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AN EXAMINATION OF CROSS MEDIA INTERFACES FOR ASYMMETRIC COLLABORATION IN DESIGN WORKSHOPS

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Abstract:

This thesis explores the development and evaluation of a networked cross-platform workshop application designed to bridge the gap between Virtual Reality (VR) and tablet users, specifically targeting asymmetry reduction in collaborative environments. Developed in collaboration with Novo Nordisk, who currently use VR workshops as a tool to design factories, the application aims to provide non-VR participants with a tablet application to interact with the virtual environment during workshops, thereby enhancing engagement during workshops. While the cross-media platform successfully reduces visual asymmetry, the current note-taking system, limited to tablets, does not fully bridge the gap between VR and non-VR participants. Usability testing indicates a generally positive reception, though areas for improvement were identified, particularly in enhancing note visibility and polish. Future work will focus on integrating notetaking with VR and expanding communication features to further decrease asymmetry and improve collaborative efficacy.

1 Introduction

Asymmetric collaboration is becoming increasingly common in the digital age with more and more work moving to laptops, phones, and tablets [36, 14, 41]. As the variety of professional applications steadily increase year over year, creating good frameworks for working together is more important than ever. The COVID-19 pandemic has shown that in-person work is not always feasible, not to mention that more and more companies and organisations now operate across borders and oceans where in-person meetings and workshops can be prohibitively expensive and difficult. This means that digital systems are relied upon to bridge the gap between different places. As such, these systems, to a greater extent, control how collaboration takes place. In a physical meeting, preparation and social conventions largely dictate what and how you can collaborate eg. if you want to draw or write something down, then you need to have brought a pen and paper. In the digital realm the software instead dictates how we can collaborate. Virtual Reality (VR) as a tool for workshops, designing and rapid prototyping has become increasingly popular in multiple industries [34]. VR provides an opportunity to experience spaces in real time before they are built in the real world [32]. Having the option to interact with a non-finished space can help the users evaluate the spaces and find flaws earlier in production decreasing costs in the long run and minimising the number of errors found in the spaces during or after production.

We have entered into a collaboration with the Extended Reality (XR) department at Novo Nordisk to improve their use of VR as a tool during design workshops. Novo Nordisk is a multinational pharmaceutical company headquartered in Denmark. Currently, Novo Nordisk uses VR to examine and interact with future factories in a virtual environment in order to find flaws or needed changes in either interior design or workflow. Their current workshops consist of one or two people in VR, with one of them casting their view to a TV while the rest of the participants are outside of VR looking at the TV (see figure 2). The non-VR participants are not able to interact with the virtual environment themselves, but instead direct the VR users via verbal communication. This can lead to frustrations and miscommunication as the VR users often receive a lot of commands, while the non-VR participants can have difficulty communicating their needs to the VR user. Since the non-VR participants have no way of directly interacting with the environment, the VR users are made to act as an indirect tool for the non-VR participants to interact with the environment. This format of workshop results in a very high degree of asymmetry as the two types of participants share no tools or methods of interaction. In order to improve the workshops at Novo Nordisk there needs to be a lesser degree of asymmetry and all participants should have the option to act as an active participant with methods of interaction in the virtual environment. Asymmetry is a measure of how different the possible actions a user can take are compared to the rest of the group [35]. While this asymmetry could potentially be solved by having all participants exclusively in VR, this is not feasible. Some employees can not use VR as it causes cybersickness, additionally there is currently not sufficient physical space for all participants to have the necessary space for VR in the Novo Nordisk offices. The VR workshops also require the participants to complete different secondary tasks during the process. Through interviews at Novo Nordisk note taking was found to be a very important task in these workshops as they have to document their findings (see appendix B). However, while many studies have proposed potentially effective text-entry methods for VR there are no current well-established industry standard that match the entry rate and usability of either physical keyboards or touch screens [10, 7, 13].

In this paper we propose a networked cross platform workshop application for VR and tablet, where all users have the power to explore and interact with the virtual environment independently of other users. The goal of this product will be to ensure that the amount of asymmetry is decreased and that all participants can contribute actively during the workshop.

2 Related Research

To create a possible solution to the problem of asymmetry in the workshops it was necessary to understand how the workshops worked already, and what research existed about creating effective workshops. It was also necessary to understand the problem-space of asymmetrical design and collaboration experiences. The following sections will present the findings used to generate a set of requirements that a solution aught to implement.

2.1 Workshops

Workshops represent a pivotal step in the design process, serving as a method for idea creation and a platform for stakeholder engagement [6, 15, 8]. By bringing together diverse perspectives, ranging from designers and engineers to end-users and stakeholders, workshops offer a ground for exploration and experimentation. Through structured activities and facilitated sessions, participants are encouraged to reflect on their products, challenge assumptions, and co-create solutions that address their challenges. Brooks-Harris and Stock-Ward's book, *Workshops: Designing and Facilitating Experiential Learning*, emphasises the experiential nature of workshops and their role in encouraging active participation and hands-on learning. By integrating experiential learning techniques into workshop design, participants can enhance engagement, promote deeper understanding, and drive meaningful outcomes [8]. According to Brooks-Harris and Stock-Ward, in a successful workshop, different elements fit together to form a complete learning experience for all participants. The most effective way to accomplish this is to choose a theme for the workshop that can be used to tie together learning activities. The chosen theme is dependent on the needs of the group and the objectives of the workshop [8]. A theme describing the current need and use of workshops at Novo Nordisk can be "Exploring, categorising and interacting with a virtual environment representing a future factory, in order to find errors before production." Apart from a theme, a successful workshop must contain three specific parts: a beginning where the participants are introduced to the workshop and get an outline of the workshops goals, content, and structure. A middle where the participants work through the learning activities. And finally a conclusion that ends the workshop with an overview of the experiences and findings from the workshop [8]. In order to have a successful workshop, there needs to be a facilitator to create the learning experience and ensure the goals of the workshop are met.

Drawing on insights from *An approach to assessing virtual environments for synchronous and remote collaborative design* by Germani *et al.*, workshops extend their reach into virtual environments, enabling synchronous collaboration across geographic boundaries. Germani *et al.*'s research underscores the importance of virtual workshops in modern design processes, highlighting their potential to facilitate remote collaboration and enhance team dynamics across different technologies [17]. As technology continues to advance, virtual reality has emerged as a powerful tool in the designer's toolkit, offering immersive environments that enable new modes of interaction [4, 1]. VR holds immense potential for enhancing workshops by providing participants with interactive experiences that simulate real-world scenarios and promotes deeper engagement. By using VR, workshops can transcend geographical boundaries, bringing together teams in a shared virtual space for synchronous collaboration.

2.2 Virtual Reality

Virtual reality has shown itself to be an effective tool for experiencing designs in three dimensional space. Instead of viewing a model

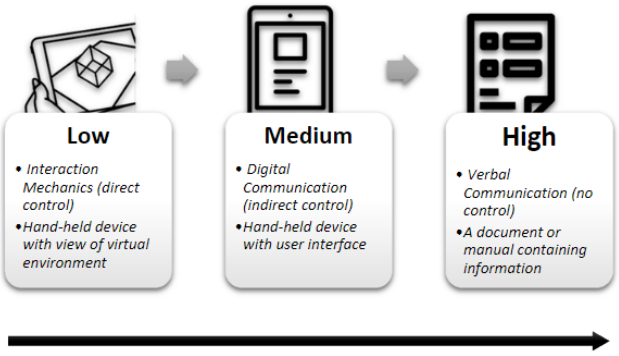

Figure 1: Degrees of interaction asymmetry in asymmetric collaboration [35]

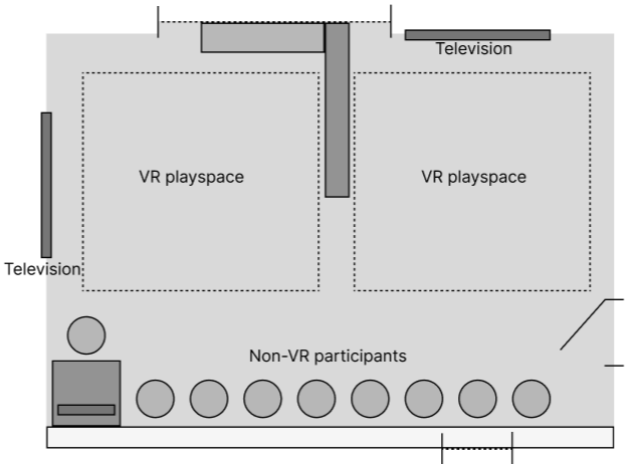

Figure 2: Figure showing the VR workshop room at Novo Nordisk containing two playspaces, two televisions and seating for non-VR participants.

on a computer screen, a VR experience can bring the user into a virtual space where the scale of an object can more effectively be felt. This allows for opportunities in architecture and the design of physical spaces [16, 11, 22]. As a prototyping tool, VR enables designers to create virtual models of products or environments quickly and cost-effectively. These virtual prototypes can be iterated upon rapidly, allowing for faster design cycles and more informed decision-making [1, 22]. By immersing stakeholders in virtual environments, VR facilitates better understanding and communication of design concepts, enabling stakeholders to provide feedback and make informed decisions early in the design process [1]. However, while VR is an effective tool for prototyping and design, it is not without shortcomings. As VR completely isolates the user from the outside world visually to create the most immersive experience, this makes it difficult to collaborate with non-VR partners. As users in VR are unable to see their non-VR collaborators and the non-VR users are not able to see the VR perspective, this creates a large asymmetry in their collaboration and options for communication [18]. In order to facilitate effective collaboration, tools must be created to ensure seamless and intuitive communication and collaboration between VR and non-VR users.

2.3 Asymmetric Design Experiences

While using VR workshops as a step in design and development of a product can provide rapid and inexpensive opportunities of otherwise expensive physical artefacts, it is not without its caveats [9]. When using VR as a platform for collaborative workshops it is often found to have problems, such as it being difficult to communicate and work effectively with the people outside of VR [19]. This is a consequence of high asymmetry. As described by Thomsen *et al.* cross platform experiences can have varying levels of asymmetry [35]. Depending on the collaboration and mechanics in an application there can be three degrees of asymmetry: low, medium and high, as seen in figure 1. In an application with low asymmetry a non-VR user has the same interaction options as a VR user and can through a handheld device freely explore and interact with the same virtual environment as a VR user. At a medium level of symmetry, a non-VR user can communicate with a VR user through a digital interface, but they do not have the option to interact directly with the environment or explore on their own. At a high degree of asymmetry there is no virtual controls given to the non-VR user as they only have written material at their disposal. In this case, all communication between VR and non-VR users must be verbal.

To combat this issue, others such as Thoravi Kumaravel *et al.* propose an asymmetric VR application where two users can collaborate between a VR HMD and a handheld touch device [36]. Using the product they have developed, while one user navigates a 3D environment in VR, another user can see the perspective of the VR user through a tablet, and interact by highlighting objects in the virtual space. This provides the users with a more direct method of communication when discussing the virtual environment. The product was tested on 10 pairs already familiarised with the use of VR in a workshop environment. The study found the use of a cross media platform improved the workshops significantly in regards to error rate, task success and task completion time [36]. similarly, Grandi *et al.* found that cross media collaboration between VR and AR users even outperform collaboration where all users are participating through AR, while Drey *et al.* finds asymmetrical applications as efficient collaborative learning tools [18, 12]. While a high amount of asymmetry can cause frustration to users some level of asymmetry can still open up possibilities to utilise the strengths of multiple technologies. For example, while a 2D interface doesn't provide the same spacial awareness as a head mounted display (HMD) 2D displays better afford the act of note taking where this can be a tedious and difficult task in VR without using a specialised tool or hand tracking [7, 13]. So by introducing some degree of asymmetry the users can maintain a high level of productivity with different interface mechanics while facilitating cross platform communication.

2.4 Novo Nordisk VR Workshop

In order to design an application to improve the current workshop workflow at Novo Nordisk, it is necessary to map out their current workshop structure. We observed a workshop as described in appendix A, and conducted interviews with three Novo Nordisk employees responsible for the current workshops at Novo Nordisk as seen in appendix B.1 and B.2. One is a currently a CAD specialist in the XR department but was part of creating the current workshop method and has acted as facilitator and workshop responsible multiple times. The other two are hired as operation readiness professionals in charge of standardisation of procedures and are currently in charge of facilitating the VR workshops at Novo Nordisk. Through these interviews and after observing a workshop this section describes in detail the current VR workshops at Novo Nordisk. The virtual reality workshops at Novo Nordisk are held within a room containing two VR play spaces and two televisions with additional seating for observers, as seen in figure 2. Participating in the workshops are usually:

- **VR players**: 1-2 players in virtual reality occopying the VR play spaces. These participants are often the same people every workshop as they have experience with VR. They are currently

only ones able to interact with the virtual environment. Their view within the VR application is being streamed to the screens in the room so all other participants can follow along.

- **Subject matter experts (SME)**: The amount of SME's present varies, but they have specific expertise in the field being examined in the workshop and are critical for success.
- **Other participants**: This might include operators of the factory being discussed in the workshop, or people responsible for the processes within the factories.
- **Observers**: Observers are there during the workshop to ensure it all runs as intended and to see if anything about the process needs to be changed. This can include elements of the VR application itself or the workshop method as a whole. The observers often comprise of either a operation rediness professional as seen in appendix B.2 or staff from the XR team.

The workshop is prepared by the facilitators who manage the VR headsets by keeping software up to date and set up the room for a workshop. The contents and theme of a workshop is managed by the participants themselves without much preparation. The structure of a workshop is as follows:

1. Facilitators prepare for the workshop by updating software on the headset to make sure the latest version of all applications are available for use.
2. When all participants are present there is a short introduction to VR and the theme of todays workshop so all participants are aware of the VR elements and point of discussion.
3. One or two participants with VR experience put on a headset, enter the virtual environment and shares their screen on the television next to them so everyone can see the environment.
4. The workshop starts as the participants walk through the needed tasks in VR and discuss what is relevant between the VR players and other participants.
5. During the workshop some participants may take notes, but it is most often just observers taking notes for technical changes for future iterations. Some participants may take notes during the workshop, but many do not write down findings before returning to their desk after the workshop.
6. The workshop ends without any collaborative summary leading to each present department to summarise on their own.

This workshop structure does not follow any peer reviewed methods such as the ones described in section 2.1. The current structure at Novo Nordisk is not a method designed through careful consideration and academic research, but instead by iteratively changing the workshop over time via feedback and trial and error.

As seen in the interview in appendix B the high amount of asymmetry is described as an issue as it creates barriers of communication and frustration from the participants unable to interact with the virtual environment. Furthermore the non-VR participants end up having more of an "onlooker" role while the VR participants end up acting as "cameramen" and surrogates of interaction for others. All interviewees express that a more direct method of interaction with the virtual environment for non-VR users would improve the workshops as this would make all participants active instead of having most in an inactive observer role. They express a want for all users to be in VR but acknowledge that this would not be feasible as there is not the physical requirements available and this could introduce other issues. These issues could include being unable to take notes effectively within VR, and some participants maybe being prone to cybersickness, excluding them from the workshop. This means that in order to minimise asymmetry a method of interacting with the virtual environment and an interface for communication can bridge the symmetry gap between the two types of participants.

3 Method

This project required a substantial amount of development on fundamental features which it would rely on. These features were developed in collaboration with Aalborg University Copenhagen MED 10 masters project group 06 who would use it for their own thesis as well. This collaboration resulted in an application which allows players in VR and players on tablet to join the same environment through networking. The product details can be seen in section 4. This foundation was required to contain a selection of different features that was settled on as requirements through discussion and interviews with some of the stakeholders of the VR workshops at Novo Nordisk which can be seen in appendix B. These requirements were then built out along with the collaboration group over the process of a couple of months. The details of the foundational application and the requirements will be elaborated upon in section 4. This project will focus specifically on features which will allow test users to take notes within the application/virtual environment to aid in workshops and information retention. After designing and implementing the note taking features an evaluation will be performed through a Heuristics evaluation with user experience experts from Novo Nordisk and a usability test with participants found through convenience sampling.

3.1 Heuristics Evaluation

To evaluate the final product of this project a heuristics evaluation will be performed to ensure the quality and usability in the eyes of our stakeholders at Novo Nordisk. A heuristics evaluation is an informal method of usability analysis where multiple evaluators are used to find usability issues in user interfaces [29]. A typical heuristics evaluation uses a defined set of heuristic principles to examine the usability of an interface. Nielsen describes the 10 heuristics that act as general principles for interaction design [28]. Not all heuristics need to be used to evaluate, it is recommended to select a set of heuristics relevant to the specific interface to evaluate. A small set of evaluators is used to judge the usability of a user interface. The efficacy of a heuristics test depends not very much on the amount of evaluators, but instead on the expertise of the evaluators [27]. In order to maximise the efficacy of the heuristics test of the application, the final evaluation of this report will enlist user experience experts from Novo Nordisk with knowledge of the current workshop processes in their field. During the evaluation they will act as both user experience experts as well as stakeholders. The heuristic evaluation will have the participants spend time familiarising themselves with the prototype through tasks and then have time to freely use and scrutinise the interface. Afterwards, a semi structured interview will be used to examine the prototype in relation to a predetermined set of heuristics to get qualitative data.

3.2 Usability Test

A two part usability test using convenience sampling will be used to examine the usability of the application in general from the perspective of a user not familiar with the Novo Nordisk workshop dynamic. The test will serve as indication of whether or not the application is usable for new users and whether it will require familiarisation with the workshop structure at Novo Nordisk in order to be used or if it is intuitive enough as an interface to be used by a broader audience. The test will consist of a short test where the user uses the prototype

to solve a set of tasks and spend time using the prototype freely followed by a short semi structured interview about the functionality of the prototype. Afterwards the participant will be asked to fill out a System Usability Scale (SUS) questionnaire. The first part of the test and interview will provide qualitative data about the usability and user experience of the prototype. This will provide information of potential errors in the design, or where the functionality meets the expectations of the user [5]. The SUS questionnaire is a ten 5-point item questionnaire widely used as a standard method of assessing the percieved usability of a product [23]. The SUS questionnaire will provide a quantitative value between 0 and 100 that will serve as an indication of overall usability.

4 Cross Media Platform

Through working with Novo Nordisk on their workshops a number of different requirements came to light during the process. These requirements were then specified through interviews with members of the Extended Reality department and users of the existing VR platform in Novo Nordisk (see appendix B.1 & appendix B.2).

The cross media platform functioned as the baseline for the project and was designed to accommodate the requirements of Novo Nordisk and their VR workshops. This system was therefore designed with a lot of features not directly used for this thesis, but as this development and these features were a large part of both time spent during development and were integral to fulfill the needs of Novo Nordisk and their VR workshops they will be described here. As mentioned the requirements were developed both through observation of existing features in the VR platform that Novo Nordisk used as well as through interviews with Novo Nordisk employees who develop or use the VR platform in production. This along with research led us to settle on these requirements for the application.

1. The participants not in VR (on-lookers) should have a way to interact with the participants in VR that reduce isolation and improve communication between users [43, 6, 35].
2. Non-VR users should be able to interact with the virtual environment via object translation and rotation to improve symmetry between VR and non-VR users [36, 35].
3. Non-VR users should be able to annotate the virtual environment to improve communication [36, 35].
4. The workshop using the application should be able to inlcude a user having a facilitator role, which encourages learning between and among the participants [8, 6].
5. The application should support real-time collaboration [17, 35, 8]
6. The application should be able to organise, collect, retrieve and share information from the workshop such as notes and environmental changes [17, 35, 8].
7. The application should support the ability to evaluate decisions made in the virtual environemt [17, 8].
8. The application should be able to support rapid prototype and mock-ups [17, 8, 1].

These requirements were then implemented into a Unity application. The first requirement was that the workshop participants outside of VR should have a way to interact with the participants in the environment. This, in turn, required that the application be networked, to afford that participants both inside VR and participants outside on other devices could collaborate. The details of the networking implementation can be seen in section 4.0.1. The ”other” medium, or non-VR device was also a consideration. The project settled on using a tablet/touch interface for the non-VR device. This was selected in part because every Novo Nordisk employee is given a touch-screen based phone to use for work and as such every user inside of Novo Nordisk would be required to some extent to have used a touch-screen in the past.

Some requirements for the project will not be described in this report and will instead be handled by our partner group as described in section 3, so for requirements 2 and 8 refer to the implementations in their report.

4.0.1 Networking Implementation Details

As the application required that multiple participants in the workshops be able to interact with each other and the environment at the same time on different types of devices, it was necessary to develop and implement a system to handle this across the network. This system was developed with the requirements of a workshop in mind as informed by the interviews that had been conducted with employees at Novo Nordisk. The application was built in Unity and it was decided to use the first-party networking systems that Unity provides as these would be most likely to be approved for use in Novo Nordisk. Networking systems are composed of multiple underlying subsystems that handle different aspects of the overall experience. The base application logic is handled by the networking library, also called Netcode. The netcode supplies a framework for how different users ”talk” to each other and how actions are replicated across different clients. For this implementation Unity’s open source system called Netcode for GameObjects (Netcode) was used. Netcode supplies a couple of different built-in components that make synchronising object state easy. This includes components for synchronising an objects position and rotation in 3D space.

Netcode divides users into two different groups: server and client. The server is the authority on the networking state and will often be responsible for running logic like calculations that need to be synced and then transmitting the results to all the connected clients. The server, per default, has authority over the state of the objects. A client is a connected user which does not have authority per default but to which the server can delegate authority. With this in mind there are a couple of different ways in which they can be organised. First, the client-server architecture relies on a server that tracks and updates the state of all synchronised data. In this model, the server is not a player and is running on a separate machine, and oftentimes doesn’t render the application itself. The host model, which was used for this project, instead designates a user or client as the server (in this case the first person to open the application) which runs all the server code on their device. The host device is then treated as both a server and a client depending on what the program requires. With the structure established it is now necessary to communicate between these different users. The fundamental communication is handled through remote procedure calls (RPC) [25, 38]. RPC’s are a way to call functions on different machines. Essentially you can tell another computer to run a specific function. This is for example used in the highlight system (see section 4.0.3). The netcode RPC system works by marking functions using the `[Rpc]` attribute. This tells Netcode that the function is not supposed to be run locally on the calling machine, but instead by a remote group over the network. Another approach for syncing state between users that Netcode offers is called Network Variables. Network variables allows for creating variables who’s value is automatically synchronised across the network. This however requires that the variable can be serialised properly to allow for the backend of netcode to be able to synchronise it. This is implemented for a lot of Unity built-in managed types already as well as all C# primitive types [37]. With the users connected it was necessary to provide each type of device with both a representation in the virtual environment and with a set of interactions and input option on their device of choice.

VR

	VR Mapping
Select:	Press trigger
Deselect:	Press trigger
Movement:	A: Walk physically within the guardian's boundaries. B: Teleport by pushing left or right thumbstick in a direction and let go to teleport.
Rotation:	A: Rotate physically B: Rotate in increments by using the ? thumbstick
Zoom:	NA
Hover:	Point at objects or interactables with the beam from either controller.
Highlight:	Press trigger to enable/disable
Grab/ translate	Ray --> grab knap Item "drops" to closest horizontal surface You can move items back and forth with joystick up/down
Grab/ rotate	Grab --> rotate with with joystick, right/left Hold for smooth "Tap" for increments

Tablet

	3D/free	POV/FP:	2D/Top
Select:	one tap		
Deselect:	one tap on selected object		
Movement:	NA (for now)	Drag and Go	Drag
Rotation:	One finger swipe horizontal and vertical	One finger swipe horizontal	NA
Zoom	Two fingers. Pinch in to zoom out and pinch out to zoom in.	NA	Two fingers. Pinch in to zoom out and pinch out to zoom in.
Highlight	One tap to enable/disable		
Translation/ grab	A: Press and hold on the object. Drag it to the desired location. B: Enable highlight. Then press and hold the translation gizmo and drag the object to the desired location.		
Rotation/ grab	Enable highlight. Then press and hold the translation gizmo and drag the object to the desired location.		

Figure 3: An overview of both VR and tablet input actions and mappings.

4.0.2 User Avatars & Input

To design the VR interactions and input was largely to replicate the interactions and input that the users in Novo Nordisk would be familiar with. This meant that most of the basic interactions like locomotion and grabbing would be using the same inputs as the VR applications already in use. This expanded to the locomotion types (teleport vs continuous move) which was also dictated by the existing VR applications and thus would be as closely replicated as possible. To speed up development, Unity's XR Interaction Toolkit was used as the baseline for VR input handling, interactions, and locomotion [40]. The base sample interactions was changed slightly to more accurately replicate the interactions found in the already existing VR applications in Novo Nordisk.

For the tablet device interactions it was necessary to create multiple different systems to accommodate the different needs of the users. To solve this 3 distinct "views" were designed. The first view, called 2D, is a view of the environment looking down from a birds-eye perspective similar to how you would see a map or a blueprint. This view was intended to give the user a sense of the spacial relation between objects similar to the functionality of a map or a blueprint. The second view, called 3D, was designed to replicate the experience of using 3D modeling or CAD software similar to Blender, Maya or, as might be more familiar to the user in Novo Nordisk, CAD software like AutoCAD. This view allows the user to rotate the room around an an anchor point, giving more control to inspect nooks and crannies of the environment and to get a better sense for the objects look and shape. The 3rd view called "first person" allows the user to get down on the ground of the environment and move around similar to the VR player or the perspective of a person walking around. As the environments are designed primarily as places for people to be in Novo Nordisk, this was a necessary view for giving the workshop participants a proper sense of the space they are helping design. Having three different views also required the design and implementation of three different input systems. The top-down view only required three degrees of freedom: moving vertically, moving horizontally and zooming in and out. This mapped well to sliding actions for moving the screen and using a pinch action to zoom. The 3D view required 6 degrees of freedom: tilt, rotate, translate in x, y and z and zoom. Tilting and rotation used the sliding action from the previous view. Translating used a sliding action but with two fingers instead similar to how many touch devices allow you to switch tabs. Zoom used the same pinch action. The first person view would require a more complex input mapping as rather than move the object as in the two previous views, instead the user would move the camera. To do this an approach called Drag'n Go was implemented [24]. Drag'n Go allows the user to navigate a virtual environment by simply touching a spot and dragging/sliding it to the bottom of the screen. This results in the player moving towards the point they have pressed on. The full list of interactions and inputs can be seen in figure 3.

Because the application afforded the users to occupy the same virtual space, it was necessary to design avatars that would represent a user in the environment. It was decided to make separate avatars for the users using a VR device and tablets. The VR avatar was designed to represent a person wearing a head mounted display and holding controllers. The head of the VR avatar was created in blender and can be seen in figure 4. The tablet avatar can be seen in figure 5. The avatars use a colouring system to distinguish the players from each other. Each player, when they join the session are assigned a colour from a predefined colour list. The colour then corresponds to the player's `ClientID` assigned by the server.

Figure 4: The VR Avatar in the networking platform.

Figure 5: The tablet avatar on the platform.

4.0.3 Highlight System

The highlight system is an implementation of requirements 1 and 3 (see section **??**). The feature was designed as a way for participants to communicate with each other as well as being a passive visualisation that a user was interacting with a specific object. As such the highlight should both be clear and distinct for each player. For VR the highlight will be activated by pressing the trigger on either controller if the user hovers the beam over a highlight-able object (see figure 3). This will then highlight the object with a tint and an outline. This highlighted state will be synced across the network, and all other users in the environment will be able to see the highlight. The process can be seen in figures 6, 7, and 8. The process for table is quite a bit simpler. A single tap on a highlight-able object will toggle the highlight on the object.

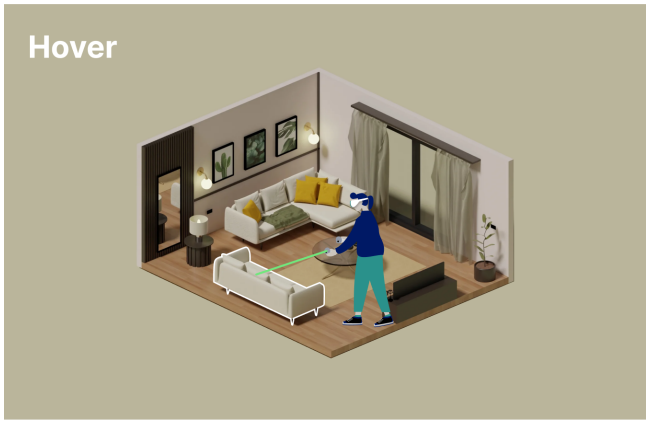

Figure 6: Hovering over an object when using VR outlines the object with a thick white outline. This is unavailable on tablet.

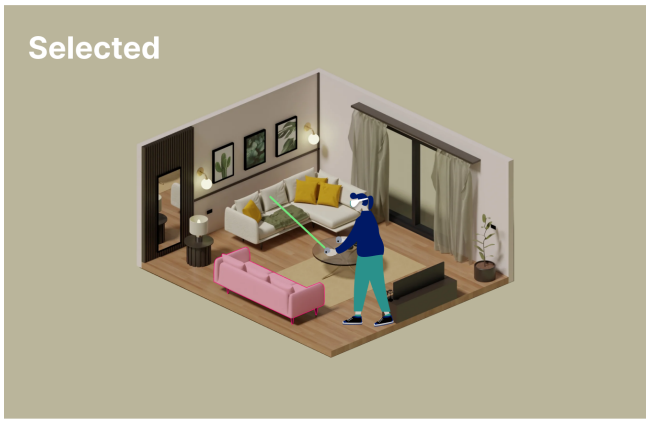

Figure 7: When the user selects an object it will be highlighted with both a tint and a thinner outline which is coloured using the players designated colour. The object's outline and tint are also visible through other objects.

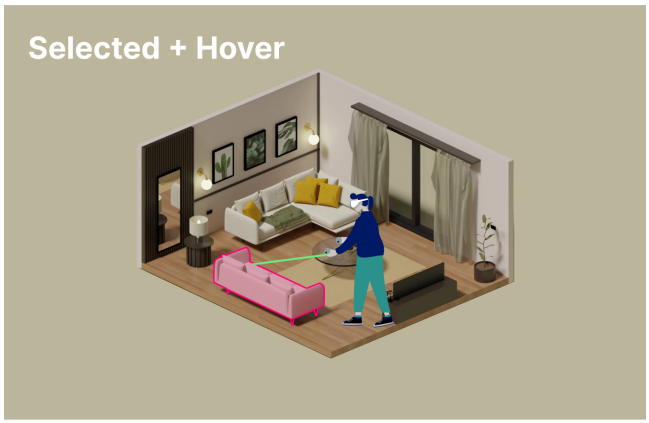

Figure 8: When a user has selected and highlighted object and then subsequently hovers over the object using VR the outline will increase in thickness.

The shader itself was designed with two distinct elements in mind as can be seen in figures 6, 7, and 8. It required both an outline and an overlay component. Both shaders needed to work on both tablets and VR headsets. The outline was the first element and needed to

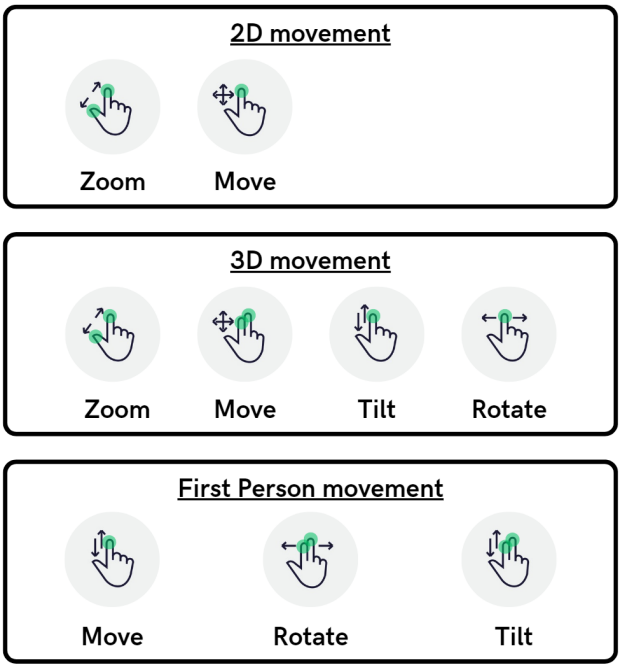

Figure 9: Figure showing the control scheme for tablet movement.

work on all kinds of objects and be performant enough to work on the devices mentioned. A Unity package called Quick Outline by Chris Nolet was used [30]. The script to trigger the outline and the overlay component were then created by modifying the included scripts in the package in accordance with the Unity Asset Store EULA, while the outline shader logic itself was kept intact. The outline used a mask shader to ”cut out” the model itself to apply the outline. This mask was then modified to fit with requirements of the highlight and overlay shader. The mask uses a transparent shader to colour the object.

4.0.4 Interactions and Usability Test

The interactions of the tablet system were of specific interest to this thesis. As the VR interactions mimicked the familiarity of already existing applications in use in Novo Nordisk they would by the nature of their integration already ideally be sufficiently usable to the intended audience. The tablet interactions however were wholly new to the Novo Nordisk VR workshop workflow and thus the application of familiarity as pretext for usability would in this case not be available. It was therefore necessary to conduct preliminary usability tests concerning the interactions of the different views using the tablet interface. Before continuing with development of further workshop features the initial systems of the cross media platform should be evaluated. After development of the cross media platform a usability test was needed to ensure the interaction methods developed for tablet where intuitive and easy enough for new users to understand and use. A full description of the method used for evaluating the cross media platform can seen in appendix C.1. A two step usability test with a semi structured interview was performed with seven test participants. All participants were given a short introduction of the control scheme as seen in figure 9 and where then given 3 tasks to complete during the test. The tasks are as follows:

1. Locate all blue boxes in the virtual environment
2. Highlight all blue boxes in numerical order

Figure 10: The virtual environment used to test the usability of the application.

3. In one minute explore the virtual environment and afterwards do a top down drawing of the layout.

All three tasks were created to make the user explore the virtual environment with whatever movement system they felt most comfortable with or they felt best suited the task. The second task required the user to use the highlight system without getting instructions on how to do so which tested whether the implementation was intuitive. During the test an observer noted down relevant user behaviour and after the test the participants were asked questions about the experience. four questions were prepared but this could be expanded depending on the answers of the participant. The prepared questions were:

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

Results, notes and observations from the test can be found in appendix C.2. While this evaluation only includes 7 participants the results can be used as an indication of what aspects of the application should be further developed, removed, or accepted for later iterations. From the results and findings of the evaluation we can conclude the following:

- While some users prefer 2D and 3D movement, all movement methods are robust and intuitive enough to continue development using this control scheme.
- Users prefered the 2D view when getting an overview of the floor plan.
- Users preffered the 3D view when getting a spacial understanding of the room.
- Everyone understood the icons and what they represented.

Based on these findings we have sufficient positive feedback about the usability of the product to continue development of added features. As described in section 4, this report will build upon this existing application and minimise asymmetry between VR and non-VR users by creating a note taking system making it possible for users to annotate and categorise feedback within the application.

5 Note Taking System

Through the interviews with Novo Nordisk employees (see appendix B.1 & appendix B.2) on of the features that would be useful to them in the workshop process would be a way to save and share information and notes with other employees after the workshop. This led to the development of a note taking system which could be used on the tablets to take notes about objects in an environment. Built on top of the collaborative platform from the previous section, this note system would allow users to save their ideas and their thoughts for future retrieval and sharing with others.

5.1 Design

The application, as mentioned before, was designed as an extension of the collaboration platform described in section 4. The application was also designed with the needs of the workshops in mind. The prototype built for this project includes some of the features that would ideally be implemented, but the for this project the primary interaction of taking notes is in focus. The design relies on the heuristics presented by Jakob Nielsen in his article *10 Usability Heuristics for User Interface Design* [26]. To speed up the design process and to avoid reinventing the wheel, an already existing open source design system called shadcn/ui [33] was used. This design system comes with a sizeable number of pre-styled components including buttons and other widgets and elements. Since the interface ultimately needed to be implemented inside of the Unity game engine, it was also decided to use the Unity system UI Toolkit which uses an approach to ui design more commonly found when developing web applications by using a markup language similar to XML to describe the content and relationship of a series of components and a styling system similar to CSS [39]. This means that it was possible to use many of the styling elements from the design system quite easily as shadcn/ui is intended for web development, specifically development in the React framework. In addition to using the design system as the baseline, it was also decided to use a unified icon set, to both give a sense of cohesion to the design, but also to make the icons more easily recognisable and provide a large set of icons. For this the open source icon set Phospher Icons created by Helena Zhang and Tobias Fried [42] was used.

5.1.1 Colours

The colours used for the design are taken from the Novo Nordisk Corporate Design Manual [31]. Colours where then selected to represent certain actions and to inform the user in accordance with the 6th usability heuristic [26]. The colours were chosen for their function based on how well they mapped to the colours used in other applications the user might be familiar with in accordance with the 4th heuristic [28]. The colours used can be seen in figure 11. The primary colour of the backgrounds and all window elements is Snow White and the other colours where then assigned to different actions. Ocean Green was associated with editing which meant that all buttons that allow the user to edit something or create new notes should be using that colour. Lava Red was used as the primary danger colour, so any destructive action like deleting a note or closing a window with unsaved changes should be using that colour. Forest Green was associated with safe actions that prevent errors, actions like saving your work. The other colours in the palette were not used in the design.

5.1.2 Initial Design

The design was done in two phases. The initial design was created in the design tool Figma and constituted a series of mock-ups which were then discussed and altered with regards to their effective use and implementation of the design heuristics laid out by Nielsen [26].

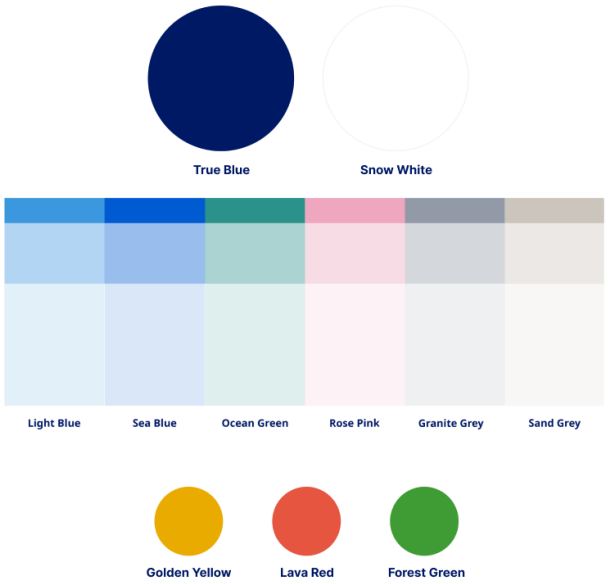

Figure 11: The official Novo Nordisk colours described in the official corporate design manual [31].

A fundamental element of the design is that when the user takes notes they should be attached to objects. This means the user can write notes for specific things in the environment. Like writing a note about a table that needs to be moved to the other side of the room. With this in mind an initial visual design was made using Figma. The first element and interaction is the object selection widget which can be seen in figure 12. The widget relies on the design principle of familiarity by using people's experience of right clicking on elements to get information or perform actions on them following the 4th usability heuristic: consistency and standards [26]. The widget contains options for creating a new note for the selected object and an option for opening the archive for already written notes.

Clicking the new note button will open a new window called the note editor window. This window should allow the user to edit the different variables of a note. In the design a note contains 3 different variables: it's name, it's content, and the associated object to which the note is "attached." The editor window mock-up can be seen in figure 13. The note editor window allows the user to directly change the name and content of the note. The top of the window shows an icon and a title to easily identify the type of window for the user in accordance with the 6th heuristic, which says that *"Minimize the user's memory load by making elements, actions, and options visible. The user should not have to remember information from one part of the interface to another [26]."* This heuristic is used throughout the rest of the interface by using clear titles for all the input fields as well as using temporary guide text inside the field which disappears when the field is selected. This design should make it clear to users what they need to do in the window without any further tutorials.

Another element of the design was the archive window or note library. This window should display the currently existing notes across all the different objects giving the user a quick overview of all the content that has been written. This view should also allow the user to perform operations to manage the different notes like editing, deleting or creating non-object notes. The mock-up can be seen in figure 14. The window consist of the title bar which similar to the editor window has an icon and title for quick identification. The body of the window contains a grid of existing notes. Each note is represented as a card with the name of the note being the card's title (In the mockup in figure 14 the notes are all named "Example Note").

Figure 12: Design mock-up of the object select widget containing the options to create a new note and to open the archive of notes.

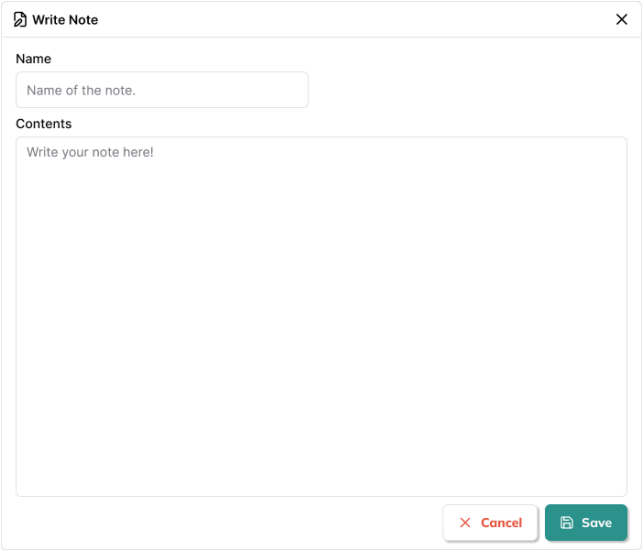

Figure 13: The note editor window which allows the user to edit the name and contents of a note.

The card also contains a subtitle which shows the name of the object the note is associated with. This is made clear by the use of the box icon which is used here to denote the concept of an object. Each card contains icon buttons for 2 actions. The first button with the Lava Red paper with an x is for deleting the note. The right button with a Ocean Green pencil is for editing the note.

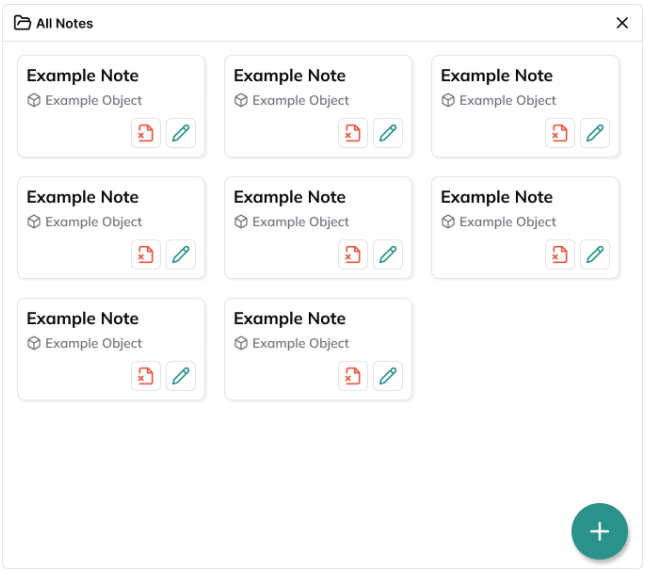

Figure 14: The note archive window. This window allows the user to get an overview of all the notes that have been written. It also allows the user to delete, edit and create new notes.

5.1.3 Final Implemented Design

The final design that was implement in Unity had slight differences to the design created in Figma, but is based on the same rationality, arguments and heuristic considerations. The update also changed some of the design of the collaboration platform (see section 4) to create a more cohesive visual presentation and design language throughout the application. This resulted in a redesign of the buttons controlling the different views though the iconography was kept more or less intact (see figure 16). The sidebar was additionally expanded with a new button in the top left which opens the archive of existing notes (see figure 15). The icon for the button was selected to be reminiscent of opening a folder in other applications, informing the user that the button and subsequent view contained files.

A couple of small changes and decisions about the design were also made for the application's windows. A window in this context referring to any contained view elements structured into a cohesive frame. The windows in the original design included the archive (see figure 17 for redesign and figure 14 for old.) and the editor (see figure 18 for redesign and 13 for old). Additionally for the final design a new window was added called the reader (see figure 19).

The archive's redesign foregoes the use of a grid to display the notes and instead uses a vertical list. This allows for more content to be shown in the individual elements. This also allows the note list elements to contain a preview of the content of the notes, as well

Figure 15: The new button to open the archive. Sits in the top left corner of the display.

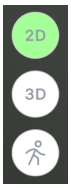

Figure 16: The redesigned buttons used to change between the different views. Sits in the bottom left corner of the display. The view is currently set to 2D causing the button to turn green.

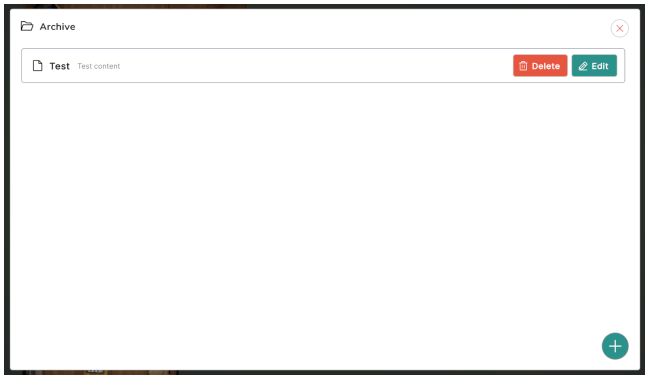

Figure 17: The final design of the note archive. The grid cards have been removed in favour of a list with larger, more clear buttons.

as have room for larger, clearer buttons for managing each note. If more notes are created than can fit in the window then a scroll bar will be shown on the right which can be used to navigate the list. The editor design received less changes overall. The basic layout remains the same as presented earlier with a few minor tweaks for legibility. These include the both the save, delete, and close buttons getting new colours which more closely reflect their purpose according to the colour design presented earlier (see section 5.1.1). Another change is that the header of the window has a new icon and that the title of window now more accurately describes the action that the user is taking. A new addition is the reader window. The reader was designed as an interface to read the contents and details of a specific note without having to open the editor window and possibly changing the contents of the note. The reader allows the user to simply access the contents without fear of accidentally changing or modifying any of the variables. The reader allows the user to open the editor for the note in question directly from the window. Also redesigned for the final implementation was the selection widget. This window would appear when the user tapped/selected an object in the scene. The widget has been update to include an icon and a close button in the top right of the window which can be seen in figure 20.

6 Evaluation

The current workshops at Novo Nordisk does not support in-application note taking, and all note taking is done externally with an added task of categorising and sharing notes after each session. With this proposed prototype users will be able to create, read, update and delete notes about the virtual environment directly within the application. The motivation for this evaluation is to examine the note taking interface on tablets and simulate some of the use cases during a workshop to evaluate the usability of the prototype.

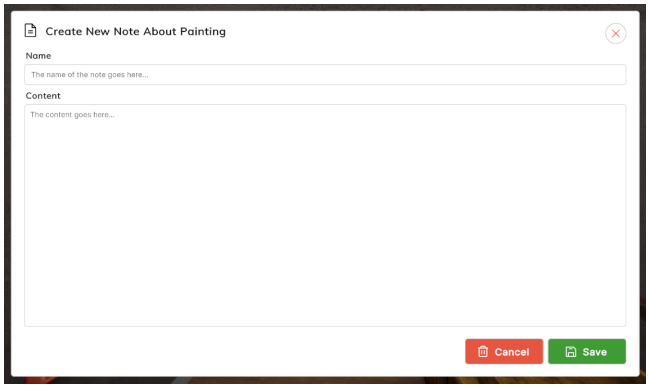

Figure 18: The final design of the editor. With clearer buttons and a more descriptive window title.

Figure 19: The reader window. Allows the user to read a specific note without opening the notes editor window and making accidental changes. Contain buttons for returning to the archive and opening the editor for the note currently being read.

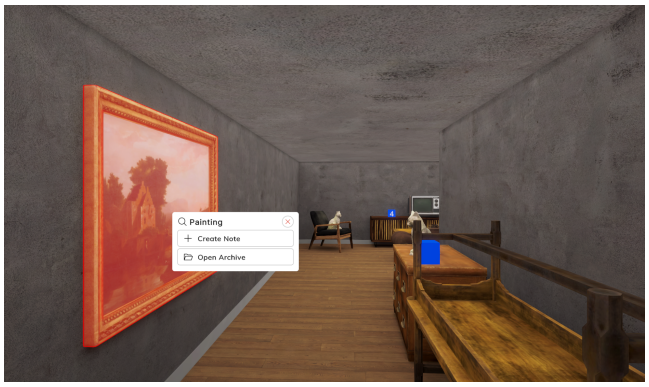

Figure 20: The final design of the widget. Now includes an icon and a close button as well as a title telling the user what object they selected.

6.1 Heuristic Evaluation

To evaluate the final implemented design a heuristic test was made with user experience (UX) experts from Novo Nordisk. This section will describe the method used to evaluate the prototype as well as the results found.

6.1.1 Evaluation Method and Procedure

To create the heuristic analysis the experts were interviewed in pairs. This approach allowed them to discuss with each other as well as us. This meant they could discuss their analysis of the software with each other and comment on each other's approach and opinions, giving greater insight into the product's ease of use. The first test was conducted with two expert UX designers in Novo Nordisk and the second test was conducted with two expert UX researchers. The tests used the same virtual environment as the usability test in section 4.0.4 (see figure 10). The heuristic tests followed a procedure which consisted of three parts:

1. Both participants would complete a series of different tasks, forcing them to interact with most areas of the application. The tasks in question were:
    (a) Navigate around the 3D environment and each select and write a note for 2 of the objects.
    (b) Open the archive of written notes.
    (c) Perform a set of actions on notes.
        i. Read a written note.
        ii. Edit a written note.
        iii. Delete a written note.
2. They were asked to freely explore the program as they saw fit for as long as they liked.
3. We conducted a semi-structured interview focusing on specific usability heuristics [26, 29, 28]. The questions were:
    (a) "Did you feel that each screen provided you with sufficient information about what interactions where possible at any given time?" This question was meant to examine the heuristic of visibility of system status.
    (b) "Did you feel it was easy to go back or change an action in case you did something unwanted or by mistake?" This question was meant to examine the heuristic of User Control and Freedom.
    (c) "Did you feel that there was sufficient guardrails in place to help you avoid errors while using the product?" This question was meant to examine the heuristic of Error Prevention.
    (d) "Do you feel the visual elements were recognisable and were you able to understand what interaction they each granted?" This question was meant to examine the heuristics of Consistency and Standards and the heuristic of Recognition Rather than Recall.
    (e) "Do you feel you were provided with sufficient information on each screen or do you feel it was either too minimal or cluttered?" This question was meant to examine the heuristic of Aesthetic and Minimalist Design.
    (f) "Was there anything that you wanted to do which you were unable to?" This was a general usability question and not examining a specific heuristic.
    (g) "Did you understand the meaning of the icons?" This was a general usability question and not examining a specific heuristic.

These three parts would be carried out sequentially after a general introduction given by one of us. They would then be asked to complete the tasks presented in part 1. Each task would be presented on it's own and the participants would be asked to complete it. Their actions, behaviour, and comments would be recorded in writing during the process. Once both participants had completed a task the next task would be presented. Part 1 task (c) was presented with all subtasks at the same time, and the participants could complete them in any order they preferred. After the participants had completed all the tasks in part 1 they would then be asked the questions presented in part 2 sequentially. The answers to the questions were recorded in writing, but not quoted directly, instead they were written down with focus on the relevant elements of the answer.

6.1.2 Results

All recorded notes during the heuristic tests can be found in appendix D. This section will highlight and showcase relevant findings. First are all the problematic elements that prevent a good user experience: The lack of a text cursor when writing in the text fields in the editor window is confusing to the user and causes the user to loose their place when writing. Another issue caused by the lack of a cursor is that it makes editing extremely difficult as it's not possible to see selections or whether the field contains any white-space. Closing the keyboard when editing text fields is problematic. Due to the nature of the text field allowing for new lines to be written pressing the return key does not close the keyboard. One way to close it is by clicking outside of the text field, but due to the size of the field on the screen it was not obvious where they could click to close the keyboard. The object selection widget doesn't close when clicking outside of it as some of the experts would it expect it to. This could be the result of not adhering to heuristic 4 [26] as that behaviour is normal for context menus on computers. Selecting objects can sometimes be more difficult than necessary, and the selection, especially when zoomed out is too precise causing inaccuracy. The archive button in the object selection widget could be confusing as the option had no relation to the object being selected.

These problems are largely addressable and are not directly related to the prime functionality of the application but are instead about the usability of the product. There were a lot of positives as well: The overall app seemed really easy to use. The concepts are easily understood and intuited even without a tutorial. The UX researchers would use the application on a daily basis, as it was so much simpler and more easy to access than a VR version. It was easy to fix your mistakes and the application prevented mistakes by requesting that users confirm destructive actions. Generally the buttons and iconography were clear and readable. They all intuited most of the actions and completed the tasks without assistance from us.

From these responses it is apparent that the application's primary functionality is easy to grasp and to execute. It was also expressed by specifically the two UX researchers would like to have the application available to them, so they could use it on a daily basis to prep the workshops.

6.2 Usability Evaluation

Along with the heuristic evaluation a usability test was performed to examine the general usability of the prototype. This section will describe the method used to evaluate the usability of the prototype as well as the results found.

6.2.1 Evaluation Method and Procedure

This evaluation is a within group study using convenience sampling to find participants. The test will use a lot of the same structure as described in section 4.0.4 but will be tailored to the note taking system.

The test will examine the usability of the note taking functionality of the tablet prototype, during simulated workshop tasks. The test will include a set of tasks to be completed by the participants, where qualitative observation data will be collected to examine the uses behaviour. Afterwards a follow-up interview will elaborate on user attitude towards the prototype. Finally a System Usability Scale (SUS) questionnaire will provide quantitative data measuring the usability of the prototype [23]. The virtual environment used for this test, is the same as in sections 6.1 and 6.2 and is the one shown in figure 10. The test will proceed as follows:

1. The test participant will receive an introduction to the test and to the movement system as described in figure 9.

2. The participant will be given a tablet and the following set of tasks to be completed without further instructions while using the think-out-loud method [21].

   (a) Navigate around the 3D environment and each select and write a note for 2 of the objects.

   (b) Open the archive of written notes.

   (c) Perform a set of actions on notes.

      i. Read a written note.

      ii. Edit a written note.

      iii. Delete a written note.

3. After completing all tasks the participant is asked to spend however long they want to explore the application freely and scrutinise the functionality of the prototype. When they feel they no longer want to interact with the prototype they will let us know and we move to the next step.

4. A follow-up semi-structured interview is performed asking the following questions:

   - Generally, how did you find the experience of taking notes in this environment?
   - How easy or difficult did you find it to solve each of the tasks you where given?
   - Was there anything you wanted to do that you were unable to?
   - Did you at any time do something you did not mean to?
   - Do you feel you could effectively take notes about the 3D environment in this application?

5. After the interview the participants were asked to fill out a SUS questionnaire

During the entire test an observer is present noting down the participants relevant actions and all answers to interview questions.

6.2.2 Results

All interview and observation notes from the usability test can be found in appendix E.1. The key findings from observations and interviews can be seen in table 1. All gathered data from the SUS questionnaire can be seen in appendix E.2. The distribution of SUS scores of the test participants can be seen in figure 21 and contains the information seen in table 2. The mean SUS score of 88.5 is categorised as an ”excellent” score [3].

Key findings	Amount of participants
Had trouble closing the keyboard	5
Had difficulty writing as the cursor was not visible	3
Was able to select an object and write a linked note without instructions	5
Was able to find and open the archive	5
Found difficulty editing notes because of bug	3
Was able to read notes easily	5
Was able to delete notes easily	5
Had difficulty seeing what objects notes was attached to	4
Found the appliation easy to use	4
Had issues with closing the widget menu	2

Table 1: Table showing the key findings from the usability test observations and interview answers.

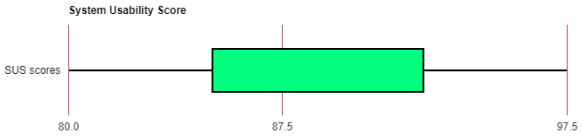

Figure 21: A boxplot showing the distribution of SUS scores from all participants.

Sample size (n):	5
Min.	80
Q1	85
Median	87.5
Q3	92.5
Max.	97.5
Mean	88.5

Table 2: Table containing the information given by the boxplot in figure 21.

7 Discussion

This paper proposes a networked cross media platform workshop application for virtual reality and tablets giving all participants the option to interact with the virtual environment. The prototype was developed in collaboration with the Novo Nordisk Extended Reality department, with them acting as stakeholders for the product. This paper focused on the further development and evaluation of a note taking system for the VR workshops at Novo Nordisk in order to minimise asymmetry, ensure all participants can contribute actively, and that decisions are catalogued for future development and changes. The platform, as mentioned in section 3, was developed in collaboration with MED 10 group 6 at Aalborg University CPH. The collaboration encompassed most of the initial research and interviews with employees in Novo Nordisk (see appendix B.1 and B.2), and the design and development of the cross-media platform. This collaboration allowed the platform to be more feature-rich than it would otherwise have been had it only been developed by us.

One of the primary goals of this thesis is to examine how asymmetry could be reduced by implementing the cross media platform (see section 4) and by implement the note taking system (see section 5). The cross media platform was largely successful in reducing the level of visual asymmetry by giving non-VR participants a tablet with a view of the virtual environment that they could control themselves. However the note taking system, as it currently only exists on tablets is not able to reduce asymmetry between the VR and non-VR participants. Still, the application shows a lot of promise and future development could allow for the note taking feature to be implemented for VR as well, thereby decreasing the communication asymmetry of the workshops.

As seen in section 4 the prototype was build based on a set of requirements found through research and interviews. While some of the requirements were shown to be fulfilled during evaluation, some also need further development and testing. Requirements 1

and 5 (see section 4) were addressed by implementing multiplayer functionality where the participants could see each-others virtual avatars, as well as a highlighting system to help create shared focus during workshops. While this addresses the requirement, further additions could be made to improve communication such as voice chat for remote workshops and screen sharing between users. Requirements 3, 6 and 7 were addressed by the implementation as described in section 5. Requirement 3 can be said to be fulfilled to some degree. The annotations or notes written about the virtual environment don't have clear visibility inside the virtual environment and through feedback it was noted that it can be difficult to see which notes are attached to what objects. It can also be hard to get an understanding of how all the notes and the objects relate. This could be fixed by creating clearer indicators both inside the archive and note reader UI components. It could also be made more clear in the environment itself by creating visual indicators on the objects or by creating a toggle-able view of notes overlaid on the objects. Requirement 6 is only partially fulfilled. The requirement states that a user aught to be able to "organise, collect, retrieve and share information." While the definitions of these actions are debatable, some are clearly missing in the current implementation. One of these is the ability to retrieve information. While you can retrieve notes you have written down in a given session while the it is still ongoing they will be automatically deleted when the app is closed. Another lacking feature is the ability to share the notes you have written. As there is currently no option to export the notes or to send them via message or email from inside the app, sharing them is virtually impossible. These two features require different solutions. To retrieve information, it will be necessary to save the state of the notes and the environment somewhere outside of the application's memory. This could be accomplished using a database or by simply saving the notes to the local storage of the device and loading them in when the application restarts. To facilitate sharing notes with others, it is necessary to implement a method or system by which the notes can be exported or sent. This could be done by collecting the current notes and creating a .pdf file which contained all the notes and then saving that file to local storage on the device. For the 7th requirement, the application is broadly successful at being able to evaluate decisions, however the issue of retrieval is still present as it only allows you to evaluate recent decisions before the application is closed.

The final evaluation also examined the usability of the prototype through a usability test and a heuristic test. While the results of both tests indicate that the product has high usability and a lot of the functions are intuitive, the study could be improved. The inclusion of more test participants in the usability test described in section 6.2 would increase the power and validity of the results [2]. The current evaluation was only performed on 5 participants which is not sufficient to definitively measure the usability of the product [20]. Furthermore while the heuristic test showed positive results, the method is often used as a step in an iterative process to constantly evaluate the usability of a product. It would be beneficial to perform larger scaled evaluations such as performing and evaluating the product through real workshops at Novo Nordisk and a larger scale usability test with a bigger sample size.

The final product was showed to have some usability issues such as lack of text cursor, issues closing the keyboard and general lack of animations and polish resulting in an application that could feel sluggish and un-reactive. These can be solved relatively fast through small changes and implementation of user feedback. In order to finalise the product it would be interesting to combine this product with the functionalities made by MED 10 group 06 and examine the prototypes efficiency in workshops at Novo Nordisk.

8 Conclusion

The introduction of a tablet interface for navigating a virtual environment in the same virtual space as a VR user has successfully reduced asymmetry according to the definition presented by Thomsen *et al.* [35] (see figure 1). For the requirements established through interviews with the Novo Nordisk employees heuristic and usability tests evaluating the cross platform workshop application indicates a successful user interface with high usability. This can potentially be able to improve future workshops at Novo Nordisk. The evaluation however does not have enough power to definitively conclude the validity of this claim [2, 20]. The interviewed Novo Nordisk employees express explicit interest in using the product as soon as possible. Before this further bug fixes, improvements to animations and overall polish should be implemented. Some interactions lack feedback and users might encounter bugs that can negatively impact the experience. In order to demonstrate a significant improvement to collaborative design workshops, and to examine the effectiveness of the reduced asymmetry, it would be beneficial to combine the current features of this prototype with the features developed by MED 10 group 06 using the combined product to perform a large scale study examining it's effectiveness in a workshop setting at Novo Nordisk.

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A Observation Notes From Novo Nordisk VR Workshop

See next page.

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.

<u>We will be looking at:</u>

- 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!".
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B Preliminary Interviews with Novo Nordisk Employees

B.1 Transcript of interview with 3D Artist

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.

B.2 Appendix: Transcript of Interview with Operation Readiness Professionals

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.

C Initial Cross Media Platform Evaluation Method

C.1 Initial Cross Media Platform Evaluation Method

See next page.

Test design

Iteration 0

What will we be testing?

Application name and version: *Tablet Locomotion and Highlight Version 1.0*"

Focus of the test

Describe your focus areas for the coming test:
Is the user able to navigate and get a spatial understanding of a 3D environment while interacting with objects using a 2D interface?

a) What are the user's approach to investigating the environment, when given the following locomotion options:

- *2D view*
- *3D view*
- *Person view*

b) Are we missing any critical functions?

c) Looking for the users initial reactions towards our concept - is this intuitive to them?

Time and place

Describe where and when the testing takes place:
*All tests were conducted at AAU CPH Campus in the **afternoon**, in a quiet setting without others to interrupt.*

Participants

Cover names should be used, but other information should be correct. Mention age, profession and maybe a hobby.

All test participants are students at AAU CPH

Test method

The test leader introduces the test, the test method and the purpose of the project. The user is given a printed guide of how to control the different views.
Test method: Think out loud:

- Test notetaker notes what they say.
- The note taker notes which view-modes are used for the different tasks.
- The note taker also take notes of unforeseen findings.

The user has to complete three tasks:

1. Find the amount og blue cubes in the scene
2. Locate objects in scene in order and interact with them (order because we want them to focus on the individual object → they need to look closely at the objects to see the number)
3. Draw a map of the room after finishing the first two tasks.

Follow up interview: The test leader conducts a semi-structured interview afterwards, and the note taker notes the participant's answers.
The test is estimated to last 10 minutes.

Test setup

Describe the surroundings in detail (maybe add a picture). Describe who is running the test. E.g.

Test leader: name
Oversees the agenda, introduces the test, instruct, conduct a short follow up interview + outro.

Note taker: Name
Note which view modes are used, important findings and takes notes during the follow up interview.
notes down think out loud notes

Test guide
Iteration 0

Application name and version: *Tablet Locomotion and Highlight Version 1.0*
(This document should be printed and brought to the test)

Brief introduction to participant(s)
Introduce yourself. Do not tell participants if you have designed or created the prototype, it will make it harder for them to be honest with you. Briefly describe setting and what the participant is going to experience during the test, and what you are expecting them to do e.g. thinking out loud. An example could be:

Welcome and thank you for attending. My name is **XX** and I will guide you through the test today. This is **YY** and **he/she** will be taking notes during the session. The test will be anonymous and will not be recorded. We will note your answers as the test proceeds.

We are a master thesis group from Medialogy at AAU CPH, who are writing our thesis about asymmetrical cross media workshops. This test is an initial prototype test, with the purpose of testing navigation on a tablet in a 3D space.
The test will have two parts: First a test of the prototype, where you have to perform three small tasks, and secondly a follow up interview. While testing the prototype, we would like for you to talk out loud about what you are doing and what your thoughts are. Are you familiar with the think-out-loud method? (*if not the participant are not, then explain it*)

Know that you can not say or do anything wrong and that we are only looking for pointers where we can improve. You are always allowed to stop the test or withdraw your consent at any time.

Do you consent to participating in the test and that we may use your answers in our thesis?

Do you have any questions?

Questions to ask during the test

During the test, I might be asking open-ended questions like:
- What are you thinking?
- What made you select that object?
- Can you elaborate on the reason why you paused just now?

Today's tasks
Describe which scenarios you want the participant to go through:

Firstly we will introduce you to the different navigation views available in the prototype. You will afterwards at all time have this printed guide available with the controls.

1. First I would like for you to explore the virtual environment and tell me how many blue boxes you can find.
   a. ***Show prototype:***
2. Now I would like for you to press all the boxes you have found in a numerical order, starting with 1.
3. Finally I would like to ask you to draw a floor plan of the virtual environment on a piece of paper. You have one minute to explore it a last time before drawing the sketch, without looking at the tablet.
   a. **Hand out paper and start 1 minute timer.**

Follow up interview

1. What type of information did the different views provide?
   a. 2D:
   b. 3D:
   c. Person:
   d. The combination of views:
2. How was the experience of controlling the views?
   a. 2D:
   b. 3D:
   c. Person:
   d. The combination of views:
3. Was there anything that you wanted to do which you were unable to?
4. Did you understand the meaning of the icons?

THANK YOU :)
Thank you for participating, would you be alright with us reaching out to you in the future with the purpose of further testing?

C.2 Initial Cross Media Platform Evaluation Results

See next page.

Locomotion/navigation test 17 & 18-04-2024

Link to Figma with Test Design:

https://www.figma.com/file/50UEiN8VNd4dLFZPRevdv3/Usability-test?type=design&node-id=42-6&mode=design&t=wDbFsiPhcwuNr3LI-0

Test participant 0: Pilot test

Participant 0 raw Notes

Observation Notes:

Task:	Think out loud Notes:	View Notes:	Extra Finding Notes:
Find all blue boxes:		2D: 3D: Person:	
Click boxes chronologically:		2D: 3D: Person:	
Draw room:		2D: 3D: Person:	

Follow up Interview:

1) What type of information did the different views provide?

- 2D:
- 3D:
- Person:
- The combination of views:

2) How was the experience of controlling the views?

- 2D:
- 3D:
- Person:
- The combination of views:

3) Was there anything that you wanted to do which you were unable to?

4) Did you understand the meaning of the icons?

5) Other Comments?

Test participant 1:

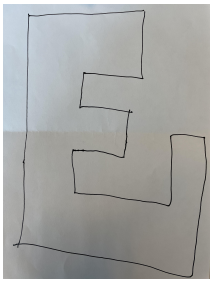
Participant 1 raw Notes

17-04-2024, Time: 11:11, Place: in group room. Consent.

Asger og Franciska

Observation Notes:

Task:	Think Out Loud notes:	View Notes:	Extra Finding Notes:
Find all blue boxes:	1. Starts with moving around in 2D. - Finds 5 boxes. 2. Switched to 3D view. 3. Switched to First Person. - Tried zooming. - Found 6 boxes in total.	The app starts in 2D 1. 2D 2. 3D 3. First Person	
Click boxes chronologically:	1. Started with 3D view 2. Switched to Person. - “wait i’m not placed in the same place as I -...”. - *Participant got confused that they did not spawn in the same spot as they were in 3D view.* 3. Switched back to 3D. - “where is it.” - *Found the first 3.* - “Changing perspectives? It gives an overview of where the other boxes are.” 4. Switched to 2D. - ”I’m in 2D now. I want to find the other boxes.” 5. Switched to 3D. - Found box 4 and 5. 6. Switched to 2D. - “Overview of the whole space again.” 7. Switched to First Person. - “Wait! There are 7 boxes!” - *(found box 7)*. - “oh I’m bad at this” 8. Switched to 3D - “I can’t seem to figure out where it is.” - The participant gives up finding the last box after being allowed to by the test facilitator.	1. 3D 2. First Person 3. 3D 4. 2D 5. 3D 6. 2D 7. First Person 8. 3D	Highlight was not enabled in the this test. The participant were asked to press the boxes once anyway and just say out lout when they pressed a box.
Draw room:	1. Only used 2D view. Stops time before one minute.	1. 2D	



Follow up Interview:

1) What type of information did the different views provide?

- 2D: *Gave me an overview of where the boxes are located.*
- 3D: *The 3D should have made me able to locate the boxes in the correct order.*
- First Person: *used to see which boxes contained which numbers.*
- The combination of views: *All the different movement options was confusing when you switched between the different view.*

2) How was the experience of controlling the views?

- 3D: *was a bit confusing. maybe because of the environment. the sofa and the bed for example was occluding other things.*
- 2D: S*traight forward.*
- First Person: *I had problems in first person view with moving forward. I was used to use one finger to move and one to rotate. It was difficult to figure out how to move in first person.*
- The combination of views: *NA*

3) Was there anything that you wanted to do which you were unable to?

- *No*

4) Did you understand the meaning of the icons?

- *Yeah, it was pretty obvious what it was meant to represent.*
- *Going from 2D to 3D for example, the icon became red. This made it obvious that you had switched.*

5) Other comments:

- *What are you testing again?*
  - Asger: Navigation.
- *Maybe it's just because I'm not used to playing video games. A bit confusing because there was so much to remember, but with the guide it was fine.*

Test participant 2:

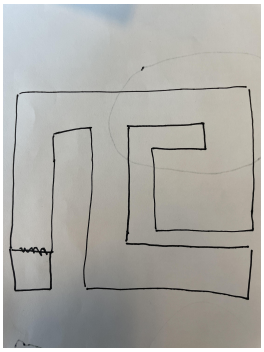
Participant 2 raw Notes

17-04-2024, Test lead: Asger, Notetaker: Atle

start time: 11:45, in group room, consent

Observation Notes:

Task:	Think Out Loud notes:	View Notes:	Extra Finding Notes:
Find all blue boxes:	1. "There are 5 boxes"	The app starts in 2D 1. 2D Only used 2D	Did not realise you could use any other view than 2d
Click boxes chronologically:	1. Oh! there are more than 5 boxes 2. Looking around 3. Mostly using 3D to find boxes - Using both move, rotate and Zoom	1. 3D 2. First person 3. 3D	Mostly using 3D view to find boxes. First person used very shortly.
Draw room:	1. Changing to 2D to look at the floor plan 2. Exploring in First person. Looking at layout and furniture. 3. Back to 2D to get a final overview. - "I'm ready now"	1. 2D 2. First person 3. 2D	Used 2D to get an overall look at the layout, but used First person to explore and understand the layout of furniture.



Follow up Interview:

1) What type of information did the different views provide?

- 2D: Overlook of how the environment was shaped
- 3D: The whole thing together in a different perspective
- Person: More game like and more fun to navigate. Get a good feeling of the room as a person walking around.
- The combination of views:

2) How was the experience of controlling the views?

- 2D: Wanted to move with two fingers while zooming.
- 3D:
- Person:
- The combination of views: Fun and intuitive, made sense together

3) Was there anything that you wanted to do which you were unable to?

- Was not aware of all the different viewpoint in the beginning and therefore misunderstood the first task.

4) Did you understand the meaning of the icons?

- Yes, absolutely.

5) Other comments?

- Want to be able to move in the 2D view using 2 fingers.

Test participant 3:

Participant 3 raw Notes

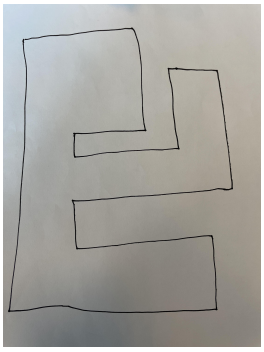
17-04-2024, Test lead: Asger, Notetaker: Franciska

start time: 12:55, in group room, consent

Observation Notes:

Task:	Think Out Loud notes:	View Notes:	Extra Finding Notes:
Find all blue boxes:	1. Starts in 2D. - Moves around. There's five blue boxes the participant can see. 2. Switches to 3D: - "If i go into 3D mode i can definitely see there are more. 6, 7." 3. Switches to FP: - "Rotation feels a bit weird. Tilting is actually more preferable. If tilting was a bit	The app starts in 2D 1. 2D 2. 3D 3. First Person	

Task:	Think Out Loud notes:	View Notes:	Extra Finding Notes:
	faster it would be nicer for rotating. I feel more centered.”		
Click boxes chronologically:	1. 3D: - Box 1 pressed. Searched, but could not find it. 2. Switched to First Person: - “Maybe I should look a bit around.” Searches. “I can’t open the oven and look inside, right?”. - “Oh, there it was. 2, 3, 4.” 3. Switched to 3D: - “ 5, 6… 7.”	1. 3D 2. First Person 3. 3D	
Draw room:	1. 2D: - “You want it with furniture?” A: “You don’t have to.” - The Participant uses only 2D in about 10 seconds, then stops and draws the room.	1. 2D	



Follow up Interview:

1) What type of information did the different views provide?

I think it’s easier to exclude what they give you.

- 2D: *The only one I used for the floor plan. That is what it affords, for the overview*.
- 3D: *Good to see where things are hidden, E.g. a shelf.*
- First Person: *The first person perspective felt a bit redundant. But I don’t have a relation to the room. If it was an apartment I was moving into then I might want to see it in first person.*
- The combination of views: *NA*

2) How was the experience of controlling the views?

- 2D: *NA*
- 3D: F*ine. Move, rotating, tilting… yeah it worked fine.*
- First Person: *Moving was fine. rotation with only one finger was disruptive, the center point from which I was rotating was weird. Like it pushed me backwards. I preferred tilting then. If I wasn’t in a hurry I would just use the tilt.*
- The combination of views: *NA*

3) Was there anything that you wanted to do which you were unable to?

- *Open the oven to check if something was inside.*
- *I wanted to interact with objects, e.g. the chess board. Move a piece.*
- *But I don’t think there is anything else I would add.*

4) Did you understand the meaning of the icons?

- *Yes, they made perfect sense.*

5) Other comments?

- *Nope.*

Test participant 4:

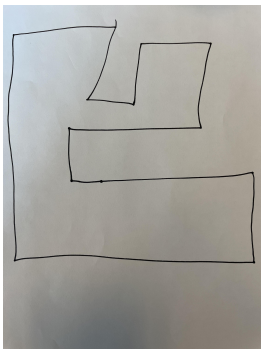
Participant 4 raw Notes

17-04-2024, start time: 13:23, place: group room, consent

Test lead: Asger, Notetaker: Franciska

Observation Notes:

Task:	Think Out Loud notes:	View Notes:	Extra Finding Notes:
Find all blue boxes:	1. "I'm in a room, it is decorated pretty weirdly. So i have to find the blue boxes. in 2D there are 5 boxes" 2. "Oh there are numbers on them, quite helpfull. Looks like number 2 is missing. No there it is. 7 boxes." 3. "Let me try first person" goes through the room checking if he missed anything. Asger: "You dont have to tell me the order right now." Participant: "Oh okay, then 7."	The app starts in 2D 1. 2D 2. 3D 3. First person	Systematically goes through the entire room and all boxes in numerical order.
Click boxes chronologically:	1. "I dont need both fingers to do this." Navigates and presses the first 5. "Am i allowed to use another view?" Asger: "yes" 2. Quickly press the last 2 boxes.	1. First person 2. 3D	
Draw room:	"Including furniture?" Asger: "You dont have to" Participant: "The 2D is probably best then. You can have the birdseye view" After about 15 seconds. "Okay i'm ready."	1. 2D	



Follow up Interview:

1) What type of information did the different views provide?

- 2D: *You could see the layout of the room from a overview. It gives an easier look at the rooms form. Couldn't see the numbers.*
- 3D: *More able to look around corners.*
- Person: *You could see the numbers from First person or 3D.*
- The combination of views:

2) How was the experience of controlling the views?

- 2D: *easiest, but not most informative.*
- 3D: *Most informative. Was easier to use than the First person.*
- Person: *You could get the same info in 3D if you were in the right angle. There was a lot of swiping. I could imagine you would get a sore wrist if you did it for a long time.*
- The combination of views:

3) Was there anything that you wanted to do which you were unable to?

- No

4) Did you understand the meaning of the icons?

- The human icon: *I understood it as first person. It made sense for me, but I come from a gaming background, so maybe someone a bit older or from another demographic background would have a harder time.*

5) Other comments?

- 1 finger icon on the navigation guide is confusing as it looks like the 2 finger zoom.
- The 2 finger interactions on the guide can look like 3 fingers.
- For the First person: *Would be nice to have control pads on the screen, one for movement and one for rotation like in video games, but it would take something from the view.*

Test participant 5:

Participant 5 raw Notes

17-04-2024, Start time: 14:11, place: group room, consent.

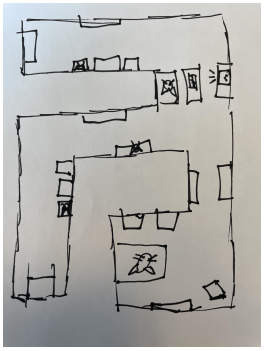
Test lead: Asger, Notetaker: Franciska

Observation Notes:

Up until now, all five participants used two fingers for rotating in person view (which is meant for tilting).

Task:	Think Out Loud notes:	View Notes:	Extra Finding Notes:
Find all blue boxes:	1. 2D: - "I've got a birds eye view. I'll start by trying out the mechanic. I can see 5 in this view." 2. Switches to 3D: - "I can see a bit more. I can zoom, I'll rotate around. I can see another blue box I couldn't see before. I can see the same as in 2D in the bedroom. I can now see another blue box hidden on a shelf." 3. Switches to First Person: - "Now I'll try this view to see if I missed anything. I glitched into a wall there, but it's fine. I see the same amount of boxes. Just had to move out of the wall again. I'm moving around just to	The app starts in 2D: 1. 2D 2. 3D 3. First Person	

Task:	Think Out Loud notes:	View Notes:	Extra Finding Notes:
	see I haven't missed anything. I'm rotating the camera around." - (*uses tilting to rotate*). - "I'm looking into the closet, as I wasn't available to look in there before. I could get a better look in First Person. It doesn't seem I missed anything. I found a total of 7 boxes."		
Click boxes chronologically:	1. Starts switching to 3D. - "So I can get a overview." Presses 1, and 2. 2. Switches to First Person: "Switches to First Person so I can easier look around. 3, 4, 5." 3. Switches to 3D: - looks a bit around, finds number 6. 4. Switches to First Person: - Clicks box 7.	1. 3D 2. First Person 3. 3D 4. First Person	
Draw room:	1. Starting in the 3D view. - zooms out to almost 2D like view in 3D. 2. Switches to 2D: - gets an overview. 3. Switches to 3D: - Goes back to this view to note the furniture. Looks around. Counts furniture and where they are. 4. Switches to 2D: - Looks at it all zoomed out. *Draws the room with furniture. Used the full minute.*	1. 3D 2. 2D 3. 3D 4. 2D	



Follow up Interview:

1) What type of information did the different views provide?

- 2D: *Great overview of the layout. Shape of room and where different objects were located.*
- 3D: *Get the depth. Better for the depth and breadth of the whole thing but slower at navigating than First Person.*

- First Person: *Didn't give me as much as the 3D. I was able to navigate it quicker.*
- The combination of views: *NA*

2) How was the experience of controlling the views?

- 2D: *Natural.*
- 3D: *Natural.*
- First Person: *Rotate and move forward would happen at the same time sometimes. A bit weird. Sometimes I got stuck in the wall, but once I got used to it it was fine.*
- The combination of views: *NA*

3) Was there anything that you wanted to do which you were unable to?

- *No.*

4) Did you understand the meaning of the icons?

- *Yes.*

5) Other comments?

- *Nope.*

Test participant 6:

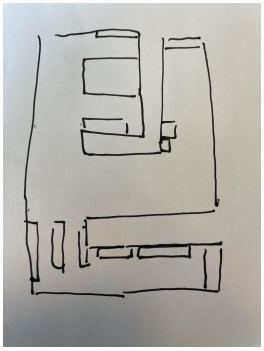
Participant 6 raw Notes

Test lead: Asger, Notetaker: Franciska

18-04-2024, Start time: 09:18, location: group room, consent.

Observation Notes:

Task:	Think Out Loud notes:	View Notes:	Extra Finding Notes:
Find all blue boxes:	1. Moves around and gets an overview 2. Tilts camera and sees from another angle "7 boxes"	App starts in 2D 1. 2D 2. 3D	
Click boxes chronologically:	1. Uses the 3D view to quickly press all the boxes.	1. 3D	
Draw room:	1. "Is the cat included?" Asger: "You dont have to" 2. Zooming, moving and rotating around the environment. "Now the problem is you are testing my memory" Asger: "You just have to make a floorplan" 3. Shortly getting an overview. 4. Very breifly. only moved a very short distance before time was up.	1. 2D 2. 3D 3. 2D 4. First person	



Follow up Interview:

1) What type of information did the different views provide?

- 2D: *The floorplan, straight up.*
- 3D: *Gave me more spacial awareness. i could look into furniture and below.*
- Person: *Didnt make much sense to me, i would get a better overview in 3D.*
- The combination of views:

2) How was the experience of controlling the views?

- 2D:
- 3D:
- Person: T*ilt and rotate is the same. I tried it a bit, and didn't get bothered by it. didn't seem like a problem.*
- The combination of views: *didn't use the guide really. I was skeptical about some of the controls (looked at the guide), but it made sense.*

3) Was there anything that you wanted to do which you were unable to?

- *No. A bit of clicking at the boxes at a distance. It didn't really register it.*

4) Did you understand the meaning of the icons?

- *Yes*

5) Other comments?

- *No*

Test participant 7:

Participant 7 raw Notes

Test lead: Asger, Notetaker: Franciska
18-04-2024. Start time: 9:33, location: group room, consent.

Observation Notes:

Task:	Think Out Loud notes:	View Notes:	Extra Finding Notes:
Find all blue boxes:	1. Starts in 2D: - Moves camera around. Tries out zoom. 2. Switches to 3D: - Tries out all controls. - "I see that they have numbers". - "I feel like I get a good overview of the scene in this one." - "I'm missing number 5." 3. Switches to First Person:	The app starts in 2D: 1. 2D 2. 3D 3. First Person	

Task:	Think Out Loud notes:	View Notes:	Extra Finding Notes:
	- "Oh, okay. The rotating I'll move into walls and such. Oh, you can rotate with two fingers actually." - *Uses two fingers to rotate.* - "7 boxes in total."		
Click boxes chronologically:	Continues using First Person mode: - "1, 2, 3, 4, - (*The tablet sometimes has a bit difficulties with registering clicks when the object is semi-occluded).* - 5, 6, 7."	1. First Person	
Draw room:	3D: "For a moment it felt like a 3D object I could spin - *(participant tried doing two finger rotation twist)* - but that was just me forgetting the interaction." - *zoomed out to a 2D topdown kind of view in the 3D view and looked at the environment for a few seconds. Used the full time.*	1. 3D	

Follow up Interview:

1) What type of information did the different views provide?

- 2D: *Good overview over the scene and the floor plan.*
- 3D: *The 3D felt natural to me. But I'm also used to using 3D modeling programs.*
- First Person: *It was more easier moving forward in First Person mode. I did use this for task 2.*
- The combination of views: *Both 3D views served the same purpose to some degree. I would imagine some people would have easier using the FP view.*

2) How was the experience of controlling the views?

- 2D: F*ine.*
- 3D: *Fine.*
- First Person: *I was a bit confused about this as it was new to me, but as I tried it it made good sense. Fast around corners and off angles. It was nice that I didn't have to first move and then rotate myself. I could get it right the first time.*
- The combination of views: *NA.*

3) Was there anything that you wanted to do which you were unable to?

- *There was something but I forgot... Oh yes it was rotating in 3D view. I thought it was a 3D object I could rotate as I'm used to on tablets instead of rotating like in a viewport.*

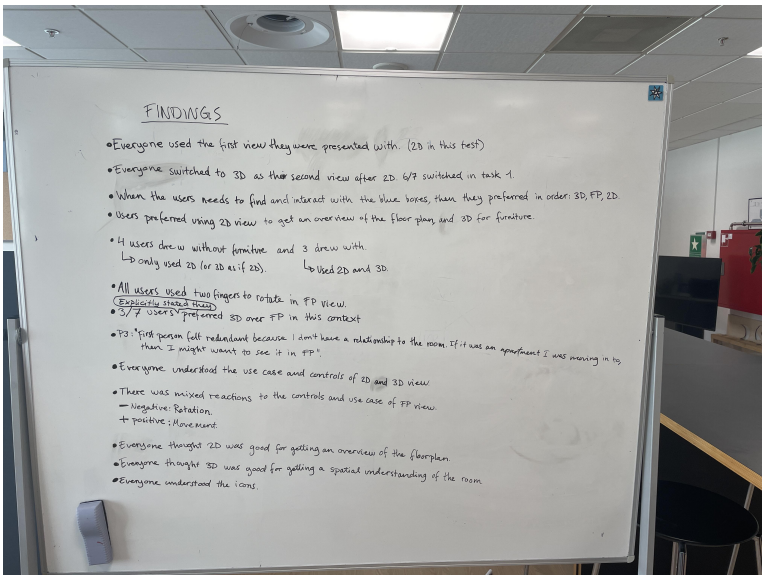
4) Did you understand the meaning of the icons?

- *They made good sense.*

5) Other Comments:

- *No. Not that I haven't already said.*

Findings



- 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 preffered (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

D Heuristic Test Notes

The following sections are notes taken by the authors during the heuristic tests conducted for this thesis.

D.1 Heuristic Test 1: UX Designers

- Asger presents
- The participants agree to participate
- Asger explains the controls

D.1.1 Task section

- Didn't know you could press on another object
- Went to archive first
- Confused by lack of indicator on text fields, annoying that you cannot
- Could not close keyboard
- Widget should close when clicking the screen.
- Fields bugged out (lack of text indicator)
- It's hard to pick objects.
- Cannot put emojis
- Removing keyboard is finicky
- Cannot delete note from reader
- Unnecessary to go into reading mode.
- Stuff does the thing you expect.
- Lack of feedback on clicks and taps (audio or other visual feedback, perchance a ring)
- Mostly stuck with one view.
- The flyout/widget should close when de-highlighting or remove.
- Does not properly distinguish mis clicks.
- The collider on one of the paintings is too big.
- Cannot select objects withing colliders.
- Find cubes are confusingly placed.
- Wants to zoom in first person.

D.1.2 Interview section

Follow up interview

1. Did you feel that each screen provided you with sufficient information about what interactions where possible at any given time? (1)
    (a) Had preexisting knowledge, so felt very natural to interact with the note taking. Would want instructions for the 3D interactions. 2D was very natural.
    (b) The first person view was the hardest and least natural.
    (c) It would be easier to take notes using the archive than.
    (d) Lack of indicators when notes are attached to an object.
    (e) Needs an image or preview of the object.
2. Did you feel it was easy to go back or change an action in case you did something unwanted or by mistake? (3)
    (a) Fairly easy.
    (b) Getting rid of the keyboard was hard.
    (c) Hard to get rid of widget.
    (d) Lacking control z and undo.
    (e) Lacking paper basket.
3. Did you feel that there was sufficient guardrails in place to help you avoid errors while using the product? (5)
    (a) The interactions are fairly simple, so the lack of choice forces your hand.
    (b) There is a confirmation box for deleting notes.
    (c) Wasn't anything that lacked really.
4. Do you feel the visual elements were recognizable and were you able to understand what interaction they each granted? (4, 6)
    (a) Yes
    (b) Yes
    (c) It's nice that we had both labels and icons.
5. Do you feel you where provided with sufficient information on each screen or do you feel it was either too minimal or cluttered? (8)
    (a) Not cluttered and not too minimal
    (b) Good idea to start with interaction tutorials.
    (c) Show tutorial but as a panel that doesn't block input. With ability to close.
6. Was there anything that you wanted to do which you were unable to?
    (a) Want to pet the cat.
    (b) Lack of sound.
    (c) Lacks polish, transitions, animations, and sounds.
    (d) Showing surplus is good for users.
    (e) Lack of zoom option in first person.
7. Last notes
    (a) Nothing.
    (b) The use case is nice is useful.
    (c) Indicator for notes in the environment.
    (d) Immediately started thinking about version 2 of this.

D.2 Heuristic Test 2: UX Researchers

D.2.1 Task section

- Asger presents
- Hector takes notes.
- They consent
- The views changes the perception completely and allow allow for different vantages.
- Found the widget to create note.
- 1 Felt it was natural to click on the object, but 2 was more natural to click on the folder.
- 1 Felt it made sense that notes would be attached to objects.
- Had toruble closing keyboard, found the slide down button.
- The test note was confusing.
- Removing the keyboard was also hard for 2
- 1 Found the
- Would be nice if the note list had a preview.
- The lack of description could be confusing in the widget list view.
- Easy to open archive.
- Easy to read.
- Found the edit button bug
- Found delete in archive list.
- Lack of delete in reader is missing.
- Lack of cursor in text fields is lacking and confusing.
- 1 Is not feeling confused and the control flow is easy to use.
- The name in the widget could be confusing if it contains numbers.
- Weird that you can open the archive from the widget on objects with no notes, feels archive should open a list of notes only on the object.
- There might be a lack of filtering options.
- It should be clear which objects a note is attached to.
- Go to object feature should be in the notes.
- It would be a really cool feature to have the 3D environment on a tablet.
- It would be really useful to write notes for things in a prep before VR session.
- You should be able to see the notes when in VR.
- The lack of manipulation makes it very easy and frictionless.
- Would want a toggle between edit and note mode as its very easy to not make mistakes.
- They would use it daily if they had it.
- Seems fucking easy.
- Would want the widget to and highlight to be more in sync.
- The highlight should be optional once an object is selected
- The ability to select multiple object would be nice.
- 1 gets an apple vibe.

Interview section

1. Did you feel that each screen provided you with sufficient information about what interactions where possible at any given time? (1)
   (a) The lack of description in the widget list.
   (b) Too hard to get the widget to go away.
   (c) Lack of objects attached to notes.
   (d) Confusing iconography in the edit window.
   (e) Confusing that you can open the general archive from the widget.
   (f) The icons are otherwise good.
   (g) Would want a menu which contains tutorial, settings and quit option.
   (h) But it is intuitive that we don't have a lot of buttons.
   (i) Maybe have tutorial in the app.
   (j) 2 spent most of the time in first person and didn't need the guide.
   (k) 1 needed guide for 3D more.
2. Did you feel it was easy to go back or change an action in case you did something unwanted or by mistake? (3)
   (a) Yes but not with the widget and the highlight.
   (b) 2 didn't feel it, because accomplishing the tasks were easy enough.
3. Did you feel that there was sufficient guardrails in place to help you avoid errors while using the product? (5)
   (a) Needed more indications about the input fields lacking cursor
   (b) Wrong iconography in the edit.
   (c) Would like an good old fashioned exit button.
4. Do you feel the visual elements were recognizable and were you able to understand what interaction they each granted? (4, 6)
   (a) Yes, but the lack of depth in the 2D view could be confusing.
   (b) Yes the buttons are clear to what they do.
5. Do you feel you where provided with sufficient information on each screen or do you feel it was either too minimal or cluttered? (8)
   (a) It was fitting but lacking a quit button, and the widget archive button is not necessary.
   (b) The lack of controls tutorial is a problem
6. Was there anything that you wanted to do which you were unable to?
   (a) Lack of interactions with the environment.

(b) Should be able to select multiple objects.

7. Did you understand the meaning of the icons?

   (a) Except the cancel trash can yes.

   (b) Should be a note pad for notes

   (c) The folder means more file types.

It's super cool.
They see a lot of value in how the product could be used.
Is really cool
Networking would be really dope.
The ceiling is a bit too low

E Final Usability Test Results

E.1 Usability interview and observation notes

See next page.

Usability tests observation and interview notes

Tags	
Created time	@May 22, 2024 9:40 AM

Test participant 1:

- Was familiar with the view’s controls already.
- Opened archive first. He imagined it was the only option.
- He selected the chess board.
- Had trouble closing the keyboard.
- He figured out that you can select stuff to write notes after.
- He already found the archive.
- He easily found the reader.
- When in reader clicking edit opens the new note window instead of the edit one.
- Could easily delete a note.
- Thought the overall experience was good.
- clicking objects and writing notes about the was good.
- Didn’t figure out that he could highlight objects to start with.
- The first task was more difficult because doing notes about objects.
- Lenovo pen button on table was confusing.
- It was overall easy enough.
- Reading and editing error prevented doing what he wanted.
- It would be nice to see that you had made a note about an object.
- Smooth enough to take notes.
- Accidentally pressed lenovo button.

- Meant to make a note about the chess board because it wasn’t through the widget.
- The move is confusing in 3d vs the other two because you use 3 fingers.

Test participant 2

- Figured out that you can click things to add notes about them.
- Confused that deselecting the object doesn’t close the widget.
- Confused that you can select objects with the note writer window open.
- Could not close the keyboard.
- Widget doesn’t close when deselecting is annoying.
- Could not cube box because of collider. And was annoyed.
- Wanted enter to close the keybaord.
- Easily found the archive of notes.
- Could easily read
- Edit doesn’t work properly in the reader.
- Deleting was also sufficiently easy.
- Was confuseed by the lenovo widget things.
- A feature that could be nice is that you should be able to go to the object from a note.
- Doesn’t understand why the archive is part of the widget as the archive is not attached to the note.
- It worked well that you can assign notes to the specific object.
- Incredibly easy to solve the tasks that were given and was overall extremely intuitive.
- Move to a an object from an associated not from the archive.
- Wanted to edit a note but button created new note.
- Worked well to take notes.

Test participant 3:

- Easily clicked on object and found widget.
- Had trouble closing the keyboard.
- Could not see cursor which was confusing.
- Would want enter to close the keyuboard.
- Easily opened the archive.
- Easily read note.
- Lack of curser makes it hard to write.
- Easily deleted and edited a note.
- Found the create general note button.
- Would be cool to apply general notes to objects already marked.
- Would want a single note to be added to multiple objects.
- Did not find the notes list in the widget.
- Felt it was an okay experience.
- Would like to be able to save the note without closing the keyboard manually first.
- Could not see the marker and it made more difficult to fix typos.
- Creating notes and managing them made sense.
- It was farily easy to solve the tasks but made it harder to edit due to missing cursor.
- Would want to copy a note to multiple objects.
- There was one point when closing the menu accidentally.
- He feels like its doable to take notes about the environment.

Test participant 4:

- She found the widget
- She had a bit of trouble removing the keybaord.
- She pretty easily completed the first task

- She immediately found the archive
- She could find the read.
- She found the edit and delete buttons pretty easily.
- It was quite easy and intuite to use,
- The symbol for the archive is intuitve
- Was similar to a different system so muscle memory.
- Was trying to write a note then select an object.
- It could be nice to see the notes outside of the archive
- Had problems removing the keybaord and accidentally tried to close the widnow.,
- Didnt find the general note feateure. But find it when prompted.

Test participant 5:

- Found the widget
- Confused about the archive button in the widget
- Confused about closing keybord
- Couldn’t see save button because of keyboard
- Created general note in an attempt to make a note about an object
- Used the widget to open the archive.
- Not able to see how the notes are corrolated to the different objects in the archive.
- Found archive button later
- Found the bug in the reader edit button
- Easily found reader
- Confused about the lack of cursor
- Deleted note pretty easily.
- Was unsure if notes on objects were tide to thge notes
- Found the list on one ofthe objects

- Keyboard didn’t show up when pressing field
- Would be nice if enter closed the keyboard.
- Not intuitive that the list is not shown.
- When creating notes it is unclear what object it is tied to if it is any.
- The list is faily intuitive.
- The functionality is pretty good but feels a little unpolished.
- Opening the archive from an object is confusing that the object is nopt tied to the note.
- The tasks were very easy to solve.
- Editing a note was difficult because of a bug
- Some of the navigation was difficult
- He accidentally created a general note and not an object note.
- Nice that the notes are attached to objects, creates a neat way to organise them.

Key findings	Amount of participants
Had trouble closing keyboard	5
Had difficulty writing as the cursor was not visible	3
Was able to select an object and write a linked note without instructions	5
Was able to find and open the archive	5
Found difficulty editing notes because of bug	3
Was able to read notes easily	5
Was able to delete notes easily	5
Had difficulty seeing what objects notes was attached to	4
Found the appliation easy to use	4
Had issues with closing the widget menu	2

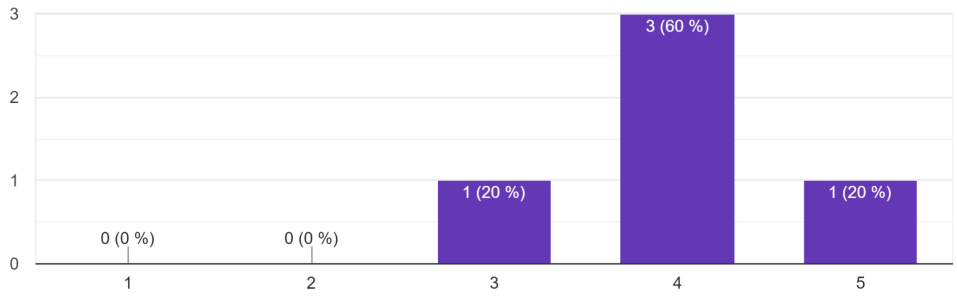
E.2 SUS questionnaire test results

The following section shows the distribution of test scores in the SUS questionnaire. Answers range between 1 and 5. 1 meaning strongly disagree and 5 meaning strongly agree.

See next page.

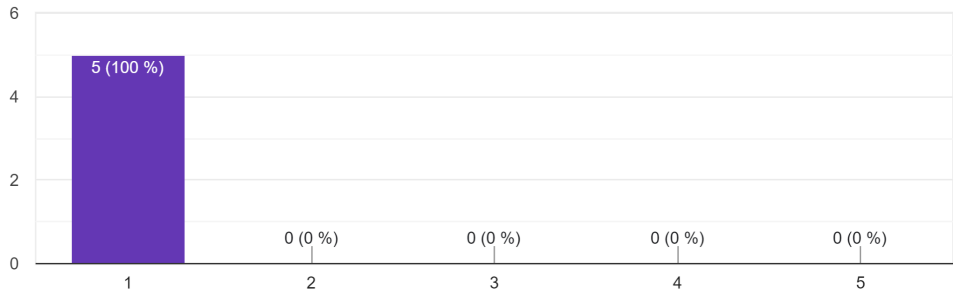
I think that I would like to use this system frequently

5 svar



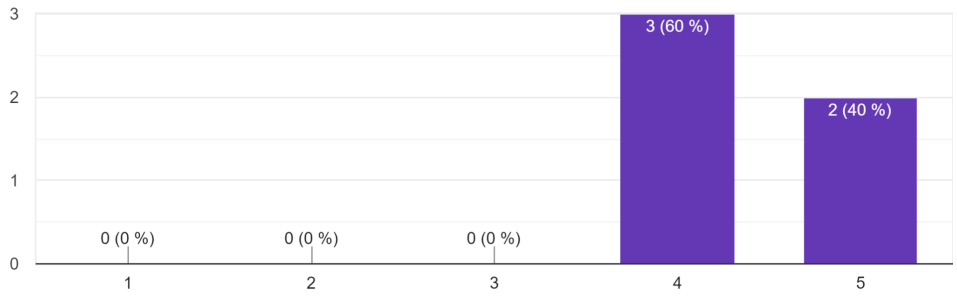
I found the system unnecessarily complex

5 svar



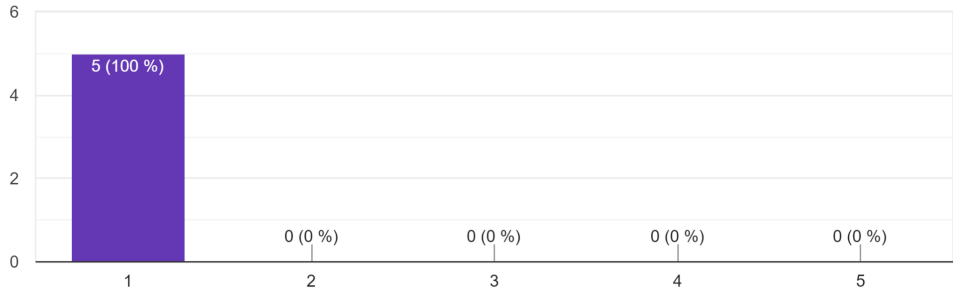
I thought the system was easy to use

5 svar



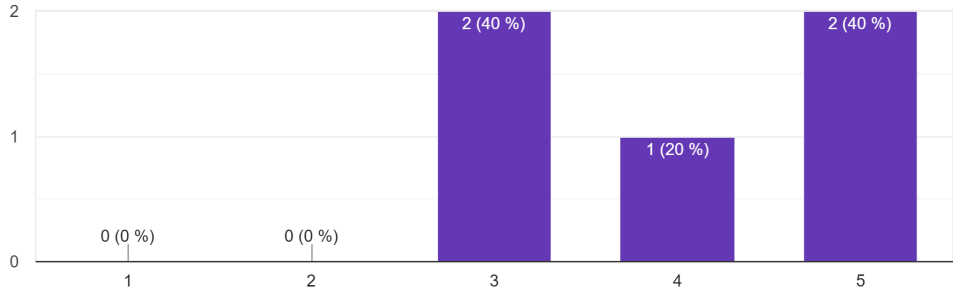
I think that I would need the support of a technical person to be able to use the system

5 svar



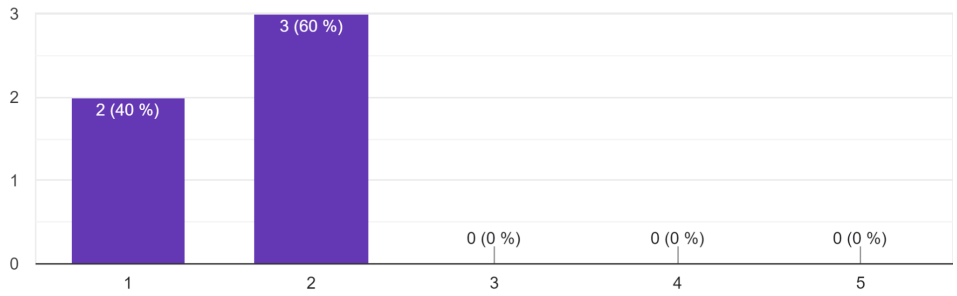
I found the various functions in the system were well integrated

5 svar



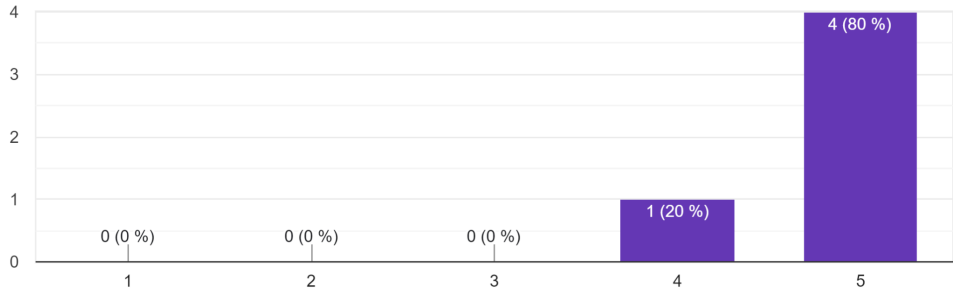
I thought there was too much inconsistency in this system

5 svar



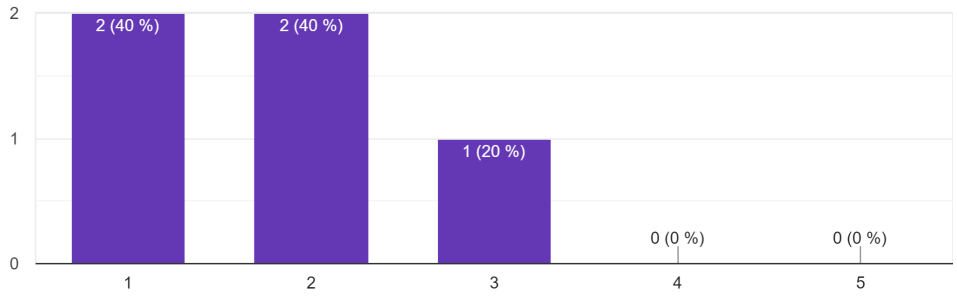
I would imagine that most people would learn to use this system very quickly

5 svar



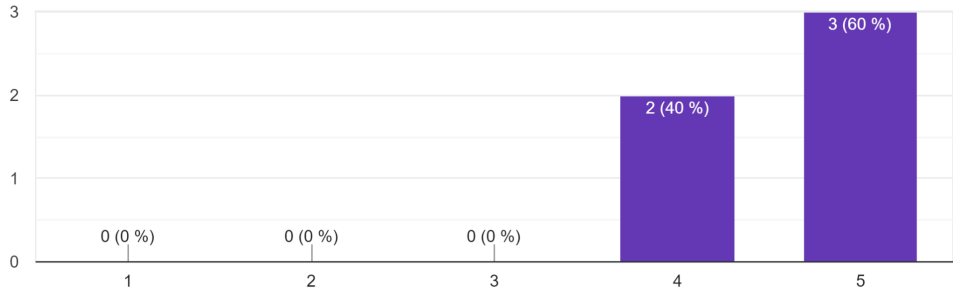
I found the system very cumbersome to use

5 svar



I felt very confident using the system

5 svar



I need to learn a lot of things before I could get going with this system

5 svar