mean	Tablet std	T-statistic	P-value
1. How many of your efforts during this task would you consider to have been individual efforts?	2.964	1.347	2.821	0.67	0.493	0.626
2. How many of your efforts during this task would you consider to have been group efforts?	3.5	0.793	3.643	0.78	-0.626	0.537
3. According to your impression, who was more in a leading/directing role during the group efforts?	2.857	0.803	2.679	0.723	0.895	0.379
4. According to your impression, how often did you communicate verbally to your group members?	3.857	1.008	3.893	0.737	-0.189	0.851
5. According to your impression, how often did you communicate nonverbally with your group?	2.429	1.103	2.5	1.036	-0.232	0.819
6. How often would you consider dialogue to have taken place?	4.036	0.744	4.036	0.793	0	1
7. How often would you consider negotiation to have taken place?	2.571	0.959	2.714	0.81	-0.61	0.547
8. Who would you say mostly iniated negotiations?	2.571	0.79	2.75	0.844	-0.895	0.379
9. The collaborated features of the system allowed me to focus on the same subject as my group members.	4	0.72	3.893	0.685	0.55	0.587
10. The collaborative features of the system allowed me to establish dialogue with my group members.	4	0.544	4.071	0.813	-0.42	0.678
11. The collaborative features of the system distracted me from my individual efforts.	2.429	1.034	2.643	0.951	-0.782	0.441
12. During the task, how much were you aware of your group members' activities?	3.286	0.897	3.679	0.819	-1.737	0.094
13. During the task, how much were you aware of group members' location in space?	2.464	0.881	3.679	1.056	-4.784	>0.005

Table 9: Table showing the means, standard deviations (std) and the results of a t-test for each question in the questionnaire. alpha = 0.005.
Question 1 & 2: 1="non", 2="few", 3="some", 4="a lot" 5="every".
Question 3 & 8: 1="mostly others", 2="mostly others, sometimes me", 3="both equally", 4="mostly me, sometimes others", 5="mostly me".
Question 4, 5, 6 & 7: 1="never", 2="rarely", 3="sometimes", 4="often", 5="constantly".
Question 9, 10 & 11: 1="strongly disagree", 2="disagree", 3="neutral", 4="agree", 5="strongly agree".
Question 12 & 13: 1="not at all", 2="a bit", 3="some", 4="a lot", 5="always".

8 Discussion

According to the results from the questionnaire (see Table 9 in Section 7.5) the participants, on average, felt like their efforts during the tasks were mainly group efforts (question 2) with a mean value of 3.5 for VR and 3.643 for tablet (VR std = 0.793, tablet std = 0.78) which is between "some" and "a lot" on the scale. Both of these values are higher than the reported amount of individual efforts, with mean values of 2.964 for VR and 2.821 for tablet (VR std = 1.347, tablet std = 0.67). This points to collaboration taking place more than participants working individually.
For both VR and tablet the communication was reported to be mostly verbal and for both groups dialogue was reported to have taken place "a lot" (question 6) with a mean of 4.036 for both groups(VR std = 0.744, tablet std = 0.793). Negotiation was reported in between "rarely" and "some" (question 7) with a mean of 2.571 for VR and 2.714 for tablet (VR std = 0.959, tablet std = 0.81). Even though there was a lot of dialogue it was not necessarily dialogue related to collaboration. The collaborative features (question 10) of the platform was reported to allow for dialogue with group members, with a mean score of 4 for VR and 4.071 for tablet (VR std = 0.544, tablet std = 0.813) indicating that the application supported the groups in their collaboration.
The results from the questionnaire indicate that collaboration took place, but with room for more collaboration. A reason for this could be the nature of the tasks. At no point were they asked to review or agree on their design, which leaves room for the task to be split up and have the participants cooperate more than collaborate (see Section 2.2). Designing an apartment is also a task which most people are familiar with, which lessens the need for collaboration to complete the task, since it could be completed alone. If this application was to be used within a workshop at Novo Nordisk everyone would have to agree on a decision, and there would be SMEs that would be consulted in order to make the right decisions for the spaces. This might improve collaboration because the users are more dependent on the knowledge of others and might be less likely to split up the task. It could also be explored whether the collaboration would be different in an only VR setting or only tablet setting to see if the cross-media setting negatively impacts the possibilities for collaboration.

From the observations and interview, it became apparent that the participants lacked the ability to highlight points of interest when there was no object there. For instance, they were unable to effectively communicate where they wanted other participants to place furniture. This problem was solved by the participants having more detailed discussions, which would not have been needed if they had the ability to mark areas for the other participants to see inside the VE. When the participants rely on verbal communication for understanding design decisions, it comes with the natural limitation that only one person can speak at a time. By adding a tool which reduces the need for verbal communication, the speed and efficiency of making design decisions might increase.

Every group mentioned that they thought the application was fun and easy to use (see Table 8), which initially sounds like positive feedback. However, having fun can also be distracting and take away focus from the main task, which is designing. This problem was also mentioned as a concern by the facilitators of the Novo Nordisk VR design workshops (see Appendix F.1.1). Looking into the observation and interview data, it can be seen that some participants in VR wanted to juggle with furniture, another group spent some time playing with the objects, and one participant even mentioned that "it was fun to mess with the other players" (see Appendix M). There is a balance between having fun doing the main task, and having fun as a distraction. When developing applications for VR it is especially important to make sure the users do not get too distracted since VR inherently has a novelty factor. However, having a positive experience with the technology can also create a willingness to use the technology again for another workshop, and can aid in a successful deployment of new technologies.

During the interviews, all groups mentioned that they found it easier to perform the tasks after they switched devices which were also noted in the observations (see Table 5 and Table 8). After switching interfaces several participants noted that the interactions between the interfaces were different. The groups also found collaboration easier in task 2 (see Table 8). This might be because that they were

now aware of the capabilities of both interfaces, making the communication easier. This does show that each interface has its own merits and is contributing with something unique, but it also indicates that having a deeper understanding of how others can contribute is influencing the participants' ability to collaborate. If the application presented in the report is to be used in a real workshop context, having all participants familiarize themselves with both the VR version and tablet version might not be feasible due to time constraints. Therefore, the application could include a feature which makes it apparent how other users can interact with the environment. One participant mentioned "It was nice to feel that you had been in the room before you used the the tablet and saw it from above" (see Appendix M), which indicates that they might also have a need for a tool which helps them convey some of the more complex information to their peers, such as the room layout. This could be achieved in several ways, for instance all users could get access to the viewport of other users, a mini-map of the entire environment, or a feature for capturing and sharing screenshots could be implemented.

During the test, all groups found that the tablet was best suited for moving furniture into the apartment, while VR was best suited for fine tuning the placement of the furniture. This is also reflected in the user data gathered from the tablet users (see Table 6 in Section 7.3) where the rotation interaction was used 66% less than the translation action. Since the translation and rotation done by VR was not logged (grab is a prerequisite for both translation and rotation), we do not know if the division of labour was also reflected in the behaviour of the VR user. Future testing could include the division of rotation and translation by the VR user to investigate this finding further.

In the questionnaire it was found that VR users did not feel as aware of other group members' location in space as the tablet users felt (Table 9, question 13). Even though the tablet users also had avatars indicating their position, it was not always possible for the VR user to see them. If the tablet users were in either 2D or 3D view and the VR player was inside the test environment, the tablet users' avatars might have been occluded by the roof of the test environment. This could have been alleviated by having the tablet avatar being rendered on top of all other objects so it would always be visible, even if objects from the environment would have occluded it. In the interviews it was also mentioned that it would be beneficial to be able to tell where tablet users were looking (see Appendix M). It could be possible to visually indicate where the camera of the tablet is pointing to. However, this would not always be representative of where the user is looking when they are using either the 2D or 3D view as they might not look in the middle of their screen. Another possibility could be implementing the functionality to highlight positions in space, as mentioned earlier, giving the tablet user a chance to indicate where they are focusing. A mini-map for the VR player with everyone's position on it might also be a helpful tool, even though a tablet's position might not be indicative of where they are focusing. Some participants mentioned that they did not know which color belonged to the other participants. Even though all participants had different colors, there was no way of seeing who had which color. A system that informs the user of what color belongs to who could be implemented.

According to both the interviews and the logged data, the first person view on the tablet was the least used and least preferred view (see Figure 16). This raises the question of whether this view type is necessary at all or if its design and implementation were inadequate. According to the interviews, tablet users felt less present in the environment. The intention with the implementation of the view was to give tablet users a sense of seeing the room from a human perspective. Seeing the environment from this perspective was not required for the task and would be performed by the VR users anyway. The movement method in the first person view, Drag n' go, while effective, is not a widespread technique and users most likely do not know it or find it familiar, which might mean that users would need more time to learn how to use it than what was provided in the test. It was not possible to move items while also moving yourself as a tablet. Since first person view has the most limited field of view, this would also be the least effective view for moving objects larger distances. Having workshops or tasks where a review phase is included might change the need and usefulness of the first person view option.

The sense of participation in the design process between the tablet users and VR users were not found

to have a significant difference as all p-values for the questionnaire except one was above 0.05 (see Table 9). This signifies that both interfaces were able to contribute in an equal way to the design process. The next step would be to try and test the application in a real workshop at Novo Nordisk to explore whether the lower degree of asymmetry improves collaboration and perceived participation. Some key differences in a Novo Nordisk VR design workshop and the test setup in this report, is that Novo Nordisk workshop participants are not designing with aesthetics in mind, but rather function. The participants in Novo Nordisk will also be of a higher age, and they will have a higher expertise in the matter they are designing. Further research is needed to see if the application still fosters collaboration under those conditions.

9 Conclusion

In this section we will conclude on whether the proposed application with a low degree of asymmetry allows for collaboration between VR and tablet and an equal sense of participation.
The perceived collaboration of the tablet and VR users were not found to have a significant difference, except for the subcategory perceived awareness of other's positions in the VE. The tablet users had a higher level of awareness of others compared to the VR users. The participants reported that the tablet interface was better at moving furniture inside the apartment and keeping an overview, while the VR interface excelled at fine tuning placement of the furniture. The mixed method evaluation signifies that a design application for both VR and tablet, where both interfaces have unique ways of interacting, and excels at different aspects of the design process, can provide an equal sense of participation. The features of the application allowed for collaboration between the two interfaces, but the collaboration was improved in the second task after the participants switched interfaces. The collaboration could be enhanced by creating a system for both interfaces to gain insight in the way other users participate in the design process, a way of communicating knowledge exclusive to each device. It could also be beneficial to add a method for indicating points of interest in the VE unrelated to objects. Further testing on real use cases at Novo Nordisk is necessary to evaluate whether the application would solve the need for equal participation at the Novo Nordisk VR design workshops.

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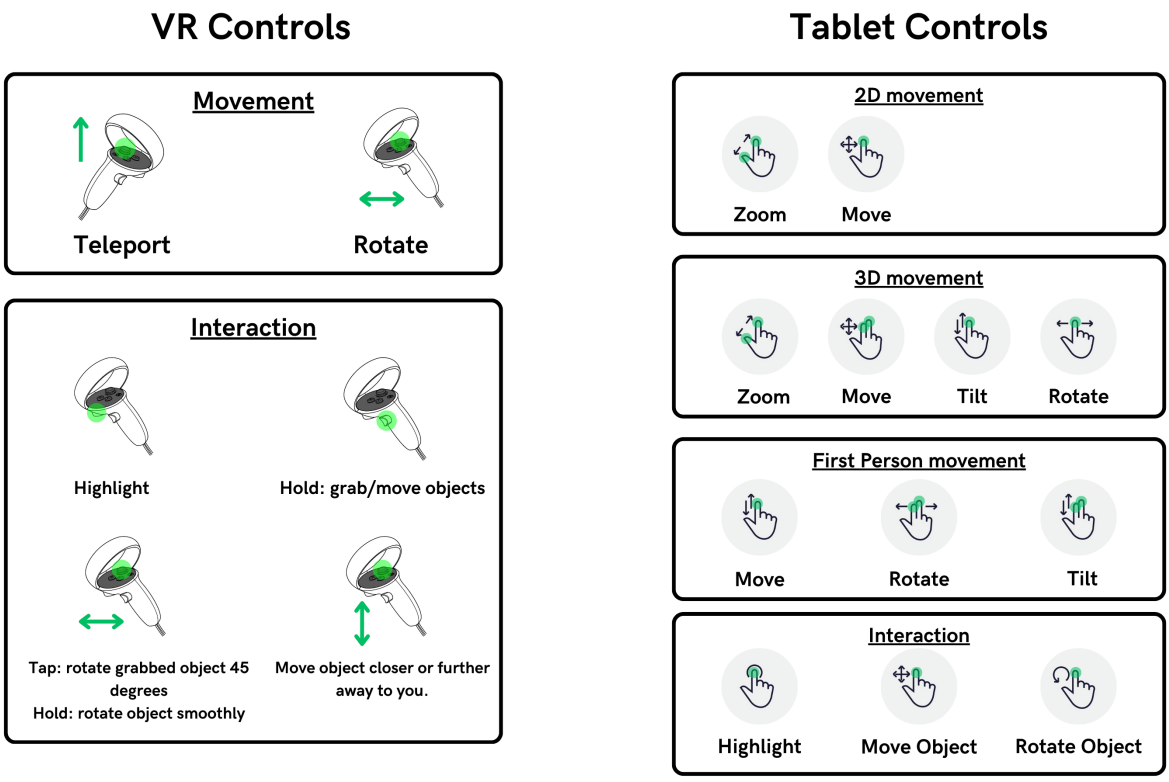
A Appendix: Interaction Guides

This section shows the guide the users were presented with prior to interacting witht each interface.



(a) Guide for the VR controls. *(b) Guide for the tablet controls.*

Figure 17: The two guides shown to participants before starting a task.

B Appendix: Tablet Locomotion Evaluation

The following section will describe the test performed to evaluate the locomotion for the tablet prototype.

B.1 Motivation

The motivation for this evaluation was to test whether the three locomotion types (2D, 3D and first person) developed for the prototype and the method of switching between them was intuitive and useful for the users when exploring a 3D environment.

B.2 Test Method

This section will describe how the test was performed including the test environment, the tasks and the full procedure.

B.2.1 Test Environment

The test environment was a furnished room with 7 numbered blue cubes hidden in different sections. The cubes were hidden in order to force the user to change view point at least once. This means that some of the cubes were not visible from top-down view.

B.2.2 Tasks

The tasks were created to let the user explore the room using the three different views. The first task wants the user to explore the environment and get an overview. The second task forces the user to look more closely at the hidden boxes, since the numbers can not be seen from 2D view. The third task explores the user's spatial sense after using the platform to explore the room.

1. Find all blue boxes in the room.
2. Highlight the blue boxes in the order they are numbered.
3. Explore the room and draw a floor plan without looking at the room.

B.2.3 Interview Questions

1. What type of information did the different views provide?
2. How was the experience of controlling the views?
3. Was there anything that you wanted to do which you were unable to?
4. Did you understand the meaning of the icons?

B.2.4 Procedure

The test was performed the following way:

1. The researchers presented and explained the test.
2. The researchers explained the two parts of the test: 3 tasks on the tablet and an interview.
3. The participant was asked to use the think-out-loud method (if the participant was not familiar with the method it was explained).

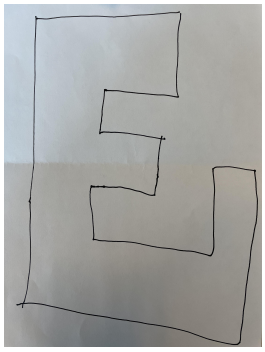
4. The participant was asked to perform task 1, 2, then 3.
5. The interview was conducted.

B.3 Results

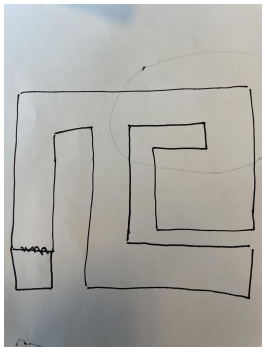
This section will present the results including the floor plans drawn for task three and the general findings from both observations and the interview.

B.3.1 Floor Plans

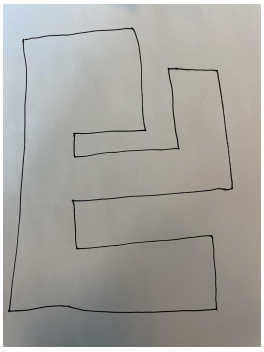
The floor plans the participants drew for the third task are presented below.



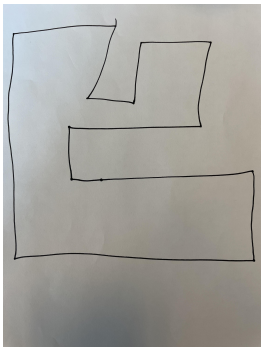
(a) Test Participant 1.



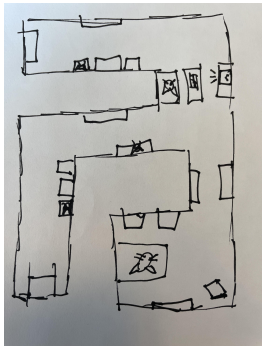
(b) Test Participant 2.



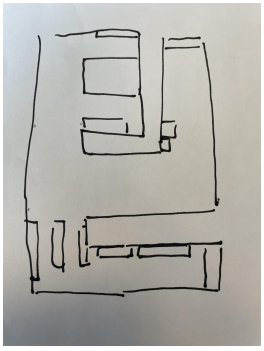
(c) Test Participant 3.



(d) Test Participant 4.



(e) Test Participant 5.



(f) Test Participant 6.

(g) Test Participant 7.

Figure 18: The floor plans drawn by the participants for task 3 in the locomotion evaluation. The participants who used the 3D-view to gain an overview also drew furniture.

B.3.2 Key findings

The raw data from the test can be found in zip folder under this name... Summarized below are the key findings from the observation data and the interview.

- Everyone used the first view they were presented with (2D)
- Everyone switched to 3D as their second view, 6 out of 7 switched in the first task
- When the users needs to find and interact with the blue boxes they preferred (in order): 3D, first person, 2D
- Users preferred using 2D view to get an overview of the floor plan and 3D for furniture
- 4 users drew floor plan without furniture only using 2D

- 3 users drew floor plan with furniture and used both 2D and 3D
- All users used two finger rotate in first person view
- 3 out of 7 users explicitly stated that they preferred 3D view over first person view in this context
- P3: “First person view felt redundant because I don’t have a relationship to the room. If it was an apartment I was movin into then I might want to see it in first person view.”
- Everyone understood the use case and controls of 2D and 3D view.
- There were mixed reactions to the controls and use case of the first person fiew: the rotation was found negative and the movement was found positive.
- Everyone thought 2D was good for getting an overview of the floor plan
- Everyone thought 3D was good for getting a spatial understanding of the room
- Everyone understood the icons

C Appendix: Spatio-Temporal Collaboration Questionnaire

The following figure shows Spatio-Temporal Collaboration Questionnaire from the article by Reski *et al.* [27].

Item	Statement	Scale
TSIA.1	How many of your efforts during this task would you consider to have been *individual* efforts?	L1
TSIA.2	How many of your efforts during this task would you consider to have been *group* efforts?	L1
TSIA.3	According to your impression, who was more in a leading/directing role during the *group* efforts?	L2
NC.1	According to your impression, how often did you communicate *verbally* to your partner?	L3
NC.2	According to your impression, how often did you communicate *nonverbally* to your partner?	L3
NC.3	How often would you consider did *dialog* take place?	L3
NC.4	How often would you consider did *negotiation* take place?	L3
NC.5	Who would you say mostly initiated the *negotiations*?	L2
SC.1	The collaborative features of the system allowed me to focus on the same subject as my partner.	L4
SC.2	The collaborative features of the system allowed me to establish a dialog with my partner.	L4
SC.3	The collaborative features of the system distracted me from my *individual* efforts.	L4
AO.1	During your *group* efforts, how much were you aware of your partner's activities?	L5
AO.2	During your *group* efforts, how much were you aware of your partner's location in space?	L5
AO.3	During your *group* efforts, how much were you aware of your partner's time reference (time point/interval)?	L5
AO.4	During your *individual* efforts, how much were you aware of your partner's activities?	L5
AO.5	During your *individual* efforts, how much were you aware of your partner's location in space?	L5
AO.6	During your *individual* efforts, how much were you aware of your partner's time reference (time point/interval)?	L5

Scale	Format (5-point Likert)				
L1	none	a few	some	a lot	every
L2	mostly other	more other, some me	both equally	more me, some other	mostly me
L3	never	rarely	sometimes	often	constantly
L4	strongly disagree	disagree	neutral	agree	strongly agree
L5	not at all	a bit	some	a lot	always

Figure 19: The original Spatio-Temporal Collaboration Questionnaire [27].

D Consent Form

Fill out before test.

Test ID

_____

Participant ID

_____

To participate in this test we need your consent in regard to anonymous collection of your personal data, exclusively used for this Master's Thesis project at Medialogy, Aalborg University Copenhagen. Giving consent for data collection and analysis within this project is entirely voluntary. If consent is not given, no personal data will be used or stored and the participant will be unable to participate in the test.

The purpose of the project is to investigate collaboration in cross media workshops.

The collected data will be used for:
Analysis, research and statistics.

Data collected from the survey will consist of:
Age, gender, current occupation, as well as your subjective opinion of the product.

The participant is able to withdraw their consent, if they wish. In this case, all personal data of said participant will be deleted. Withdrawal of consent must be done by contacting fifver19@student.aau.dk .
The participant has the right to gain insight concerning their data, as well as being able to change incorrect information regarding their answers and personal details, as in compliance with the Danish data protection rules.

Personal data will be deleted after the project exam is finalized. At maximum, the data will be deleted one year after the consent has been given.

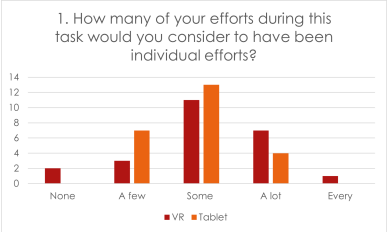
For further information regarding data processing, the survey or withdrawal of consent, please contact the project group at:
fifver19@student.aau.dk

The data protection advisor of AAU:
DPO@aau.dk

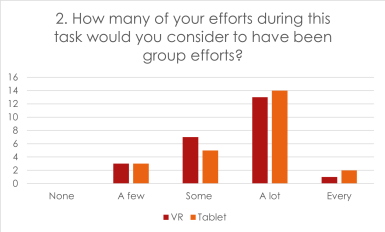
Should you have complaints regarding AAU's data processing, please contact 'Datatilsynet' at:
Borgergade 28, 5
1300 KBH K

E Appendix: Questionnaire Results

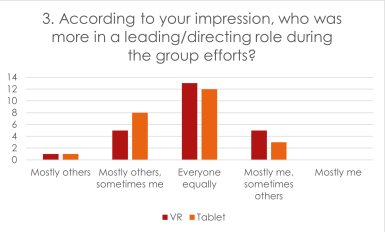
This sections presents all the data from the Spatio-Temporal Collaboration Questionnaire.



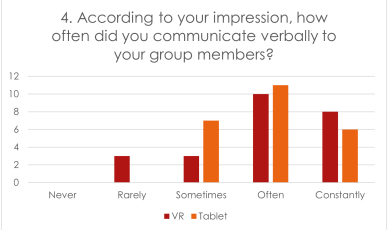
(a) Question 1.



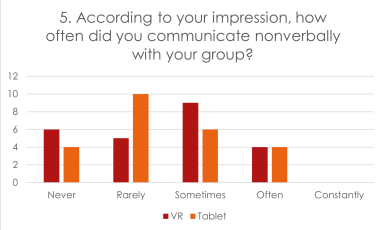
(b) Question 2.



(c) Question 3.



(d) Question 4.



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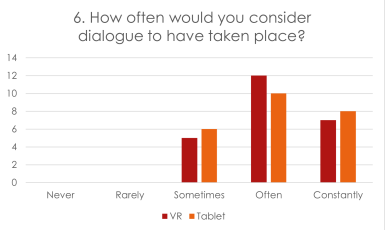

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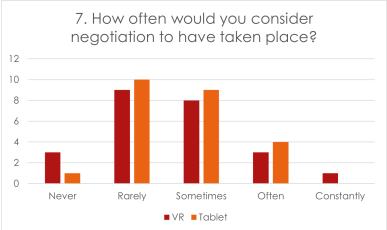

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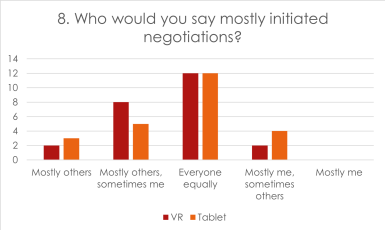

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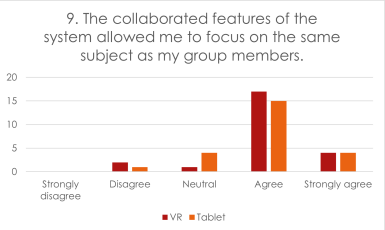

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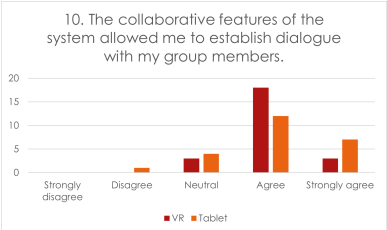

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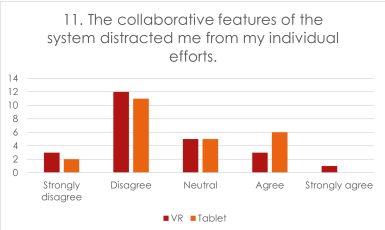

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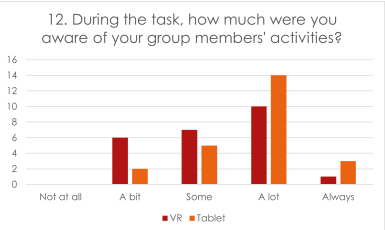

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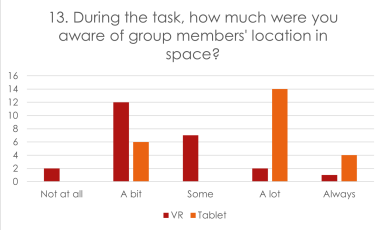


(m) Question 13.

Figure 20: Spatio-Temporal Collaboration Questionnaire Results. On the x-axis are the answers and on the y-axis the frequency of the answers. Red represents VR and orange represents tablet.

F Appendix: Interviews With Employees At Novo Nordisk

The interview contained business critical information, therefore sections have been rewritten to omit critical information.

F.1 Interview with XR Employee

Attendees at the interview:

Novo nordisk employee

Interviewer

Interviewer: Think we'll just proceed in English from here.

Novo Nordisk Employee: Totally okay.

Interviewer: Okay, cool. And you know the purpose of this project, or do you want me to introduce

it?

Novo Nordisk Employee: Just refresh me. I have a lot of stuff in my head right now. Yeah,

Interviewer: okay. So this of course, is our master's project, and the focus is that we want to work with this, like cross media in workshops. So, like, the asymmetric part is right now what we're trying to focus on. But, yeah, generally, also for this project.

Interview, it's about VR workshops here at Novo Nordisk.

Novo Nordisk Employee: Right, that's pretty relevant to what we're doing.

Interviewer: Yeah. So, so first I just want to ask what is your position at Novo Nordisk?

Novo Nordisk Employee: That's a good question. I formally on paper, I think my position is VR slash AR developer.

Interviewer: Yeah.

Novo Nordisk Employee: But that's sort of on my contract, but what I was hired to do and what my, I think what my My, sort of, job posting I got the job on said was, I think, 3D modeler and CAD specialist.

So that's sort of the second layer of the answer. The third layer is sort of what I actually do. And I think my, our colleague, [redacted name], who's a 3D artist the other day, described my job as like connector of dots. So I am informally in charge of the 3D asset team or the art team in video game terminology.

And what that effectively means is that I am responsible for, getting all the, the data and all the 3D assets and all the information on what we need to add in VR. And then making sure it gets updated and, and optimized and stuff correctly.

Interviewer: Cool. And yeah, then can you describe the goal of facilitating VR workshops at Novo Nordisk?

Novo Nordisk Employee: Oh, that's a really big question. Yeah. I think the, the formal goal is, well, it's kind of transient. The goal of any workshop, I think it depends on who's hosting. But, if our clients are hosting a workshop, the purpose of the goal of the workshop is usually for them to gain some kind of understanding of their own work or their own project using VR.

So if the subject matter experts for a certain room or work area conduct a workshop using VR, it's most often for the purpose of getting training. Using VR as a design revision tool, right now at least. I think if we're hosting a workshop, it's sort of the opposite. So we're bringing people who have knowledge that we don't have about a certain area or topic into VR for the purpose of asking them questions and extracting knowledge about what's missing or what's lacking or what's wrong.

If that makes any sense.

Interviewer: Yeah, and just when you said we, now you're referring to the XR department?

Novo Nordisk Employee: Yes, when I say our client, I'm referring to [redacted other area of the company in charge of site expansion]. And when I'm referring to we, I refer to the BRD extended reality department. Yes.

Who's developing this VR product.

Interviewer: Cool. So, how would you say that VR is aiding in achieving the goals?

Novo Nordisk Employee: The goals being ours or theirs?

Interviewer: Both, I would say. The different goals.

Novo Nordisk Employee: Well, I think that, again, it's an annoyingly transient question. And when, when I say transient, I mean that it's a sort of time variable thing.

And that, how VR aids our stakeholders, I think, changes as the project progresses. That's a key thing, in my opinion, at least. For the time being, while the whole project is still in the sort of design phase, or until it's done to the best of our knowledge, VR aids in being a communication tool and a design revision tool.

We've discovered that there's an awful lot of chaos running this project that I think the average sort of ingenuity or like, Age in Novo of a, of a employee is like three, four months. So there's a lot of stuff people don't know and nobody knows what is anything. So people use VR as a sort of meeting point.

And that's more often than not, it's the only way they have of really looking at an example of a proposed finished design and discussing it and making changes. And, I think in the long term the goal of the project is to create a training platform where we would have a more or less fully realized replica of the entire factory.

So that anything that they want to train, that is hard for them to do so in real life, because of borders or costs or safety, they could do in VR.

Interviewer: Yeah. Cool. And which type of people are normally attending these VR workshops?

Novo Nordisk Employee: I think that well, I think broadly engineers.

Yeah.

That's because I think like 90 percent of the people employed here are engineers.

So I think it makes sense to go into a little bit more detail because there's a lot of engineers that's saying like consultants, okay, that can be anything. But most of the people who attend workshops are, are what you would call SMEs in Novo Lingo. That means subject matter experts.

And that they come in a lot of different flavors. And I'm not actually even sure that the subject matter experts covers all of them. There's a lot of process responsible people, who are the people who design and, are hired to make sure the, the work processes that have to happen in these places in the factory are correct.

both according to like health and safety standards, but also like, do they do the job? Are they possible to be done by people? And also eventually there will be a lot of what we call operators who are sort of the staff that staff the factory and run the processes. There's also a lot of external vendors and people from who are not formally Novo employees, but who have been hired or are collaborating with Novo to deliver a product.

So if somebody is making like a big washing machine or a big thing that cleaned carts or something, then they will usually be employed quote unquote at Novo for a period while they sort of design the product with Novo. Just spitballing here. I think there's also often a lot of the logistical people who make sure that all the parts are there and, it's too many to list, but yeah.

Interviewer: And then, of course, there are sometimes us.

Novo Nordisk Employee: Right, that, sorry, I assumed too much, yes. In addition to all the stakeholder types, there are the people from our own team, who would be UX researchers, UX designers, connectors of dots, aka me, product owners, students a lot, you guys, yeah.

Interviewer: Cool. And what has your role been in the VR workshops that you have attended?

Novo Nordisk Employee: Well do we want to talk about prior projects or just this one?

Interviewer: I think actually a bit of both, both. Right. Just to get like a full picture.

Novo Nordisk Employee: But it's just important to ask because I think my role in all these workshops are sort of hard to grasp unless you have the historical perspective.

About a year ago when we were four people a lot of the sort of non-dev tasks fell to me. And so, I have a vague background in, I'm from ITU in Copenhagen,

and I have a sort of somewhat similar background to Medialogy, in that a lot of design, a lot of stakeholder stuff, a lot of UX, a lot of interaction design.

And I've sort of been facilitating workshops for the sort of mutual gain for a long time. So usually in workshops, what I've done in the past and still do is attend workshops run by stakeholders. And then when there's stuff that they're unsure about, because we're trying to replicate the thing and that's a sort of in Sisyphus Greek thing.

Like it's an eternal pushing us down a hill and it's never done. And it's kind of keeping up with changes from their end, which is hard enough for them. So I'm there to both answer questions if they're unsure of if something in VR is correct, or if it's done, or what, what level of detail they can sort of expect.

And also, if they have input, I bring them back to the rest of the team and get on that. So for historically, the format has been sort of a symbiotic thing. They get input out of it for their end and then we get input out of it for our end

I facilitate that, I guess. Yeah. So I've done everything. Take notes, set them up, coordinate them, make sure the VR stuff is ready. Set up cameras and sound and everything.

Interviewer: Then I have two questions about like before the workshop. So, what tasks, if any are required from, your role before a workshop?

Novo Nordisk Employee: I think there's a couple of categories of tasks. I think there's, there's sort of coordinating tasks, and then there's technical tasks. As far as coordinating goes This project we're working for is super uncoordinated and super chaotic, so sometimes workshops happen and I'm not sure who booked them and who did them.

And so a lot of the data is sort of figuring out what the context from our stakeholders end is, what they want out of it, so as to align on what they want, and what they want to do with the workshop, and then making sure that happens. And then figuring out like time and place and stuff like that.

The other end is the sort of technical part, which is making sure that if there's a workshop happening on like a cleaning room or a thing that cleaned parts, then making sure that whatever the stakeholders want to do in the workshop is supported by our product.

And that is a whole rabbit hole of digging up 3D parts and files and, and data and figuring out if we can replicate it in VR, if it's possible and feasible and when the time would be right. And then also. Sometimes booking rooms and figuring out if we have, and like updating headsets and making sure they're charged and making sure that everybody knows where it is and that they should be involved in VR and that we have TVs and Chromecasts and cables and all the basic stuff.

Interviewer: Mm. Cool. And do you know if the other attendees have any, like, required tasks before workshop? And if so, what they would be?

Novo Nordisk Employee: A required task, meaning

Interviewer: like for example, that you now know that, I have to make sure that the headset are charged and so on.

Novo Nordisk Employee: Sorry, I'm not aware of if, of what their sort of prep, if any is No. So sometimes it seems like there is none. Yeah. More often than not.

Interviewer: fair enough.

Okay, and then a bit about during the workshop. In your own words, could you describe in a sort of step by step manner how a VR workshop takes place?

Novo Nordisk Employee: So, yeah, but I think it's important to note that this is a sort of the format that has been historically established, and it's subject to change, so I think there's a distinction between the way we've run workshops, and can run workshops now, until we come up with something better, and then whatever that something better will be.

So it's a very imperfect, sort of organically developed format. But during the workshop it's usually a matter of like, so you said step by step what I do.

Interviewer: Yeah. So for example, just, I don't know, maybe the latest workshop you attended or sort of like what happened.

Novo Nordisk Employee: Right. Yeah. So the very last workshop, they're all kind of unique which is horrible.

But, we have three people involved at, the, big project here, and then they are our sort of liaisons with the other stakeholders. So they, right now, they actually

take care of the practicalities of, setting up a, site room and making sure that headsets are real and stuff, and the technical stuff happens.

So while the workshop runs, I think actually, my role step by step is a iterative dialogue with stakeholders where I try to, I wouldn't say mediate, but I try to, hover and not influence them, but if there are notes or questions I have, or if they have questions to me, I answer them.

And so step by step they would show up. Assuming that, the tech app works and we don't have major glitches or anything. They would go into VR, find the area they need to look at or talk about then start going through their own process of revision and sort of open discussion about things.

So say they would navigate to something and then they would say, look at it and say, okay, this is wrong. I would say, wrong in what sense? Is it wrong from our end? Is it a thing that you have asked a vendor to do and they did not do correctly? Is it something that you can do? you don't like or want to change based on this input?

And then I note that down, if it's something that we should change, or if it's a change that VR's model has enabled them to reflect on.

And if it's a change from our end, I make a note of it, and then they move on. And then occasionally, if I notice anything that, an assumption's being made on their end about, Okay, this looks wrong.

And they are, well, they seem to want to change it from their end I would interject and say, sorry, that is a shortcoming of the VR sim. And that sort of happens for about an hour or something, until they've gone through everything they want to go through. And then we wrap up, and they usually ask some questions, and I try to answer them.

And then we try to decide next steps for the next workshop. So I know not very, not a lot of sort of steps, but I hope that works.

Interviewer: Yeah, it's pretty good. So during the workshop how do the people collaborate that are, like, the ones who

Novo Nordisk Employee: The stakeholders.

Interviewer: Yeah, the stakeholders,

these SMEs.

Novo Nordisk Employee: Well, right now, it's, it's a weird format where there's usually, there's some, there is definite design friction, like, sort of user friction. Right. Hmm. As far as using VR, so the, the sort of historical format has, should have been a sort of camera man audience approach. Not that we like it, I will interject, but where one or two people should of agree to be the volunteer people who put on a headset and do the VR thing, and then we usually screencast that to a big TV and then a sort of quote unquote audience or a council of people observe from the sidelines and have a workshop like, or not workshop but a sort of open design discussion based on that. So they more or less use one person as the code cameraman, and then they talk about that. But, we would like it to get to a point where everybody joins in VR, and everybody has a headset on, or if not a headset on, then they observe from their own client as a WebGL build or an executable.

So, until we go away from that. But that's the way it usually happens.

Interviewer: Yeah. So, yeah, right now we have, for example, at a workshop it would be TV and a VR headset.

Novo Nordisk Employee: Yes.

Interviewer: And then sometimes also a computer, WebGL. That would be the medias that people interacted with or like used.

Novo Nordisk Employee: Yes, that would be correct.

Cool. Do you know anything about how The different roles like sort of wrap up at like the end of the workshop. How do they note down decisions made?

Novo Nordisk Employee: I don't. No. I think that that varies to an extreme degree depending on the individual people.

Interviewer: Yeah. And like before you mentioned that you would take notes, right?

Novo Nordisk Employee: Yes.

Interviewer: For example, and would that like be on your phone?

Novo Nordisk Employee: That would be on my work laptop. Sorry, that's a stupid thing I forgot. I would, of course, take notes, write notes in sort of shorthand during the workshop. For the last workshop, we actually had multiple people taking notes and ensured that everyone sort of shared notes and compared and then made like a official list of changes, which was very, very beneficial.

So I think that's a format we should expect from now on.

Interviewer: Was that like the was that within groups, for example, just the XR department, or was it also between sMEs and

Novo Nordisk Employee: No, that was, that was across borders. It was, yeah. So I took notes we had two UX designers present they took notes.

At least one of our liaisons took notes. And then one of the stakeholders named [redacted] took notes. And then I believe we also got his, so everyone compared notes and then agreed on a sort of by text, at a later date, agreed on a list of changes we needed to make. So actionables from both ends.

Interviewer: Yeah. So, yeah. But those are actionables for the XR department, right?

Novo Nordisk Employee: No, actually, also, the interesting thing about that, which is, sorry I forgot to mention it, but it's a completely new thing that actually happened, was that the list of actionables was both for XR changes and also for vendor changes.

Design changes. I know there's always design changes coming out of them, but this is the first time I've actually seen the list, or like, we've agreed on a list.

Interviewer: Okay. Cool. And then a bit about after workshop. Again, what tasks, if any, are required of your role after a workshop?

Novo Nordisk Employee: That's a lot more interesting.

Not that workshops aren't interesting, but that's, I say interesting, but what I mean is that's where the majority of my actual day to day work happens. So usually there will be a rather lengthy list of requests. And in this case, that list was sort of trimmed down based on agreements about on what sort of we will promise to do and some of the changes of things we can get to doing right now. Like we, we missed an object in like there was a railing on a thing that wasn't

in, that should have been, it wasn't the source files we got. Or like, we would like all these things to be interactable.

And then, for that case that's a sort of, I would say, semi blocked task, because I know where to go to get the info I need to get moving on it. So usually all my tasks following this would be sort of either things I can go do now or ask people to do, things I know how to get the info for so I can solve it.

For instance, we need all these things to be interactable. Okay, cool. I know how to, I know to ask [redacted name] for a list of things. They have a list. I know of it. And as soon as he sends me that, I can make tasks for a backlog and that'll happen. The other things are things where I need, I'm sort of progress blocked by info. So people say, we need this thing. And then I need to spend a lot of time reaching out to people and going to people and asking them questions about what is it? Do you have designs for it? I know you want it soon? But is there a file for it? Is there a design for it?

Who's the vendor? And the outcome of that ranges from, yes, here's the file to we have an idea that there needs to be a thing here. And then I figure out what to do about that. So usually it's like the list turns into more questions.

Interviewer: And do you know if the other attendees have any required tasks after the workshop?

And if so, what would those be?

Novo Nordisk Employee: In this case, the, the required tasks from the SMEs would be. based on the compiled list of changes. They would, I would heavily assume, take those changes and act on them. And if there is a design that is wrong from a vendor's part, when I say vendor, that is Novo speak for a, supplier, external supplier of things.

That can be a company that makes a thing we buy from them, or a company that designs rooms or something. Anything that is external is a vendor. So. I would assume that they would take those changes and return to their vendors with them and pass the list of changes to them. Or if it's something that they need to do, they would make changes themselves.

But for everyone in this case, the outcome would probably be, like, compare notes first off.

Interviewer: Yeah, and you also mentioned before that [redacted name] or [redacted name] would reach out to you if there was, something.

Novo Nordisk Employee: And then obviously decide on a sort of target for what we want to do in the next workshop. They have these workshops sort of scheduled.

So there's, I think, four rooms and they run a workshop each, every month at different dates. So there's a sort of running sort of for the next time.

Interviewer: Yeah. So for until the next workshop in a month. Yeah. What should we do? Cool. Is there something that you would like to be able to at the workshops that you currently can't do?

Novo Nordisk Employee: Yes, I think there's a lot of stuff in sort of varying degrees of plausibility. I think I would like to, first off, I would like to, to try to not enforce or force, but change the format a little bit. So instead of having this sort of audience cameraman approach. I would like to see a scenario where people use it just like they would use Skype or Teams or Slack, and that you just use VR as a conversation tool.

And so everyone is either equipped with a pair of VR goggles or headset or HMI, whatever you wanna call it, or they're comfortable using the, the desktop version or the computer version. And so when there is a workshop, everybody just joins it the same way. They would've team call. I sort of view the format now as people being afraid of using, like, VR teams.

And then they would, instead of joining a Team's call, they would have one person from the Team's call and then all sort of stand around the screen looking at it, which is weird and awkward. And I hope that that would encourage more physical collaboration and sort of more hands on approach. I would really like at some point to see a sort of talkback tool.

Which is something that exists in other software, which is a tool for like, if you as a user in a VR environment, or whatever, you can attach notes to things and then that note creates like a, runs a script that sends an email with a screenshot of it or something, or the part to the right person.

I know that that happens on other pieces of software, but that would drastically lighten my load in making sure that I know the right changes to make to the right area.

Interviewer: Yeah.

Novo Nordisk Employee: Yeah, I think that's, that's the two big things I'd like to change.

Interviewer: Yeah. Yeah, so for example, so when they say, oh, this part is missing something, then they could write a note and you would

Novo Nordisk Employee: get the note.

Yes. Yeah.

Interviewer: Okay, cool.

Novo Nordisk Employee: Yeah, it would all work just natively within.

Interviewer: I don't think I have anything more in this. Do you have any last comments?

Novo Nordisk Employee: No, just sort of, sorry, the questions, the answers are so chaotic. I think that reflects the very chaotic nature of the workshops as well. But I think it's also, again, I'd like to sort of reiterate that it's, the format is very much sort of a thing that just happened.

Like, it's not like a,

it's very emergent. format, right? It's not a thing we designed and tested. It's just sort of the way it happened based on a lot of stories and a lot of back and forth and format that just sort of settled into place. Yeah. So don't take anything that happened there as like good or bad. It's just a thing.

Interviewer: Yeah. Makes sense.

Novo Nordisk Employee: Cool. Actually, I have one last thing I'd like to change. Yeah. Yeah. One of the biggest problems with this format is that it's sort of, it's not always clear who. the owners are. And so say for instance, like for this interview, right? This interview is very clearly owned by your team, your project, right? Your group. And you are interviewing me for your own purposes.

Interviewer: Yeah.

Novo Nordisk Employee: So it's like you, they're, I'm not supposed to get anything out of this. And that's okay. And that's agreed upon. For these workshops. It's not always clear who is getting anything out of it, who's benefiting from it. And that can lead to sort of conflicts of interest, if I talk too much, or if I steer too much, or if I don't get enough out of it.

And so I think I would also very much like to change the format in a way to be more clear on if stakeholders conduct a workshop, I attend as a guest and provide input. And if I run a workshop, I invite people and they show up and help me with stuff. So it's more clear on whose motives are the priority.

Interviewer: Yeah.

Novo Nordisk Employee: And now it's worked so far as a sort of weird symbiosis, but we have seen cases where like, I've called for repeated workshop for another project, and at some point it was less interesting to our stakeholders than it was to me, and then the attendance dropped.

And that's a problem.

Interviewer: Yeah.

Novo Nordisk Employee: If that, if that makes sense.

Interviewer: Yeah, it does. Yeah.

That makes a lot of sense. Yeah. Thank you so much. Thank you.

F.1.1 Interview with Workshop Facilitators

Attendees at the interview:

Novo employee 1 = NN1

Novo employee 2 = NN2

Interviewer

Interviewer: Of course you guys can always say that you don't want us to use this and withdraw your consent to participate in the interview along the way if you want for some reason.

NN1: I don't think so, but thank you.

Interviewer: Well yeah, that's always important to say. Ok, cool. So yeah our first question is what is your position at Novo Nordisk? Each of you.

NN1: Do you want to start NN2?

NN2: I can start. I'm operation readiness professional, working in aseptic production operational readiness. So the team, with focusing on standardization of procedures and processes across new AP facilities that we are going to build. So in my daily task I focus on process AP processes mapping. I focus on digital use cases so all the digital tools that can support standardization and digitalization on the shop floor and lastly, but also importantly, VR as a tool to support both design discussions, but also training of new operators in the future and of course here also standardized training of operators.

NN1: Yeah, and well basically NN2 and I work in the same team. So it's basically or more or less the same for me, but I can add that I'm also working in the ramp up track.

In the ramp up track we are looking at how to basically increase production as fast as possible, so when we are ready to produce that we can achieve the highest capacity of the lines as soon as possible. We are right now looking at for example how to hire in a timely manner all the workforce that we'll need for the [redacted process] lines and how we can do a training of the operators. We want to get the workforce as ready as possible to sort of, yeah, get everything optimized and the lines working at the highest efficiency.

Interviewer: Thank you. And can you describe the goal of facilitating VR workshops in Novo Nordisk

NN1: Just to clarify, which workshops?

Interviewer: The VR workshops that has taken place here in [redacted location].

NN1: It's because we have also other workshops where we meet with subject matter experts or SMEs in different work packages or areas in [redacted location]. The aim for that is to gain knowledge and expertise on how to basically do all of the different processes and different like detailed steps that will happen throughout the whole process of production.

So we are in that sense those workshops are for process mapping.

And then we use VR a little bit here, just as a side tool. Basically it's like and aid like helping them understand like how the [redacted location] or the room will look, but it is not actively used in that scenario. And then we have workshops that you have also attended to where VR is the main tool that we discuss.

And in those I would say our main role or purpose is as facilitators is to ensure that the VR development team and the SMEs have a place or space to talk and to discuss about different updates. And that the VR team has this point of contact with the knowledge from the SMEs and vice versa.

I don't know, maybe you can add a little bit on top?

NN2: I can add a little bit. So as it is today, the workshops most of the time focus on making sure that the VR applications are somewhat updated to the states they will be in the future. So some of our workshops focus on gathering different work packages and just having discussions on, oh do we have something missing?

In terms of what we'll have in the real room that we need to have in VR as well. So that's the majority of discussions now.

And the reason is basically because we are still in design phase where we are in the process of designing the room, furniture and so on.

And then we have a little bit of workshops that support other workshops as NN1 mentioned for process flows. We also supported Ergonomic workshops and VR was used as a supportive tool to basically like give this impression of how big the rooms are. What are the size and how much space is between different kinds of equipments and what is physical flow of tanks, equipment, people and so on. But I would say that primarily we focus on these design discussions these days.

Interviewer: Oh so yeah that is like the goal of the VR workshops. So you mentioned how VR is aiding these goals like designing and so on. Can you describe specifically how VR is aiding in achieving these goals?

NN1: So, I would say, for instance for [redacted process]. VR is helping a lot. In this position of certain equipment within the room and how will the move of tanks or racks. How will this be in the room and how will this affect for example movement area or remaining spaces for the operator to stand. Stuff like this, but then also its not only for design, its also ensuring that we have the right design of the VR model when we move in the training. So its very important that we are developing this VR models for training purposes also and we want to get them right now to get them ready for when we need them for training operators. So during this process it's aiding the design of the module, but then the ultimate purpose is to get them as close to reality as possible for training.

So that's also where the SMEs are giving their input. Like oh ok, this is right or this is wrong. We are missing something here. Actually for [redacted process] last day, [redacted SME] said that in between to of the [redacted machinery] we were missing something that from [redacted machinery provider] they were not even clear how the design of that will be. So [redacted provider of machinery] they didn't even know exactly what parts were going to be there, so it feels a little bit like a black box area. But we know that we are going to have the design in a few weeks.

Interviewer: Yeah, cool. Thank you. And which type of people are normally attending the VR workshops? Like for example, you mentioned SMEs and yeah, who else would you say are attending?

NN2: So I think NN1 mentioned the most important participants so…

VR is developed per work package usually, so we have [redacted five production processes] and for each of the workshops we discuss design in both directions. So what is missing in VR and what is missing in the real world after seeing it in VR?

We always try to involve SMEs because they are the ones knowing the equipment, knowing what is needed, knowing how the room should be set up. And I would say that sometimes there are some project managers who are working in specific work packages joining there might be a discussion about their area. An example could be a project manager working on a specific part of equipment, let's say [redacted equipment] in [redacted process] then that person joins our workshop to be in the discussion about [redacted equipment]. But if we have a discussion in general about the entire area, SMEs are the people we invite.

Interviewer: So what has your role been in the VR workshops that you have attended?

NN1: I think we discussed a little bit of that before, but yeah our role is mainly to ensure that the technology is available that the SMEs have basically everything ready to jump in and participate and share their knowledge. Because they shouldn't spend time on trying to figure out how to connect the headset to the internet or to cast on the TV of the room. So all these practicalities to make sure that they are ready and not to waste the SMEs time. And then act as a middleman between VR development and SMEs or work package.

Interviewer: I think that makes sense. Yeah, then I have two questions about like before the workshops. What tasks, if you have any, are required from your role before a workshop?

NN2: So I think that NN1 mentioned the most important one. So to make the technology and the tool available. So from such a simple practicality, such as making sure that the headsets are charged and the internet is available and that casting to TV works, but also ensuring that the current version of the application is uploaded to the headset so it requires some sort of communication with the VR dev team.

To make sure what is the latest version do we have? Do we have anything missing? Also depending on the workshop topic we need to align with the work package. What is the focus of the workshop? So we can potentially prepare either from our side with some sort of knowledge about this area or to make sure that maybe the VR dev team can develop something real quick for this workshop's purpose.

So these are two things that this communication related to the topic of the workshop and then all the practicalities for hardware.

NN1: Yes. And our initial idea was that the work package would lead these sort of workshops and that they would come up with a purpose and would have something specific in mind to check in VR. But then also we was that this was not really working out due to involvement of work packages. And I think it's a little bit dependent on a specific case. So it might be that the work package has a really specific topic to discuss or not. So yeah, I would add to that, that we are also taking a lead role as facilitators in these sort of workshops.

Interviewer: yeah, that makes sense. So those are kind of what it has turned into over time?

NN1: Yeah, exactly. We try to lead them on. So we agree with the work package, what are the areas to discuss more or less, but then we actively lead the discussions or like lead the direction of the workshop in a way.

Interviewer: Yes, during the workshop?

NN1: Mmm. It might not be the case always, it depends on the people involved or if they really like have something specific to look into, they jump there, discuss, and we are more in the background. It can depend.

Interviewer: Do you know if the other attendees have any required tasks before a workshop, and if so, what would those be?

NN1: Yeah so, there are different kinds of workshops. There are workshops where we only jump in VR with physical attendees in the room, and then there are some other workshops where we connect with people from other countries such as [redacted] and [redacted].

And then we require the VR leads or the people using the headsets to be updated in the technology and have everything ready prior to the workshop so that we ensure that it works basically. And when we are in that time slot we are not looking at like other technical issues or practicalities on how we connect to the internet or something. So that's something we need to take care of.

So other stakeholder in VR, we need to make sure they are on boarded on how to use the technology.

Interviewer: Yeah, when it's not physically together.

NN1: Exactly. And it is a little bit tricky and we experienced a lot of difficulties at first because trying to onboard someone that is not familiar with VR from a distance, it is tricky. There are a lot of issues that you are not able to feel right away because you are just communicating with them through a teams meeting and you are not able to see what they are seeing in the headset. So your only way of trying to help them is what they can communicate to you. And then your interpretation of that and trying to solve that through, yeah… it's a little bit tough process.

So in that way it's really really important that for these people that we either ensure that they are previously onboarded in VR or otherwise, if that's not possible, that we provide them with good material to have them onboarded in VR. So the idea would be that they are basically self-sufficient with certain, I don't know, documents or videos and then that they receive this documentation in the headset.

Yeah, self sufficient so they would be able to just put on the headset, follow some instructions, look at the video to see how the controllers work. So when we talk to them, they already know how this works because they undertook this short onboarding or whatever. Because we spend a lot of time trying to fix these issues for [redacted location] and [redacted location] in the first meetings for [redacted process] and it was a pain in the [redacted body part].

Interviewer: Haha yeah I remember. Do you know like for example how the SMEs prepare? Like, for example, you said that you guys might communicate with them and then you facilitate during the workshops, but how do they prepare before the workshop?

NN1: I would say they don't really prepare. It's their knowledge about the line and about the provider that we are using in that workshop. It's more like they are using a tool as a workaround to have an enhanced discussion in way. Enhance discussions on the topic or from a different perspective, but the knowledge they already have the knowledge. So I don't think that we need to prepare them in any way, it's more like the technology, but in terms of what we discuss, they know.

Interviewer: yeah, cool. And yeah, then I have a few questions for during the workshop. In your own words, maybe one at a time, but could you describe in a sort of step by step manner how a VR workshop takes place? And it can for example just be the latest one that you attended.

NN2: I can start this time, sorry for being off for a few minutes.

Interviewer: That's fine.

NN2: I believe that we need to consider 2 scenarios. If we have workshop only locally in [redacted location] or if it is the workshop that happens across the sites. In the first scenario we usually set up the headsets in advance, so when participants come to the workshop everything is prepared or ideally is prepared.

Then we usually have a short introduction. Because very often there are people there who haven't tried VR yet, so we have a short introduction telling what kind of applications are available in headsets for [redacted location], and then we invite one or two of the SMEs to jump into VR and the rest can see what they see on the TV screens. Then depending on the topic of the workshop, we would try to get to this place where the discussion should happen and just discuss.

Then usually us or some representatives from the VR development team take notes on updates for VR. And also we take notes if there's any open discussions that affect the design of the room right? Because if it is only update for VR like a thing is missing and should be there. That's specifically for the VR dev team, but again sometimes we have discussions that oh, something should be changed because it takes up too much space right? And then we take these notes and share it with the package afterwards.

It's a little bit different if the VR workshop happens across the site because usually we have a prep meeting before the proper meeting with people who will join from site in VR. Just to make sure that they can turn on the headset and they have the latest application.

Because that's the biggest struggle as NN1 just said about how difficult it is to support them remotely. While to turn on the headset and join the application is not that difficult to explain, the biggest pain is to sideload a new application and make sure they have the same version as we have in [redacted location] and so on.

So in this case, the workshop is more or less the same, but we need a prep meeting first and usually I don't know about 15 minutes is spent on some technical issues either on VR connection or teams connection. Just making sure we can all hear each other in each room and so on.

NN1: Adding on what NN2 just described I just wanted to say that there is functionality within VR that we didn't have until a few weeks ago, maybe 3-4 weeks ago and that is a web application. So being able to join the VR environment from a laptop. And I really believe this is a game changer on how we are using or how we are performing these workshops. Because there was a clear barrier for us when we were running this and that was we either joined through a VR headset or we physically join next to someone with a VR headset that they are casting to a TV so we are able to see what they are seeing. But otherwise it was not possible to join a Teams meeting from the headset or we couldn't cast to a laptop. There was no way of showing other people what someone in VR was seeing. The alternative was maybe just to point a laptop towards a TV that someone was casting to, but that was obviously not ideal because of how you like, see the quality of the image and stuff and the lack of video. But now there is an option to join through a web application. And this is allowing to increase the audience of the workshops by like I don't know how many, infinite if I may say you know?

It is really a game changer and I feel it might affect how we run workshops with VR from now on because we won't need everyone in the same room. We will have people hopping in the background of someone with a headset on. We will be allowing them to have their own perspective on the line while they are having discussions and it's probably allowing them to increase the rate of potentially more insights on the topic. So all that I'm actually looking at, we're looking at the same thing from another perspective. And I have some input I wasn't aware of if I was just looking at what the user with the headset is looking at. And the accessibility to it is much better. And I also believe that it will create these workshop participants that are

much more engaged with the conversations if they are actually seeing in real time through their laptop, what the VR user is experiencing.

Interviewer: So can you maybe describe a bit how you are using this computer? Is it then a person casting that to the TV? Or do you still use the TV for casting the VR person's point of view? Or are you not using the TV anymore?

NN1: So the TV was originally used because it was the only tool available that we had to see what someone with the VR headset was seeing. So otherwise it was not possible to know what they were seeing if we were not also in VR. So if you join the same model and meeting in VR, then you can see them, but it was the only option. Now we have this option of joining through desktop or this web application and we don't really need a TV if you are joining from a laptop.

But we still need to investigate what are the functionalities, because this has recently been developed by the VR team. We don't know exactly if you are only allowed to hop in the back of someone with a headset or you are allowed to move around freely. How you can interact with the model and such.

I think we need to wait a little bit, but it's definitely going to change how we run the workshops.

NN2: Yeah and I will just quickly add to that.

To cast to TV screen is still very important because for any person being in the same room, I think that is the easiest perspective. If one of the colleagues is in VR and they can see what that person sees, because that is the easiest way to discuss. The web application will be the biggest support for those people joining remotely I think.

Interviewer: Yeah, so it's not that the people physically present sit with their laptops and joins a computer version?

NN1: No no. But however last workshop that we had with [redacted process] we were sitting in the VR room in [redacted location] and as you know there are two TVs. On one TV we were casting what [redacted employee name] was experiencing in VR. And on the other TV we were actually sharing the screen from my laptop where I joined the web application and I had a slightly different perspective on the same topic.

So one thing was exactly mirroring what [redacted employee name] was seeing in VR as the usual casting, and the other one was having this little bit different perspective from the web application. And I feel that brought a deeper level for the workshop, deeper level of like discussion and its just like bringing VR to the next level of usefulness

Interviewer: Then how do you wrap up after a VR workshop? For example you mentioned that someone might take notes so like, how do you end the workshop?

NN2: So usually in the workshop we have a large group of people taking notes from different perspectives because us as facilitators, we always have some people from work packages taking notes. Most of the people is just joining for their knowledge, but somebody always takes some notes relevant for them. And we usually also have somebody from VR development team to make notes related to improvement of applications because we are not always able to catch all the details. So usually we have at least three perspectives on the notetaking and what we did so far was basically to have one person gathering all the notes and just making sense of it. So joining by topic and sharing with participants. So sharing those notes related to work packages and those related to VR to the VR dev team. That's at least the practice that we had so far.

Interviewer: So for example, in some decisions that have been like designs that have been made during the workshop and so on, how are those like wrapped up or stored. Do you have a media or a format for that?

NN2: The summary of the workshop is usually shared via email with participants and since our role is facilitating of the workshop, we do not need to make sure that decisions are taken into account. We just share the outcome of the workshop with people attending and they are taking the action of doing something, storing information, changing the design, et cetera.

NN1: Usually action owners would be package itself.

Or VR development team to make sure that the changes to the model are introduced for the next sprint and so on.

NN2: Exactly.

Interviewer: Do you know what media they use to take these notes, is it a computer or…?

NN1: It could be a notebook also.

NN2: Yeah so the person gathering notes at the end of the workshop usually ask people who noted on paper to translate it into pc anyways.

Interviewer: Yeah. Then I have a bit about after the workshop. What tasks again, if any, are required from you after the workshop? And I think you mentioned a bit here with the sending out emails, but is there anything else?

NN2: I don't think there much things that we have to do after the workshop. The summary of notes are one thing. We also just make sure that the topic was covered entirely or whether we need to do a follow up session.

And it really depends on the work package, because some work packages reach out with a specific topic and then it's a question do we need a follow up session or not. And other packages they would like to have these recurring meetings. And for example [redacted department] is going through the entire [redacted machine] step by step and there is no boundaries of what are we going to discuss in this session. It's like how far can we get, and in a few weeks we continue.

So we are just making sure that the topic has been covered, but not much more actions than that from our side I think.

NN1: And also we make sure to capture some feedback if we can improve the workshops in the future.

And then maybe follow up with the VR development team for the next sprint that the models are updated.

So maybe for the following workshop, we would make sure that, oh we wanted there objects or these pieces of equipment to be movable for [redacted process]. Do you have that model? Can we check, and then just like download it to the headset and make sure everything is fine.

Interviewer: So for example, like the other attendees, their task would be for the VR team to update the feedback they have gotten?

NN1: Yes

Interviewer: And what would the work package do after a session, do you think if you know?

NN2: I think it depends on the actions of the workshop. Probably assign like each action to some project manager or SME to take care of, but honestly we don't know how they handle these things.

Interviewer: That's fine. And then the last question. Is there something that you would like to do at the workshops that you currently can't?

NN2: I think it would be really cool if one day every single participant could join in VR. And of course it's impossible due to limitations of number of headsets and space and so on. But I think it would be really nice to have, I don't know, 5-10 people at the same time and having the workshop entirely in VR.

NN1: Yeah, that would be awesome.

Interviewer: Yeah. And why so? Like what aspect of VR is it that makes you say that?

NN2: Well I think it's to finally like experience a fully immersed workshop where you talk to people in VR and just participate in VR. Because right now it's always like, people being in the room. So we need to make sure that its casted and the Teams connection, and the sound, and the microphone. All of these things make it like you know a regular Teams meeting with VR additionally right. And I just think it would be another level of discussion to experience that.

NN1: Yeah, and to add on to that. Sometimes when we are onboarding someone in VR or when we have a user that is really new to VR, when they join, they can easily be distracted on the technology itself. Like oh so fun! I'm like moving this [redacted item] around! You know playing with it or throwing a [redacted item] or something. And he's like oh so cool! But then it would be awesome to have this discussion with as many people as possible in VR but also that they are already like seasoned or using VR.

They are fully immersed in the production site so that VR is 100% transporting the person to that place and that they are actually having the discussion on one topic. And you know, there are no barriers to it. They can swiftly teleport to one place to another and another to change the perspective. Because some people are joining VR very stiff You know they don't move basically. But they are instead moving around as they were in the room and stuff. So this would really improve the tool and the value that it brings. But of course it is difficult.

NN2: Yes, and I think it was really good points. It's of course also the entire point of using VR because it is fun as well. But sometimes this fun overtakes parts of the workshop where people just… and it's also important part right? But sometimes it would be nice to take place in a serious discussion for a couple of minutes.

NN1: Exactly.

Interviewer: Yeah. I don't know if this is correct but maybe it's also having everyone feel like they are participating more?

NN1: Mmmm

Interviewer: Yeah, so as you say, because right now it's only one or two people who can be in VR like the other people could be more immersed in participating if that is correct?

NN1: My perspective is that the users with the VR headset on lead the discussion. And then if we would have everyone with headset on, it would be a little bit more equal from my point of view. And then if we would have everyone also seasoned and accustomed to using this technology we would remove these distractions introduced by the technology. Because of course it's weird to join another virtual space from

the office but if you are you know, fully immersed, that's the end goal, like what we want to achieve with this I guess.

Interviewer: Yeah. Do you think that some other media could give some of this, like now that you have the PCs also as an option.

NN1: Definitely the laptops are helping.

Interviewer: Do you think this could give kind of a more collaborating experience?

NN1: So as we said it is practically impossible to have everyone join in VR due to space constraints and also we don't have as many headsets.

And definitely it really helps all the participants of the workshop be more involved if they can see from their own laptop what the user is seeing. And not only that but also take advantage of being in the model and looking at what they want to see. So they can hop in the back of the VR user but they are not leaving. They are just following exactly.

But if they can also hop off and just see the same thing from another perspective, or see another part of the [redacted machine] as they are talking about something. This is also giving them more ownership and more feeling of participation in the workshop because they are taking the lead in what they can see and what they can discuss.

If they have a doubt about something in an exact moment, they probably not able to communicate that to the person with the headset on because they are engaged in some other discussion. They don't want to interrupt but they are like, oh wait a second, what about here? If they can just look at that thing themselves and then hop in the discussion a little bit later I that really makes a difference.

NN2: I agree, and I think that's my impression and I have no idea if that's true, but I think that the setup with people in VR and then every other person being on his or her own computer in a phone booth for instance, and being able to be in application with an avatar and joining the discussion. I think it could be more efficient than sitting in the same room and looking at the TV screen because this sense of ownership as NN1 said. That they are like independent and they can move around and take action and join the discussion. And in other scenario doesn't matter if it's following somebody in VR or following the casted web desktop on teams, it's always following somebody else's movement and the interactions.

NN1: But having said this, this is still a hypothesis because we still haven't tried yet so I think we need to test a little bit more.

NN2: yeah, and that's why I said I don't know.

NN1: Yeah, and the web application need to be a little bit more advanced.

Interviewer: Yeah, ok, I mean we've discussed this a bit but is there anything else that you would like to do in the workshops that you can't do currently? I don't know maybe it would just be something to help with the design process like within the application.

It's also okay if you don't have anything.

NN1: I think that the flexibility of the models in terms of placing or removing objects easily would be really great.

If you're for example want to see the whole room empty for a reason, or you want to see the room with only 2 pieces of equipment like for different settings. Imagine you have the room like the distribution of everything is set.

[Redacted process] it has a certain setting, and then when you are actually [redacted process] you have a [redacted equipment] close by and then when you do the [redacted process] you have a different piece of equipment there. It will be great to just be like, oh, this this and this out and I bring this piece of equipment in and you know, easily move it around.

Of course, it's hard to develop, but I think it would be great and of course when we join level 3 models like the ones for [redacted project] that's insane. I mean that's really really really helping that you can almost like practice the whole process, like taking our pieces of equipment, put them into the [redacted machinery], opening the doors and stuff. This is great, but we know that it takes a lot of resources and a lot of time to have that ready.

So I mean it's a balance and we know that we are aiming at that, but it's still gonna take some time.

Interviewer: Thank you, I just have one more very small question because we have also been thinking about this. As mentioned in the beginning like how can we get the other people in the room to be more engaged in collaborating with the people in VR. And for example now the XR department has started developing this Web GL version and we were considering maybe using another media for example like a tablet. Do you know if people are used to tablets in their work life normally?

NN2: I don't think so.

Tablets are used in the production, that's for sure, but not in the project as it's office based and honestly I cannot see any other tool that is easily accessible.

NN1: No, I don't see the benefit of using tablets versus using a laptop.

What would from your perspective what would be the main differentiator for like arguing, OK we use tablets because of something?

Interviewer: Yeah I think initially we were thinking that it can sometimes be a bit difficult to control or like navigating from a laptop.

NN1: And then how would you control the tablet? Would you have with the thumbs or something?

Interviewer: Yeah maybe, we haven't looked much into it yet. But we're considering if you were actually able to do some like designing of the room, then maybe some of the tablet interactions would be more intuitive for a new user, but i'm not sure.

NN1: Could be yea, could be.

I'm not sure about it but it could be. And I think it also depends on the user. So if you're used to playing video games on the laptop or with a keyboard then I don't see a difference, but I think it depends. Yeah it can definitely be tricky.

Interviewer: But has it been a problem so far for the people that have tried?

NN1: Not for me no, but I think it has only been NN2, [redacted name] and me who tried it and I don't think we are a good representation of other VR users in the project yeah. I think we are a bit biased.

Interviewer: Yeah that's also because we're also like, yeah of course us developer gamer kind of people would be like, Oh sure, mouse, WASD lets go. But it may not be as intuitive for people who just have to join in for a workshop.

NN1: Yeah that makes sense.

Interviewer: But yeah, we're still trying to investigate how could the media make sense, it was also more if you knew they had any prior experience with using them. But thank you.

NN1: Sure, no problem,

But we have to leave for another meeting, but thank you so much for the interview.

Interviewer: Yeah. Thank you so much.

G Appendix: List of 3D Assets used in the Final Test environment

Thise section presents the sources for the assets used in the project.

- A 3D model of an 4-room apartment, scanned by Ali Adjorlu.
- Various furniture from Poly haven: https://polyhaven.com/models
- Apartment Kit by Brick Project Studio: https://assetstore.unity.com/packages/3d/environments/apartment-kit-124055
- Free Kitchen - Cabinets and Equipment by Boxx-Games Assets: https://assetstore.unity.com/packages/3d/props/interior/free-kitchen-cabinets-and-equipment-245554
- Kitchen Appliance - Low Poly by Alstra Infinite: https://assetstore.unity.com/packages/3d/props/electronics/kitchen-appliance-low-poly-180419.
- Bar chair by HarpetStudio: https://assetstore.unity.com/packages/3d/props/interior/bar-chair-106889.
- Bathroom set- interior by Geniuscrate Games: https://assetstore.unity.com/packages/3d/props/furniture/bathroom-set-interior-263462.
- Office room furniture by Elcanetay: https://assetstore.unity.com/packages/3d/props/furniture/office-room-furniture-70884.
- Lowpoly Art Deco furniture by Evgenia: https://assetstore.unity.com/packages/3d/environments/lowpoly-art-deco-furniture-249606.
- AllSky Free - 10 Sky / Skybox Set by rpgwhitelock: https://assetstore.unity.com/packages/2d/textures-materials/sky/allsky-free-10-sky-skybox-set-146014.

H Appendix: VR User Data

The raw VR user data can be found in the folder "Appendix/Log Data". The graph of every VR user can be found in "Appendix/Log Data/Graphs".

I Appendix: Tablet User Data

The raw tablet user data can be found in the folder "Appendix/Log Data". The graph of every tablet user can be found in Appendix/Log Data/Graphs". For the graphs, blue line = change view to "2D", green line = change view to "3D", yellow line = change view to "Person".

J Appendix: Observation Notes From Final Evaluation

The observation notes from the final evaluation can be found in "Appendix/Oberservationsnoter.pdf".

K Appendix: Observation From Novo Nordisk VR Design Workshop

The following section presents the notes taken during the observation of a VR design workshop at Novo Nordisk.

Observation Notes for NN VR Workshop

Focus of the observation:

1) What are they trying to design?
2) Which tools do they use to design?
3) How do they note when a decision has been made?
4) How do they collaborate?
5) How much time is spent on preparation and evaluation?
6) Which file format or media do they store notes/findings?
7) What is the final product of the workshop?

Observation technique:

We will act as passive observers, but will help with technical issues if they were to occur.

We will be looking at:

- What the participants are doing.
- The emotions of the participants.
- What the participants are trying to accomplish.
- When are people doing what - note time at major breakpoints.
- Describe how we are observing VR.
- The space and objects (create a sketch) add peoples placement if relevant.
- Participants: Who is there.

Participants:

- 6 x workshop participants, who were all Novo Nordisk Subject Matter Experts. Two of them only joined for the last five minutes.
- 2 x facilitators from Novo Nordisk.

Observers:

- Franciska Kruse Ifversen, Medialogy master thesis student.
- Atle Søeborg Nyhus, Medialogy master thesis student.
- 1 x 3D artist from Novo Nordisk XR development team.

- 2 x online observers from Novo Nordisk XR development team.

Documentation:

We will be taking notes by hand in notebook and on PC.

Observing VR:

The first three observers will be physically present in the room with the workshop participants and will be observing VR through a TV in the room, which the participants' VR HMDs will cast to. The two online observers will observe through a Teams call from a laptop in the room and by joining in VR with their own headsets.

Observation notes:

The participants in the sessions will be referred to as Participant(s) or P1, P2, P3, P4, P5 and P6.
The facilitators in the session will be referred to as Facilitator 1 and Facilitator 2.
The observers will be referred to as Student 1, Student 2, XR Observer, Online Observer 1 and Online Observer 2.

- Pin codes/sessions are tedious and are not working properly.
- P1: Did we get the latest STEP files?
- XR Observer: Sprints make the process slower, therefore the VR room is not that quickly updated.
- Facilitator 1 and 2 are guiding and introducing the participants in how to use VR.
- It seems like the participants are just pressing buttons, and accidentally opens the menu. The facilitators does not know how to close the menu. The XR Observer told them how to close/open the menu.
- They need a cover for [redacted object] to hide small machine parts.
- They will provide more STEP files for [redacted object].
- The participants can only move some objects in the Virtual Environment (VE). A Participant: "I'm not sure what can be moved".
- They request format changes, would like to have some wheels moveable (their position is off) and change the model to something more accurate.
- Some walls have to be glass, which is currently solid gray in the VE.
- The [redacted object]'s cover should be moveable.
- Participant: "When do we get the new [redacted object]? Well, we have the STEP, but need to be imported."
    - They want the [redacted object] and a cage around it.
- They need some special parts for an overhead suspension, but they might not have files for it. If they don't have the files, they will draw it for us.
- They are giving examples of things they want to use as level 3.
- They are starting to look at how they can operate the machine. Participant: "I can't reach from this side. Maybe the other side". The participant is stretching their arms to see if they can reach.
- Up till this moment, they are not taking notes. Just talking.
- They are using the measuring tool in the VR application to see if something will fit. Participant: "55 cm? No, that won't fit!".
- Participant in VR: "Do anyone of you want to try?" The three other participants: "No!".
- Participant: "Show where the cage could be". They are pointing at the screen and using the VR application as a 3D traversal tool.

- The participants are using the measuring tool in VR to measure the height of doors in the VE. They are currently 2.5 meters which is too high).
- The participants are moving a small room around in the VE to its right place.
- Participant: “This thing needs to be moveable since we do not know the end location for it”.
- They want chairs and desks to move around in the room.
- BUG: The measuring tool is stuck to VR player 2’s hands from the other VR player’s perspective. Might not have been disabled correctly.
- They want a “reset room” button, as they accidentally moved one of the machines.
- The [redacted object] model is wrong as there was a gap. Needs to be updated.
- Picnic and guns. They often mention they would like guns in VR.
- They mention they would like to have snapshots from inside VR so they could use them for discussions outside of VR.
- They want to mark an area/outline of a machine part that is currently missing. It could e.g., just be a picture on the glass wall and not an actual 3D model.
- [redacted object] is no longer a box placeholder and should be replaced with the actual thing.
- They are still not taking any notes and only talking.
- Participant: “It is much easier than in real life”.
- They are joking about having full body avatars.
- One participant takes off VR and offers it to another participant, but they don’t want to try it.
- The other VR participant also takes off their VR HMD.
- After they get new STEP files they would like to have meetings with other teams. They are discussing what the topics of their next talks should be.
- Next time they will start with a quick pre-workshop to make sure everything in the VE is up to date.
- One participant wants info on how the doors open.
- They are asking about what level of detail the XR development team would like, and they would like all the detail they can get and the models.
- They want to test out if a palette could fit through different spaces.
- “We should also do a layout session in VR”.
- Five different pieces of [redacted object] and have a session with operators walking around and doing the things for figuring out the room layout.

Post VR Workshop Interview with the people present at the workshop

1) *What is your experience with VR?*

The participants have tried it a couple of times before (Quest 2 headset). One participant is fond of the game Beat Saber. he has a VR headset at home.

2) *How would you describe the VR experience you just had?*

They are normally drawing things on the floor, and creating a mock up with e.g., tables and carboardboxes. Now they can move around the machine and be inside it. Right now it is the

overall view and flow where this is really nice. It is easy to join a session online and show it in VR across physical places.

3) *Did you at any point feel limited by the software? (Optional: Was there something you wanted to do, that you could not do?)*

They could do all they wanted, but for now it makes sense. As they progress in their design choices, the items they would be designing/layout deciding will be physically smaller and smaller.

4) *Were there any features missing?*

The VR measuring tool is good enough. They would like a VR laser pointer, to make it easier to highlight objects for non-VR participants to clearly indicate what they are pointing at in the VE.

5) *How do you store the decisions you have made?*

Right now it gets written down from memory to an email or action tracker. They have an excel sheet where they write down their decisions. Could be nice with snapshots. Normally they would be designing with a 2D drawing.

Timeline:

12:00:
- Pin codes not working. Have to generate new ones. Unsure which APK to use.

12:08:
- 5 minutes introduction to the XR department, the students, the people online, and the Subject Matter Experts (SMEs).

12:13:
- Two of the SMEs put on VR headsets. The two other SMEs observe through the screen casting on the TVs. They discuss missing features (3D models) in the Virtual Environment (VE).

12:23:
- One of the SMEs gives their VR headset to one of the observing SMEs. They are all discussing the placement of an object and are using the measuring tool.

12:32:
- The last SME who put on VR takes it off again. Now only one of the initial two people is still in VR.

12:33:
- The last SME also takes off VR and they collectively wrap up their findings from the workshop.

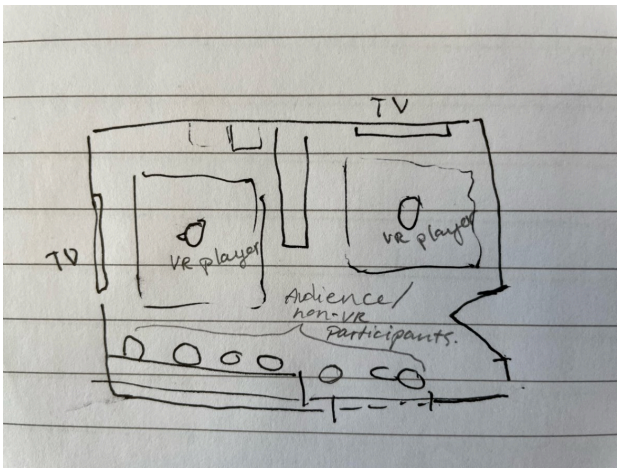
12:40:
- Franciska conducts the interview with the four present SMEs.

12:55:
- Two more SMEs joins the workshop and tries on VR. One of the SMEs has to quickly take it off again due to feeling dizzy from it.

13:05:

- The workshop ends.

Sketch of physical setup:



L Appendix: Focus Group Interview Results

The sound files of the interview can be found in folder "Appendix/Focus Group Recording". The raw notes from the focus group interview can be found in "Appendix/Oberservationsnoter.pdf".

M Appendix: Observation and Interview Notes English

The coded data for the final evaluation observations and interview can be found in "Appendix/Observation notes and focus group Interview.csv".

N Appendix: Test Method Document

Test Method

Set-up:
1 researcher as facilitator: will provide tasks and help if technical difficulties are encountered.
1 researcher is an observer: will observe and take notes during the test.
4 test participants were found with convenience sampling.

Devices:
2 VR headsets
2 tablets
4 laptops for questionnaires

Other:
4 labels for computers

Procedure:

1. Welcome to the test. “You are now going to test a cross-platform design tool for VR and tablet, the purpose of this test is to explore collaboration in design processes between VR and tablet”.
   Dansk: “Hej. I skal nu teste et cross-platform design værktøj til VR og tablet. Meningen med denne test er at udforske samarbejde i designprocesser mellem VR og tablet”.
2. Each person receives a number from 1-4.
3. “Before we begin we want you to sign a consent form and provide some information about yourself. Use the computer labeled with your number (1-4)”.
   Link: https://www.survey-xact.dk/LinkCollector?key=215CFA5QJ636
4. When the participants are done with the first part of the questionnaire they will each be assigned a device; either tablet or VR. Assign randomly. 1,2: VR, 3,4: Tablet
5. The test facilitator will first go through how you control the tablet, and then how you control VR. The participants will then be given the physically printed guide as a tool they can always use throughout the test.
6. The test participants will be given the first task: *Put furniture in 2 rooms of the apartment. You can use all the furniture from outside as you like. The apartments should have a kitchen, living room, bathroom and bedroom, choose 2 of these for this first part. You have 10 minutes to do this.*
   Dansk: Møbler 2 af rummene i lejligheden. I kan bruge alle møblerne der står udenfor som I har lyst til. Lejligheden skal til sidst have et køkken, en stue, et værelse og et toilet, I skal vælge 2 af disse til den første del. I har 10 minutter.
7. After 10 minutes the test participants will answer post-task-1-questionnaire on their assigned computer.
8. Now the test participants will switch to the device type they have not yet tried with their control guides.
9. The test participants will be given the second task: *Put furniture in the 2 remaining rooms of the apartment. You can use all the furniture from outside as you like. The apartments should have a kitchen, living room, bathroom and bedroom. You have 10 minutes to do this.*
   Dansk: Møbler de 2 resterende rum i lejligheden. I kan igen bruge alle møblerne

der står udenfor. I skal nu møblere de 2 rum typer I ikke valgte før. I har igen 10 minutter.

10. After 10 minutes the test participants will answer post-task-2-questionnaire on their assigned computer.
11. Pack away devices and set up for a focus group interview.
12. Set up recording.
13. Facilitator will ask questions while the observer takes notes.
    a. What was your initial reaction to the prototype?
    b. Can you describe how you interacted with other players during the session?
    c. Did you find yourself contributing equally to the design process, regardless of whether you were using VR or a tablet?
    d. Did you work individually, in pairs or all together?
    e. Were there any features or functionalities you would like to see added or improved in future versions of the application?
    f. Are there anything more you would like to add?
    g. Did you at any point experience any kind of physical discomfort, such as nausea or dizziness, while using the devices?

Danish

    h. Hvad er jeres umiddelbare reaktion på applikationen?
    i. Kan I beskrive hvordan I interagerede med hinanden i løbet af designprocessen?
    j. Føler I at I bidrog lige meget til designprocessen lige meget om I brugte tablet eller VR?
    k. Arbejdede I individuelt, i par eller alle sammen samlet?
    l. Er der nogle funktionaliteter I manglede eller kunne tænke jer at have i applikationen?
    m. Andre kommentarer?
    n. Var der nogen af jer der oplevede nogen form for fysisk ubehag, såsom kvalme eller svimmelhed imens I brugte udstyret?

O Appendix: Demographic Data

The demographic data can be seen in "Appendix/Questionnaire Results Raw.csv".