Master's thesis

NTNU
Norwegian University of Science and Technology
Faculty of Information Technology and Electrical Engineering
Department of Computer Science

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Career Guidance in Collaborative Virtual Reality

A Design and Creation Research project exploring the effects that collaboration has on virtual reality career guidance, both remote and co-located.

Master's thesis in Informatics
Supervisor: Monica Divitini
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Christian Bernard Bouwhuis Røkke and Simen Ulvestad

Abstract

The use of virtual reality technologies for workplace training and education is increasingly popular. Using virtual reality with the goal of helping young job seekers to gain insight into different professions is an ongoing project called *Virtual Internship* developed in partnership by the Norwegian University of Science and Technology and the Norwegian Labour and Welfare Administration.

This thesis will look into the effects that collaboration has on virtual reality career guidance, both remote and co-located. By using an already existing *Virtual Internship* application and modifying it to allow for collaborative work, we will investigate whether or not collaborative features are conducive to career guidance in virtual reality. For software development we adapted an agile development method with three iterative phases. Both qualitative and quantitative data was utilised to help answer the research questions.

Collaborative virtual reality was found to lead to increased user engagement and self-efficacy. It also eased the process of providing guidance during the use of a *Virtual Internship* system. For remote career guidance we found features that simplify communication to be imperative. Adding multi-user functionality in an existing single-user virtual reality application can vary in difficulty, but the developed framework in this thesis should help ease future development so that existing applications can accommodate collaborative mechanisms.

Keywords: *Virtual Reality, Collaboration, Career Guidance, Remote Career Guidance, Multi-user Virtual Reality*

Sammendrag

Bruken av virtuell virkelighets teknologier for opplæring på arbeidsplass og utdanning blir stadig mer populært. Å bruke virtuell virkelighet med hensikt til å hjelpe unge jobbsøkere å få innsikt i forskjellige yrker er et pågående prosjekt kalt *Virtual Internship* utviklet sammen med Norges Teknisk-Naturvitenskapelige Universitet og NAV.

Denne oppgaven undersøker effektene samarbeid har på karriereveiledning i virtuell virkelighet, både over avstand og samlokalisert. Ved å modifisere en allerede eksisterende *Virtual Internship* applikasjon for å legge til samarbeidsfunksjonalitet vil vi se hvorvidt samarbeidsmekanismer hjelper eller hindrer karriereveiledning i virtuell virkelighet. For programvareutvikling tilpasset vi en smidig utviklingsmetode med tre iterative faser. Både kvalitative og kvantitative data ble brukt til å svare på forskningsspørsmålene.

Samarbeid i virtuell virkelighet ble funnet å føre til økt brukermedvirkning og mestringstro. Det lettet også prosessen med å gi veiledning under bruk av *Virtual Internship* systemet. For ekstern karriereveiledning fant vi funksjoner som forenkler kommunikasjon for å være helt nødvendig. Å legge til flerbrukerfunksjonalitet i et eksisterende virtuell virkelighet program designet for én bruker kan variere i vanskelighetsgrad, men rammeverket utviklet i denne oppgaven kan hjelpe til med å lette fremtidig utvikling slik at eksisterende applikasjoner kan bedre legge opp til samarbeid.

Nøkkelord: *Virtuell Virkelighet, Samarbeid, Karriereveiledning, Avstandsbasert Karriereveiledning, Flerbruker Virtuell Virkelighet*

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Abbreviations

VR	=	Virtual Reality
MR	=	Mixed Reality
XR	=	Extended Reality
NTNU	=	Norwegian University of Science and Technology
NAV	=	Norwegian Labour and Welfare Administration
IMTEL	=	Innovative Immersive Technologies for Learning
CSCL	=	Computer-supported collaborative learning
HMD	=	Head-mounted Display
FOV	=	Field of View
SUS	=	System Usability Scale

Chapter 1

Introduction

This master thesis explores the use of virtual reality (VR) to create a collaborative environment for career guidance. A YouTube video found at *https://www.youtube.com/watch?v=ZNnK4ohWSag* showcasing the final system. In this chapter we present the context, motivation and research questions of the master thesis.

1.1 Context

This master thesis is part of a master's programme in Informatics at the Norwegian University of Science and Technology (NTNU) in Trondheim. It is a collaboration between the Department of Computer Science (IDI), the Department of Education and Lifelong Learning (Innovative Immersive Technologies for Learning, IMTEL) and the Norwegian Labour and Welfare Administration (NAV).

NAV is currently funding a Research-and-Development project in partnership with the IMTEL lab at NTNU investigating different extended reality (XR) technologies and attempting to determine their viability in helping those receiving support from NAV to find employment. As part of this, NAV and IMTEL has collaborated to create several virtual workplace experiences with the goal of helping young job seekers gain insight into different professions using immersive and interactive VR experiences [3]. These VR experiences are called *Virtual Internships*.

This master thesis attempts to research the effects that multi-user experiences have on the learning efficacy of users using virtual internships to help them find employment.

The thesis and the underlying development are a part of the Virtual Internship project, and can be considered a branch project. From the Virtual Internship project we received access to VR expertise and existing codebases from previous projects, a VR lab with other students facilitating knowledge sharing, multiple VR seminars, and integration into a well established partnership between IMTEL and NAV. As part of the partnership the work was carried out in parallel with both IMTEL and directly with NAV. Thus, the development was done at the VR lab with guidance from a professor and researchers at IMTEL, while testing and obtaining requirement specifications was done in collaboration with NAV.

Our contribution to the partnership consists of two main components. Firstly, the evaluation results obtained over the course of the thesis. Perhaps the most important part, the results obtained will be used to decide whether or not NAV will pursue multi-user experiences for future Virtual Internship projects. Secondly, is the software system itself. The more general pieces of code and game objects can be used in other projects, assuming that future projects will contain multi-user experiences. This can include lobby systems, underlying network architecture, local features and other pieces of useful code. Consequently, parts of the project will be devoted to creating general scripts and *prefabs* (see section 2.2 for more on prefabs) that can be used as building blocks for later development. As a Research-and-Development project, both of these components can be considered important contributions, and need to have high standards.

The research objective to explore a collaborative multi-user mode was defined by the results of the first phase of the Virtual Internship project [56]. As such, IMTEL suggested a research direction to explore how multi-user experiences would affect Virtual Internship projects as end-users evaluated multi-user functionality as a one of the most wanted features in the report summarising the evaluation results [56].

The master thesis duration spans from September 2019 to June 2020. During the course of the project, we developed, researched, and tested a multi-user experience where young job seekers can try their hand at a virtual workplace, either together with a counsellor from NAV or with one of their peers.

1.2 Motivation

VR has been around for decades and the term was first introduced introduced in the mid 1980's [7] with research centres such as NASA utilising head-mounted displays to create a virtual environment workstation. This is achieved by generating digital 3D content simulating different scenarios creating a greater feeling of presence than conventional displays. Recent technology advancements has provided the foundation for for low-cost and high quality devices available to the public. Major contributors such as Oculus with the Quest, HTC with the Vive and Valve with the Index has pushed the technology of VR headsets facilitating a convincing user experience.

According to *Greenlight Insights* [6] the market size of VR and AR is predicted to grow close to a factor of 10, from $27 billion in 2018 to $209 billion by 2022. This growth facilitates processes of research and development, pushing the boundaries of how we use and take advantage of such technologies.

Gaming has long been the major sector of VR applications, but other sectors have also seen investment such as education and healthcare. Applications such as the MIST system [48] that allows for training and assessment of surgical skills as well as other VR technologies has proven to have a positive effect on students' understanding of scientific concepts such as biology according to Shim et al. [67]. As Kaufmann [41] points out, several authors have suggested that the use of VR can raise interest and motivation in students with a high potential to enhance the learning experience. Also, gamification of workplace training tasks or other learning tasks within medicine, safety training or history has proven to be successful at utilising VR and augmented reality (AR), made evident by the NAV FisheryVR application [62].

Using these technologies for workplace training and career opportunities has been increasingly popular. Major companies including Walmart and Deutche Bahn is using VR as a mean to educate and present themselves as an innovative and advanced employer increasing the growth of job applications and training its associates for different operations with success [74].

As mentioned earlier, one of the most requested features during evaluation of phase 1 of the Virtual Internship project was multiplayer functionality. This is also evident in the 2019 paper by Henrichsen, both from the case study of existing applications as well as the research done for his own workplace application [38].

Multiplayer interactive games have been shown to have multiple benefits and great educational potential [24] [55] [72]. There are strong indicators that multi-user functionality would be very useful for Virtual Internships. It could potentially increase engagement compared to a single-user experience, and also lay the foundations for an interesting collaboration aspect between job seekers and career counsellors, a relatively unexplored research topic.

1.3 Problem Description

The IMTEL lab has for the last three years (since 2017), through different projects including other master thesis and bachelors assignments, developed several applications of workplace training such as windmill electrician [38] or fishery- and construction worker. The aim of such applications has primarily been to create virtual environments simulating a real world workplace in order for job seekers to experience and gain valuable information from them.

These single-users virtual internships do not facilitate interaction between the job seeker and the career counsellor. In chapter 3, a comparison of related work will discuss other types of similar research papers and display the fact there are several gaps in the current relevant research into career guidance in VR. Most interesting for this paper is the lack of research into remote and co-located collaboration and its effect on career guidance. As such, this thesis will explore and evaluate collaborative mechanisms for Virtual Internships as employed by NAV. It will look at how such mechanisms can contribute to career guidance by potentially making them more engaging as multi-user applications. Due to the Covid-19 pandemic we will also investigate the merit of using a multi-user VR application for *remote* career guidance.

1.4 Research Questions

The research questions for this thesis focus on how the addition of collaboration opportunities to a virtual internship application affects it in terms of in-person and remote career guidance, necessary features and rising challenges. They are as follows:

Primary RQ:
“How does collaboration in virtual reality workplaces contribute to the career guidance of young job seekers?”

Secondary RQ1:
”How is career-guidance affected by seeker-seeker collaboration compared to seeker-counsellor collaboration in virtual reality?”

Secondary RQ2:
”Which features are effective at facilitating collaborative virtual reality for remote career guidance?”

Secondary RQ3:
”What type of collaborative features are technologically feasible for virtual reality workplaces?” *

Secondary RQ4:
”What challenges arise when implementing collaborative features in an ongoing single-user virtual reality project?”

By technologically feasible we mean features (such as laserpointer or hand gesticulation) that can be developed and carried out to fulfil its objective.

Chapter 2

Background

2.1 Concepts

This section explains some of the essential concepts for this thesis.

2.1.1 Reality-Virtuality Continuum

In 1996, Paul Milgram described the *Reality-Virtuality Continuum*[51]. The paper describes in detail the different types of virtuality and reality that exist on this scale, and the major differences that separate them. As Figure 2.1 illustrates the the real world and virtual world are opposite ends of the continuum, with mixed reality (MR) covering the majority, but not including, the fully real and fully virtual environments.

The application system developed for this project find themselves at the right hand side of the continuum, as mostly virtual environments, but also within the mixed reality concept.

Virtual Reality

The definition of virtual reality has changed over the years, for example when Milgram et al. defined it 1995 [51] as an environment in which "...participant-observer is totally immersed in a completely synthetic world, which may or may not mimic the properties of a

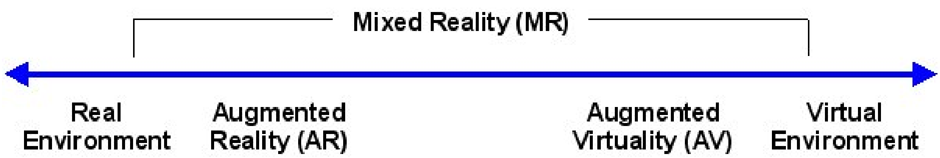


Figure 2.1: The Virtuality-Reality Continuum

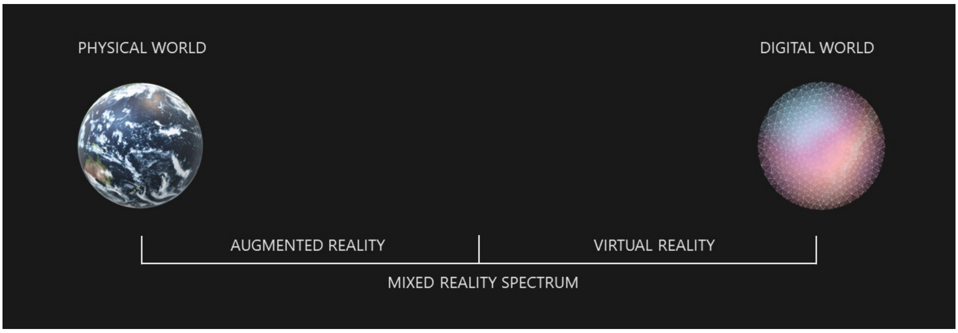


Figure 2.2: The mixed reality spectrum according to Microsoft [50].

real-world environment, either existing or fictional, but which may also exceed the bounds of physical reality by creating a world in which the physical laws governing gravity, time and material properties no longer hold." D. Guttentag [34] later defined it in 2010 as "the use of a computer-generated 3D environment...that one can navigate and possibly interact with, resulting in real-time simulation...".

Although definitions differ, the concept remains the same - a virtual environment which supports navigation and interaction. Today, these environments are often displayed to the user using a head mounted display (HMD), but there exists other ways, including room scale projections.

Mixed Reality

As with virtual reality, the definition of mixed reality (MR) has changed from when Milgram et al. defined it [51] as an environment where "...real world and virtual world object are presented together within a single display...". It can been seen as anywhere on the continuum except on the extrema, see Figure 2.1. However, the usage of the term MR has been somewhat loose with manufactures such as HP and Microsoft putting it on their headsets or in their desktop application. In the *What is mixed reality?* [50] article by Microsoft they describe it as a blend of physical and digital world where the mixed reality spectrum covers and fully includes the physical world and the digital world, unlike the continuum by Milgram et al. which does not, see Figure 2.2.

Although, they are quite similar it is important to note and that for this project we will follow the definition of MR defined by Milgram et al., which means whenever we refer to mixed reality we do not include the fully real or fully virtual environment in that reasoning.

2.1.2 Immersion and presence

It is important to note the difference between presence and immersion. While immersion refers to an an objective level of fidelity, which can be measured against the immersion levels of another application, presence refers to a person's subjective feeling of being in a location while physically being in another [69]. With this project we hope to increase the presence of the user in the virtual workplaces, not necessarily the immersion.

Social presence

Presence refers to the subjective feeling of being somewhere else than you are physically, but it can be split into three types of presence, of which social presence is the most relevant for this paper. Self-presence refers to the feeling of being connected to your virtual body, tele-presence refers to the subjective feeling of being spatially located elsewhere than your physical body, and social presence refers to the feeling of being in the presence of another intelligence. If the feeling of social presence is not high enough, the other part is felt to simply be an artificial entity.

One of the goals of the project is to create a high level of social presence. Social presence was defined by Biocca in a 1997 paper as ”*The minimum level of social presence occurs when users feel that a form, behaviour, or sensory experience indicates the presence of another intelligence. The amount of social presence is the degree to which a user feels access to the intelligence, intentions, and sensory impressions of another*[20].”

There are several conditions that can affect the social presence of a user, one of which is the visual representation. While it may seem logical to assume that a higher degree of photographic or anthropomorphic realism for avatars would increase the feeling of social presence, studies show that this may not be enough, and in some cases detrimental. The two things that seem to be the most important for social presence is the presence of a visual representation of any sort, and a more behaviourally realistic visual representation. People show increased involvement and engagement when the person they are communicating with is visible at all, or has a profile picture instead of a default picture. While a high degree of photo realism can be used, it will be detrimental if there is not a commensurate increase in behavioural realism [59].

Interactivity is another part of social presence. Skalski noted that being able to interact with virtual agents increased users feeling of social presence[68]. There are also several other aspects that can affect social presence, such as haptic feedback, depth cues, audio quality and display types[59].

In general, social presence is at the heart of this paper, and seeing the effects social presence has on the overall presence and what that can do for the overall engagement and experience of the users will be an important part of the project. The hypothesis that an increase in social presence will make the applications more engaging than they are now appears to be supported by the literature, as ”...studies show that the vivid perceptions of another person often lead to greater enjoyment and social influence in neutral and positive contexts[59]”.

2.1.3 Workspace Awareness in Groupware

When collaborating with others, there are several ways in which we gather information. Many of these are subtle and perhaps not outright obvious, but are important none the less as ways to collaborate efficiently. The awareness of others’ location, actions and intentions in regard to the task are referred to as *workspace awareness*.

When working with groupware, workspace awareness is not a given. It must be implemented by developers and rigorously tested to make sure it works well. The developer must explicitly create the forms of interaction and tools to support workspace awareness[35].

In spite of this, one does not need to start entirely from a blank sheet. There are certain elements that make up the core elements of workspace awareness, as seen in tables 2.1 and 2.2[36]. Using these categories as a framework, one can more easily consider what parts are necessary for the workspace you are creating and make decisions based on that.

Table 2.1: Elements of workspace awareness relating to the present

Category	Element	Specific Questions
Who	Presence	Is anyone in the workspace?
	Identity	Who is participating? Who is that?
	Authorship	Who is doing that?
What	Action	What are they doing?
	Intention	What goal is that action part of?
	Artifact	What object are they working on?
Where	Location	Where are they working?
	Gaze	Where are they looking?
	View	Where can they see?
	Reach	Where can they reach?

Table 2.2: Elements of workspace awareness relating to the past

Category	Element	Specific Questions
How	Action history	How did that operation happen?
	Artifact history	How did this artifact come to be in this state?
When	Event history	When did that event happen?
Who (past)	Presence history	Who was here, and when?
Where (past)	Location history	Where has a person been?
What (past)	Action history	What has a person been doing?

Table 2.1 describes the elements of workspace awareness that relate to the present, while table 2.2 refers to the past. When working together in a workspace, there are three major categories of perception that a person can employ to quickly orient themselves in the workspace, namely ”Who”, ”What” and ”Where”. By observing the other participants of the workspace, either consciously or subconsciously, a person will be able to infer who’s doing what, what they are doing and where they are working. In certain groupware, like a shared text editor, this would be solved by showing the caret of other users to indicate *where* they are currently working, as well as icons to indicate *who* is in the workspace. For a VR application, there is a whole new range of affordances available to the user, and one needs to tackle the issue of a shared workspace differently than one would in a non-

immersive application. A popular and effective technique for 3D environments is the use of avatars as a mean to assist the ”Who” in workspace awareness [19]. Avatars uses 3D models to represent users from the real world to the virtual world, and according to Dyck and Gutwin it provides valuable awareness information [25]. The use and form of avatars various a lot, from robots to more realistic human representations as seen in figure 6.2.

In the versions of the applications made for one user at a time, the guidance counsellor/operator would have to explain how things like tasks worked and where objectives were located without existing in the same virtual space. This disconnect proved disadvantageous and ineffective, and the presence of the user suffered due to the disconnect between the virtual space they were in and the instructions coming in from outside of this space. Enabling workspace awareness with others, be it other users or supervisors, enhances several activities. A brief summary of these can be seen in table 2.3 [36].

Perhaps the most significant activity that can easily be enhanced with VR is *simplification of communication*. This refers to the deictic gestures like pointing and waving, interacting with objects to show other users, etc. These interactions will be included as a byproduct of achieving the level of immersion deemed necessary by us, the IMTEL lab and NAV. The other activities are also important, allowing greater ease of communication and planning for the users and significantly increasing their awareness of the current status of the work being done, and how they can best assist each other.

Table 2.3: Summary of the activities in which workspace awareness is used

Activity	Benefit of workspace awareness
Management of coupling	Assists people in noticing and managing transitions between individual and shared work.
Simplification of communication	Allows people to the use of the workspace and artifacts as conversational props, including mechanisms of deixis, demonstrations, and visual evidence.
Coordination of action	Assists people in planning and executing low-level workspace actions to mesh seamlessly with others.
Anticipation	Allows people to predict others' actions and activity at several time scales.
Assistance	Assists people in understanding the context where help is to be provided.

2.1.4 Computer-Supported Collaborative Learning

The field of Computer-Supported Collaborative Learning (CSCL) is highly relevant to the task at hand. CSCL is a multi-disciplinary field seeking to use technology to empower users to collaborate and learn together [71]. It is also important to make the distinction between *collaboration* and *cooperation*. Where as cooperation is defined by Dillenbourg as the division of work into subtasks which eventually are pieced together to form a final result, he defines collaboration as working ”together” [23].

The concept can roughly be split into two parts. Namely, the computer support and the collaborative learning. CSCL is inherently social, and the technology must strive to support that. The technology also offers unique opportunities that need to be catered to, rather than attempting to create something that does not take advantage of these opportunities, or tries to solve problems for which the technology is not suited.

The collaborative learning aspect is interesting because not only do you use collaboration to increase the learning effect, the learning itself is constituted of the interaction between the participants[71]. That is to say, even should you attempt to learn something on your own, the knowledge you gain is inherently different from the knowledge one would gain through collaboration.

CSCL stresses collaboration among the users. When used properly, the users will learn together, motivate each other and gain a richer learning experience in general through collaborative learning.

This sentiment is further reinforced in a 2017 paper by Greenwald et al. [30], which states that ”*...direct mutual exchange about the digital content increases their relevance for users and supports mutual confirmation. Our studies show that users can build on body language and deictic gestures just as they do with real world objects and that collaborative visual search increases the understanding of all involved users.*” This supports the motivation that applying collaborative learning to the Virtual Internship project will yield positive effects. The inclusion of VR allows the users to apply deictic gestures, use demonstrations and coordinate better. In general, it is a good way to increase workspace awareness, and will support several of the activities listed in Table 2.3.

2.1.5 Collaboration in Virtual Reality

There are many upsides to collaboration in VR. In the CSCL section, the concept of learning through interaction was discussed, and how that collaborative learning can be fundamentally different from normal learning. Through VR, one can transfer a lot of the usual interactions performed when working with other in the real world directly, allowing for better efficiency and larger degree of presence for the users[30]. While the procedure of creating a virtual collaborative experience can be both expensive and lengthy, it is a one-time cost where the benefits can often offset the cost. A 2017 study showed that using a collaborative virtual environment made users more involved and immersed in their task. The testers also reported that they enjoyed using the tool as well, showing that there are a lot of positives to using virtual reality in this way. They also reported that they experienced a greater workload, so usage may have to be managed so as to not burn users out[47].

In a research project by R.L. Jackson, an attempt was made to use collaborative virtual learning experiences as a way to introduce VR into existing school curricula. While the project tried to discover differences between single-user, peer-peer collaboration and student-expert collaboration, they could not pinpoint in a conclusive way what was the better format, citing highly variable results for each individual in each group. Nevertheless, they noted significant potential for collaborative VR as learning tools, but highlighting that designers and developers "...must make sure that it is easy for multiple participants to collaboratively navigate and perform tasks in [virtual learning experiences]"[40].

2.1.6 Learning in Virtual Reality

Using VR for learning purposes can be useful as the technology provides means of giving experiences through virtual environments which can be difficult to obtain normally, such as being a astronaut on Mars or a wind-turbine electrician. VR changes how content is delivered to users compared to traditional learning situations. It allows users to both experience and interact with virtual environments. However, a VR environment needs facilitation and work so that it supports learning for its users. VR does not implicitly create learning experiences, but provide unique learning experiences if properly capitalised on.

A literature review in 2015 found that the uses for VR in education were many, stating that "Immersive VR can offer great advantages for learning: [...] it supports training in a safe environment avoiding potential real dangers and [...] it increases the learner's involvement and motivation..." [28]. While there is a general consensus among the scientific community that virtual reality can contribute to educational efficacy there are some aspects to consider when developing VR applications for educational use. Roussos et al. describes several dimensions in relation to virtual reality and learning including *technical*, *orientation*, *affective*, *cognitive* and *pedagogical* aspects [63], as seen in Table 2.4.

Table 2.4: Summary of the aspects defined by Roussos et al. [63]

Aspect	Description
Technical	Usability regarding the interface, software and hardware.
Orientation	Navigation, spatial orientation, presence, immersion and feedback.
Affective	User engagement, and confidence in the virtual environment.
Cognitive	Internal concepts through the users learning experience.
Pedagogical	Gain knowledge about the environment and concepts being thought.

Career Guidance

By collaborating with NAV, the expertise in career guidance that NAV has is available to us, allowing for easier exploration of possibilities within the field. When considering how to build the solution for testing VR career guidance, any questions we have regarding the career guidance process can be swiftly answered by NAV.

There are, however, considerations that need to be accounted for. According to the literature, the most popular method of career guidance when using computer supported career guidance appears to be individual counselling, followed by classroom and group

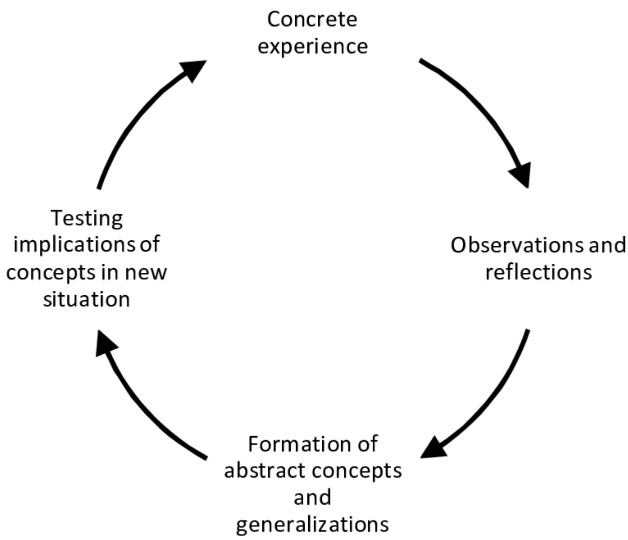


Figure 2.3: Kolb's experiential learning cycle [8].

counselling [64]. They are also mostly used as complementary systems in the counselling process [64]. This lines up well with what NAV has described, and needs to be considered for how the application is developed.

Workplace Training

The use of virtual reality for workplace training is at the core of this project. Previous studies have shown that there is a strong desire for virtual reality workplaces to be applied on a larger scale, both from job seekers and welfare professionals [61]. While these applications are being used to some degree, so far it has mostly been for specialised industries or purposes like safety and hazard training. Using the applications to help job seekers enter the workforce has on the other hand been less pervasive.

Experiential Learning

Experiential learning refers to learning by doing. Kolb described a more specific 4-step learning model which proposes a cycle of experiential learning[43].

The model, as seen in Figure 2.3, describes what Kolb meant constituted experiential learning. To explain the model starting at the top, the person attempting to learn would first gain some form of concrete experience by doing or seeing. Based on this experience, they have to reflect on what just happened and use their observation and reflections to create a new plan based on what worked, and what did not. They can then test these new concepts and again gain new concrete experience, starting the cycle over again.

While the goal of the project is not necessarily training users for a specific workplace, or even preparing them for it, there are many aspects of experiential learning that are useful either way. When considering the target audience for the project, it is important to remember that one of the goals is to increase their self-efficacy and improve their ability to make educated choices about what type of work they want to pursue, Through the use of experiential learning in virtual reality, users are able to try their hand at different scenarios without fear of failure or messing up. This allows them to gain more confidence in their own aptitude for work, and has seen positive reactions [27] [61]. A 2015 study used collaborative experiential learning in VR to proactively reduce safety hazards in a workplace, and participants agreed that VR was good fit for experiential learning [44].

Tutoring

For those struggling to enter the workforce, it is important that they are able to get the proper impression of a workplace. If more time is spent failing certain tasks rather then organically exploring the tasks at hand, the participant may be discouraged from trying more. Having a tutor or another similar figure present to help keep them on track can be quite beneficial as long as they follow some basic tutoring principles, according to a study by Douglas C. Merill in 1995 [49].

2.1.7 Gamification

Gamification has been a common practice of enhancing a service by including game design principles in a non-game context in order to add value and thereby encourage the user to complete tasks which might seem less interesting on their own. A study by Hamari et al. [37] showed that the process yields positive effects and concludes that gamification methods does work.

The IMTEL lab has used gamification principles in most of their Virtual Internship projects as a means to engage its users. Although these applications use game elements in workplace tasks and situations it is important to note their primary use is *not* to entertain or learn how to do certain tasks but to inform and let users (eg. young job seekers) experience the various workplaces in an introductory manner.

Serious Games

Serious games is a subsection of games that do not hold entertainment as their core principle. B. Sawyer defines serious games as ”any meaningful use of computerised game/game industry resources whose chief mission is not entertainment.” [65]. They can be made to tell a story, educate players about a topic or serve as an immersive way to explore a location otherwise inaccessible [73]. They offer a way to use gamification principles directly in an application, but even so, they differ somewhat from normal games when it comes to development and game play. According to Zyda [76], and illustrated in Figure 2.4, serious games has an additional pedagogical component which is one of the aspects identified by Roussos et al. in relation to virtual reality and learning, see Table 2.4.

Using serious games for training and education comes with few requirements. For the user to gain anything, it is important that they can gain feedback and be properly assessed.

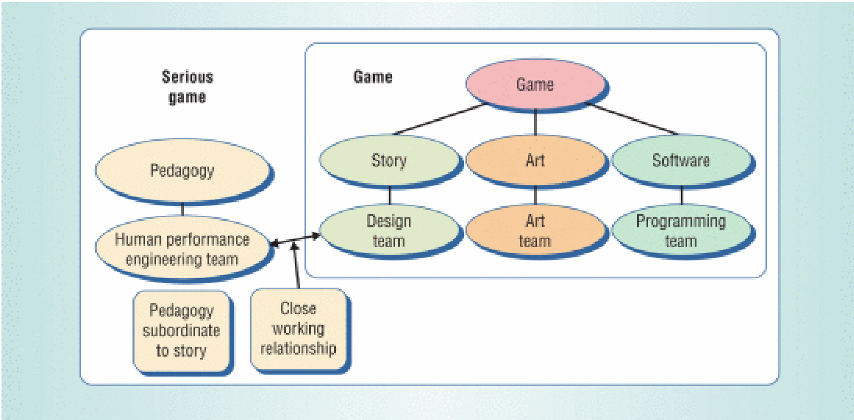


Figure 2.4: Differences between serious games and game according to Zyda [76].

They must also offer the correct level of challenge. Too little, and the player loses interest, while too much difficulty can cause anxiety and stress [22]. Prasolova-Førland et al. [61] recommends care should be taken to balance the educational purpose and entertainment aspects when developing applications for career guidance.

2.1.8 Virtual Internship

The IMTEL lab has developed the concept *virtual internship* as part of the ongoing NAV project. The concept is designed as a means to provide a virtual and interactive experience of various occupations with elements of workplace training [27]. The target audience for immersive job taste is young job seekers, e.g. unemployed high school graduates, with the aim of giving the unemployed a look at workplaces and experience a different occupations so they can get a feeling for the daily activities and atmosphere so they can potentially avoid erroneous career decisions.

According to Fominykh and Prasolova-Førland [27] this concept can make job searching more motivating and provide a more accurate image of a workplace compared to text descriptions. In their research paper confirms that immersive and gaming technologies used in immersive job taste applications contributes to an engaging alternative for young job seekers [27]. The concept has also seen recognition from the world, being awarded in EuroVR 2018 conference for best demo and was a breakthrough finalist in AWE (Augmented World Expo) 2018 [57] [15].

2.2 Technologies

This section briefly explains some of the main technologies and frameworks that were used during the development of the software components necessary for the project.

2.2.1 Git

Git is a version-control-system for collaborative software development work. It makes it easy for multiple participants to work together on single project, and abstracts away a lot of the work involved in merging multiple pieces of code together. For this project GitLab [2] was used as Git-repository manager since the IMTEL lab has their own codebase there. To make Unity work with Git we needed to configure Unity for version control adding specific *.gitignore* settings and using Git LFS (large file system) with corresponding *.gitattributes* settings so that Git tracks large files properly.

2.2.2 Unity

Unity is one of the most common game development engines used recently [12]. It is free to use, has a large community and a rich asset store. Unity allows for both 2D and 3D game development with support of physics, advanced graphics rendering and has basic and complex game objects ready to use. As this project contributes to an already established project, the same tools need to be used. Unity allows for quick editing of a scene, and provides a powerful toolset within its layers for developers. Scripting can be done with the C# or JavaScript coding languages and it integrates well with numerous frameworks and plugins.

Other considerations: Unreal Engine 4

Another alternative to Unity for VR developments is the Unreal Engine 4 development suite. It delivers real-time technology and provides a solid foundation for demanding applications across multiple platforms [13]. Unreal Engine 4 offers highly advanced visuals but has generally been considered to have a steeper learning curve compared to Unity. It uses C++ for its coding and scripting needs. As mentioned in Section 2.2.2 previous applications has been made using Unity so using Unreal would disallow the use of existing code without rewriting it.

2.2.3 Virtual Reality SDKs

For developing VR applications in Unity there exists several software development kits (SDKs) including SteamVR, Oculus and Windows Mixed Reality which is used for connecting with the VR hardware and enables support for building applications for targeted devices.

Previous Virtual Internship development at the IMTEL lab has used SteamVR which is mainly targeting HTC Vive and other OpenVR HMDs, but is fully compatible with other HMDs including Oculus Rift and Touch. For this project OpenVR and SteamVR is chosen as OpenVR enables support for building applications for OpenVR/SteamVR supported devices (eg. most devices at the IMTEL lab). Using SteamVR, we can develop for any headset that supports OpenVR easily, as SteamVR is an implementation of OpenVR. As long as the headset works for OpenVR, which most do, SteamVR will function without issue. Figure 2.5 describes the arrangement of the SDKs in this project. The greyed out boxes are SDKs not used in this project, and the green (OpenVR) and red (SteamVR) are SDKs and APIs used in the VR application. As illustrated in the figure we target the SteamVR API in our application but it uses OpenVR which is why it wraps the SDK.

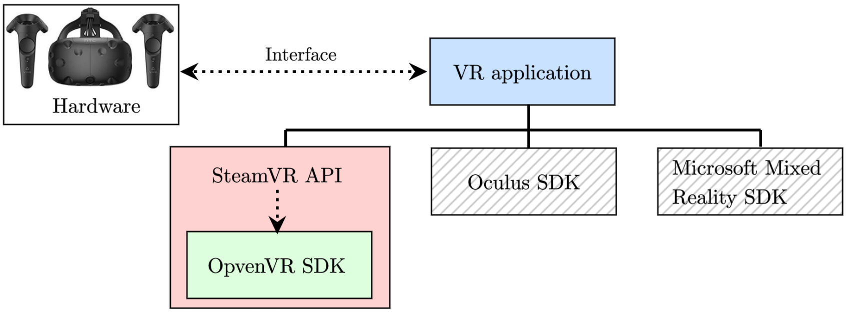


Figure 2.5: Illustration of virtual reality SDKs their connection to the application and VR hardware.

OpenVR

OpenVR is an SDK and API distributed by Valve Corporation that allows access to VR hardware from multiple manufactures like HTC, HP and Oculus. It functions as a interface between the software and hardware [9]. SteamVR implements the OpenVR application programming interface (API).

SteamVR

SteamVR is an API and runtime distributed by Valve Corporation. It makes development for VR significantly easier, in that we only need to target the API, and it will make it work for all the major VR headset brands without any extra effort. It also handles input from headsets, and translating the controller input to a fully animated controller inside the application [10][11].

2.2.4 PUN2 - Photon Networking

Photon is a multiplayer game development framework that enables fast and easy setup of a multiplayer server and matchmaking. Specifically, their own wrapper of the framework for Unity, Photon Unity Networking (or PUN) can be imported directly into a Unity project and work seamlessly from there with basic coding required to function. While the base level of functionality is quite simple, considerable work is required to make it fit more advanced certain applications [4]. PUN2 includes specific features like callbacks, interfaces, components to synchronise GameObjects and Remote Procedure Calls (RPC). It uses the client-server architecture, a highly common and used distributed model for networked related communication as illustrated in Figure 2.6, for tasks such as matchmaking and synchronisation of data between all clients.

Take for example an RPC or a data stream writing procedure for the updated position of an GameObject. Here the data flows from one client to the PUN2 server using the network (i.e. internet) where it is processed and is sent back to all or specific clients where the GameObject is transformed with its new position (x,y,z coordinates in 3D space). In this project we have configured the application to use servers located in in Europe for a boost in performance and reduced network connectivity related issues. PUN2 also allows for targeting specific clients for RPC calls (see Section 6.2.2 for more).

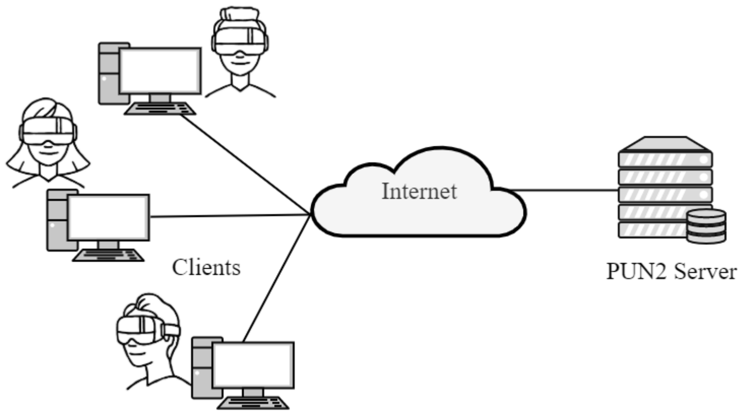


Figure 2.6: Illustration of client-server architecture used for this application.

The framework operates on an application/version system. For every program you intend to create and use with Photon, you need to register with Photon as its own application. You can then use this to watch over traffic, manage subscriptions, etc. Each application also supports versioning. If two players running the same program have different versions of it, as dictated by the *GameVersion* variable, they will not be able to connect to each other, even if they are on the same application ID. With this, it can be ensured that players will only connect to those on the same version, hindering serious bugs from appearing due to differences in code or scenes.

Photon comes with several features straight out of the box, including matchmaking, in-room communication and dedicated servers. This makes it well suited for creating the necessary software components for the project. Features can be customised as needed, and while one can use the provided example scripts for basic game objects, they do not properly account for all the logic a game object can contain. In most cases, a custom script implementing the API has to be created to cover the needed functionality. As mentioned earlier, one of the end-goals of the project is to create a general platform which can be used to develop new projects without needing to do the more basic setup of Photon every time. This would include functionality like voice chat, lobbies, launchers and avatar functionality.

It is therefore important that sufficient time is set aside to not only learn the framework, but also create general solutions that can then be refined in more specific scripts on a per-need basis and embedded in future and existing workplace applications.

2.2.5 VR Hardware

A VR system consists of three major hardware components. As seen in figure 2.7 these are the input and output devices (I/O devices) and the VR engine (computer system) [16]. Input devices includes devices which transmits user actions to the VR engine so that the system can make appropriate actions. This can include headset position data from tracking sensors or simple button presses from the controllers. The VR engine has the responsibility of displaying 3D models through computing tasks such as physics calculations and rendering. Feedback from the engine are sent to the output devices to simulate the virtual environment, such as visuals and sound.

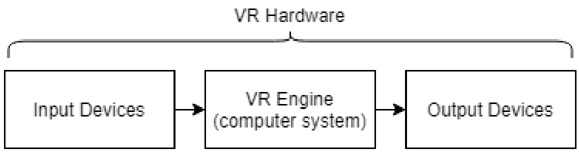


Figure 2.7: The hardware components of a VR system.

Displays

According to Alexander et al. there are three different types of displays used for virtual reality [14]. They allow a varying degree of immersion and involvement in the synthetic environment [14]. Figure 2.8 shows the different types which includes handheld, projection and head-mounted display. For this project we will only use head-mounted displays as they give the user a high immersive experience and is already used by previous workplace projects.

Figure 2.8: Different types of VR: handheld, projection and head-mounted display [14].

Head-mounted display

Most virtual reality headsets are head-mounted devices that has separate images for each eye. This is a technique known as stereoscopy which creates the illusion of depth from images in order to provide a virtual reality experience. Commonly virtual reality headset systems comes with speakers, a microphone, tracking sensors and game controllers. These systems tracks position of the player and the headset using the sensors which enables the program to correctly display part of game scenes relative to the angle and position of the head-mounted display (HMD).

Head-mounted displays gives a high feeling of immersions but there are important considerations in terms of display and hardware to be aware of as it can greatly effect the experience of the user. These are described in the table 2.5. HMDs provides a vivid and immersive experiences, however they can also have negative side effects like motion sickness. Reports shows that many users transition from a pleasurable sense of immersion to a high sense of discomfort, disorientation, and nausea [54].

Table 2.5: Important specifications for head-mounted displays to consider.

Specification	Description
Resolution	The number of pixels used for the display. The more pixels the higher the resolution and thus the details in-game, providing a more immersive experience.
Refresh rate	How many frames the display can display per second. The higher the refresh rate the smoother the experience is. To avoid motion sickness in VR it is recommended to have a minimum of 90 Hz.
Field of view (FOV)	How much the user can see of the virtual world. The higher the field of view the more the user can see without rotating the head. A narrow FOV can make the user feel like they are looking at a screen through binoculars.

Since this thesis uses OpenVR and SteamVR we are not limited to the development of software for specific head-mounted displays. The IMTEL lab offers several modern HMDs including HTC Vive Pro, Valve Index, HP Reverb Mixed Reality and numerous Oculus headsets. The main difference between these HMDs is the use of *base stations*, i.e. wall mounted tracking sensors. HTC Vive Pro (seen in Figure 2.9) uses these sensors, whereas the HP Reverb (seen in Figure 2.10) does not. Instead it tracks controllers and position using built in sensors in the headset. This is useful when performing test outside the IMTEL lab as there is no need to use base stations, but the tracking itself may not be quite as good as it would be with base stations.

Figure 2.9: HTC Vive Pro with controllers and base tracking stations.

Figure 2.10: HP Reverb Mixed Reality with controllers.

Chapter 3

Related Work

The recent advancement in virtual, augmented and mixed reality (VR/AR/MR) technologies by companies such as Oculus and Microsoft has contributed to the development of applications which aims to solve real world problems. The field of Computer Supported Collaborative Learning (CSCL) (see Section 2.1.4) and Computer Supported Cooperative Work (CSCW) has according to Ens et al. over the last three decades culminated in rich theory about collaboration and how it can be more than just the sum of its parts [26].

Although the use of VR/AR/MR for collaborative tasks has been studied considerably over the years, not much research has gone in the field of using VR, collaboration, design principles and tools for developing and evaluating collaborative virtual internship and experiences.

Inclusion Criteria

For related work to be eligible to included in this thesis there are elements that must be present in the research paper for it to selected. These characteristics are used as inclusion criteria in order to adjust scope of the search for related work. These are listed below:

- Date of publication. Must have been published in 2014 or later.
- Language of publication. Must be in English or Norwegian.
- Must include virtual reality (VR).
- Must include either collaboration aspect or teaching/workplace training aspect.

This chapter will review and discuss related work and then compare their respective features that are relevant for this thesis.

3.1 Virtual Workplace Internship Using Virtual Reality

The IMTEL lab (see Section 1.1) is researching an ongoing project called *virtual internships* which aims to help young job seekers getting insight into various professions including road construction and fishery worker using virtual reality. Prasolova-Førland et al. [61] published a paper in 2019 detailing the results of their developed concept *immersive job taste*, an immersive and interactive experience in regards to the virtual internship project at IMTEL. The paper evaluated different virtual and augmented reality prototypes (including the "Fishery VR" application) and found that results indicate a generally positive attitude towards the concept of immersive job taste [61]. The idea of the prototypes is to provide the feeling and interactive experience of a real world workplace with basic training and introduction of its everyday tasks. This is illustrated in Figure 3.1 showcasing some of the virtual workplace internship tasks and experiences available in the FisheryVR application, including fillet cutting and boat driving.

Figure 3.1: FisheryVR screenshots (left) and the user (right) [61].

Prasolova-Førland et al. [61] states that it can provide a low-threshold alternative or supplement internships using innovative technologies with gaming elements. Gamification for training and educational purposes is a supported method as concluded by Hamari et al. [37]. These virtual reality applications allows young job seekers to gain interest and understanding about the workplace which was evident by the project test participants as they found them to be enjoyable and engaging.

However, there are several aspects to consider when using virtual reality as a immersive tool for workplace experience. This includes the importance of feedback, engagement and self-efficacy. According to Prasolova-Førland et al. (2019) the literature and results indicate that more feedback in the application is needed for a higher educational experience. They suggested NPCs (non-playable characters) in different roles, e.g. colleagues. This can be transferable to our project, but instead of utilising NPCs we can embed multi-user functionality. This enables participation of career counsellors, other peers and industry representatives in the same simulation which might increase engagement and realism. It also opens up for collaboration amongst players and as the paper describes the typical self-efficacy amongst the target group (i.e. young job seekers) is low, but perhaps with collaboration opportunities and feedback this can have an positive impact and contribute to the learning efficacy.

3.2 ElectroVR: Collaborative Learning in Virtual Reality

In 2019 Greenwald et al. published a paper were they presented ElectroVR, an playground for collaborative simulation-based exploratory learning using virtual reality [33]. The project presents a demo application combining three learning approaches including embodied learning in immersive six-degree-of-freedom (6DoF) VR, simulation-based exploratory learning, and collaborative learning. The system allows two co-located users using HTC Vive as HMDs to explore and interact with the environment which is based electricity and magnetism simulations, see Figure 3.2.

Figure 3.2: ElectroVR in use with visualisations and avatar representation (left) [33].

Greenwald et al. (2019) convey that the system shows off co-located, multi-user tracked virtual reality and a playback system for narrative sequences prepared by instructors. The system can therefore support the use of only peers (learners) or a more instruction focused use with a single peer and instructor. They use a client server architecture to allow for synchronisation of interactive objects such as tools or avatars. The avatars are simple representations of the users with corresponding movement which according to Greenwald et al. [32] yields a strong a sense of social presence and is effective for gesture based communication. There is also narrator functionality allowing recordings of sound to be played back to learners as part of the instructions, but there are no real-time voice chat.

Noticeably the system is built on previous work and integration done by the same author in 2017 where they described *"CocoVerse"*, a shared co-located virtual environment for collaboration [31]. The paper lacks adequate data results and analysis and cannot therefore a this point of time conclude with any legitimate findings based on the system. They do however emphasise that this is a ongoing project and that initial testing by students have given positive feedback. The future of this project will investigate the effectiveness of collaborative learning in virtual reality through rigorous testing [33].

3.3 CoVAR: Virtual and Augmented System for Remote Collaboration

In 2017 Piumsomboon et al. published a paper presenting a remote collaboration system combining augmented reality, virtual reality, and natural communication to create new types of collaboration [60]. Named *CoVAR*, the system aims to combine the best of both VR and AR and use their respecting strengths by reconstructing the environment seen by the user who is wearing AR headset (Microsoft HoloLens) and displaying it to the VR user (using HTC Vive) so that they both share the same view, see Figure 3.3. Thus enabling collaboration for the use of observing 3D objects, experience scenes/environments or other. Remote collaboration is achieved by using an client server architecture where data synchronisation is handled by Unity networking, UNet (which at the point of writing this thesis is deprecated) [1].

Figure 3.3: CoVAR in use with reconstrucuted enviroment (A left) and AR user (B left) and VR user (B right) looking at a block object. [33].

The system has various interaction methods, virtual awareness cues and view enhancement to support and enhance collaboration. Interaction methods includes hand gestures, head gaze, and eye gaze input. The paper describes collaborative gaze as a technique where users gaze at the same target object to trigger an action such as revealing hidden information [60]. Virtual awareness cues includes methods as a ray showing the users eye direction. View enhancement techniques includes features like ”god” or ”miniature” mode and snapping the VR user to the AR users head placement.

This system is intriguing as it provides a new approach to collaborative VR and AR, combining both of them. The gazing technique is interesting for collaboration as it illustrates interest in objects and according to Piumsomboon et al. (2017) allows the VR user to know exactly where the AR user is and what they were looking at. However, CoVAR supports remote collaboration but does not implement voice communication solely relying on gestures and gazing which can be potentially be challenging for the users.

3.4 Mixed-reality to support co-creative collaboration

Gardner and Sheaffer (2017) examines and discusses in Chapter 9 of the *Virtual, Augmented, and Mixed Realities in Education* [46] book, the use of mixed-reality in education and learning. Their work is focused around collaborative perspective with the *MiRTLE* platform (Mixed Reality Teaching and Learning Environment) as their platform base. As Gardner and Sheaffer points out, the concepts *immersion*, *presence* and *engagement* are important for the use of VR in education. In a multi-user environment the concepts can all contribute to an improved feeling of achievement for the participants within such multi-user virtual spaces [29]. As such, they developed the MiRTLE system, a mix between video stream and virtual reality with the aim of being used in classrooms for educational

[1] https://support.unity3d.com/hc/en-us/articles/360001252086-UNet-Deprecation-FAQ

proposes to support co-creative collaborative learning environments. In the paper it is described that the MiRTLE was extended by other institutions and universities, such as the *BReal Lab* application (see Figure 3.4) which provides geographically distributed learners to collaborate around physical engineering [29]. It is a mixed-reality environment maker space. The testing of BReal Lab application showed a positive effect for learners experience and that it has potential for online education.

Figure 3.4: Screenshot of the BReal Lab application, a mixed-reality maker space for collaboration.

Although the tests of the different systems (MiRTLE, BReal Lab etc.) are generally positive and show potential, there are also challenges for designing and making such co-creative collaborative spaces. According to Gardner and Sheaffer making them effective can both be demanding and time consuming, requiring high technical knowledge to include a high degree of immersion to increase the user experience [29]. In other words, virtual and mixed-reality worlds are exciting and have great potential, but can struggle to compete with the real world in terms of immersion, presence and experience.

3.5 Virtual Reality Job Interview Training

Smith et al. describes in their 2014 paper a developed prototype called *VR-JIT*, a virtual reality job interview training system [70]. The system was aimed at training adults with autism spectrum disorder for job interviews. Through randomised testing they measured both the feasibility and efficacy of the VR-JIT system where adults with autism participated in simulated job interviews with virtual characters using speech recognition software. Figure 3.5 shows the VR-JIT system in action with the interactive virtual character which is part of the interview training.

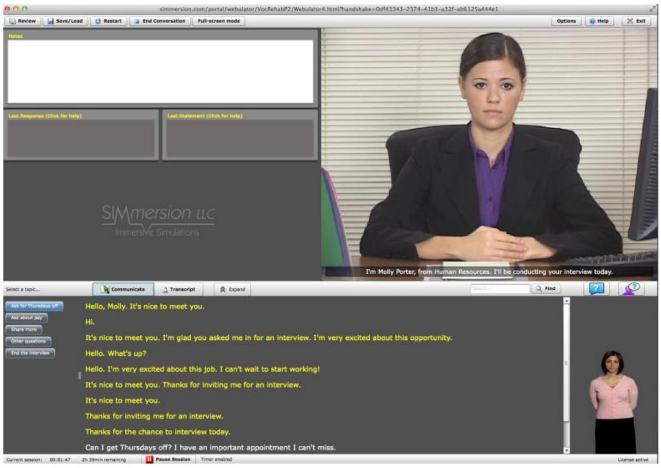


Figure 3.5: The VR-JIT system.

Testing was done with two groups, one using VR-JIT and the other using treatment as usual. According to the results, participants who used VR-JIT had greater improvement during live interviews and was reported to have higher self-confidence. Smith et al. found indications that the VR-JIT system is feasible and efficacious to enhance practical job interview skills for adults with autism [70]. The study was however limited in scope and resources, but it provides support that VR can be used effectively for virtual workplace training.

3.6 Other considerations

As described in the beginning of this chapter we presented inclusion criteria (see list 3) for related work. There are however some research papers which fall short of these but contribute with interesting and noteworthy features. These will be presented in this section.

3.6.1 Collaborative Virtual Reality Neurosurgical Training

A 2007 paper by Kockro et al. describes their attempt at making a collaborative virtual reality environment for planning and training for neurosurgery [42]. This came at a time where HMDs were less accessible, so the technology is not quite the same as is used now, but still falls within the MR spectrum. This project uses an interactive console with hand- and device-tracking that allows for manipulation of 3D data. This data is then displayed with a stereoscopic projector to the rest of the team so the collaboration can take place.

Perhaps the most interesting part is that they mention they underestimated the importance of collaboration for learning, stating that ”*...collaboration is more important than we imagined, and that the mutual exchange of individual concepts and ideas is a real benefit...*” [42]. A previous attempt had been made without the collaborative aspect, but had not achieved the same results. This lends some credence to our initial hypothesis that the efficacy of the NAV applications could be improved were multi user functionality to be introduced.

3.6.2 Language Teaching in Virtual Reality

The IMTEL lab has produced several master theses in relation to VR applications. One thesis by Morte and Skjæveland [53] is not relevant in regards to workplace internship, but their application has features which can be beneficial for this project. The project focused on language teaching using collaborative techniques to help immigrants learn Norwegian. While their focus was on language teaching, there are still some valuable experiences to learn from, particularly when it came to the technical implementation including voice-chat and their networked multiplayer framework utilisation. Morte and Skjæveland (2019) found that distributed collaboration has potential and that the increased presence affects the motivation of the users. Their application also included the option of having symmetric or asymmetric roles for its users, meaning one can be a student and student or student and teacher displayed as avatars in the VR environment. This can be transferred to our projects where we would have the possibility to be either a job seeker or a supervisor/mentor in the workplace training environment.

3.7 Comparison of related work

Table 3.1 provides an overview of the relevant features the different related work have. The comparison includes features which we have identified as important for this thesis by studying previous related applications and existing research in the field. As evident by the table, there are gaps in the field of research. There exists systems with collaboration and workplace training or guidance, but few combine both. Previous research done by the IMTEL lab shows there is a lack of this combination, and the need is further strengthened by users as the most request feature from a report summarising the results [56].

An application has the features if it uses virtual reality, has multiplayer functionality (networked connection), includes workplace training, allows for collaboration, provides real world simulations (e.g. changing a tire), allow users to talk and hear each other using microphones and speakers, users are situated in the same space (co-located) or provides functionality for remote use (users not in the same space) and it allows for users to have the same role (symmetric role) or asymmetric roles such as peer and instructor. It is intended to summarise the the superficial aspects of the works, and act as a guide as to where one can find information about different implementations of a feature or combination thereof, e.g. multiplayer and VR or remote workplace training.

"$\surd$" = has the feature.
"$\div$" = has the feature, but is limited.

	Related Work				
Features	**Workplace Internship**	**ElectroVR**	**CoVAR**	**BReal Lab**	**VR-JIT**
VR	√	√	√		√
Multiplayer		÷	÷	√	
Workplace training	√				√
Collaboration		√		√	
Real-world simulation	√	÷	√	÷	√
Voice-chat					
Co-located	√	√	÷		
Remote			√	√	
Symmetric role	√	√	÷	√	
Asymmetric role		√	÷		√

Table 3.1: Comparison of applications, and relevant features for each of them.

Chapter 4

Research Design and Methodology

Over the course of this project, both quantitative and qualitative data gathering and analysis methods were employed. Both of the methods offered something valuable to the project, and using both allowed for gathering the data best suited for this master thesis. In the early stages quantitative data, such as questionnaires, were used to gather opinions and thoughts from potential users of the program. Using these surveys, a base could be created to build from, and develop a better prototype. With this prototype finished, more qualitative measures were used to gather more specific and more detailed data. Figure 4.1 provided an overview of the research process applied in this thesis, from the strategy, data generation methods and data analysis methods.

4.1 Design and Creation Research

One of the more common research methodologies in computer science, Design and Creation Research uses common development techniques and adapts them for research and is the research methodology that will be used for this thesis. It focuses on development of new IT products, also called artefacts [58]. In the case of this paper, the artefact being developed is a prototype aiming to investigate whether or not collaboration is conducive to career guidance in virtual reality. This type of research can be split into a few different types, mostly depending on whether the artefact itself is the end goal, a vehicle for research or if the focus is on the development process itself. The most relevant case for this project is the second case. To expand upon this slightly, to say that the artefact is a vehicle for the research means that while the artefact itself is important, its *usage* in real life is what's really important. By developing something that can be used in real life, it is possible to point to something concrete and measure the perceived effects the artefact has on the system it is introduced to.

While the artefact in this project is a vehicle for the research, the aim is to have one of the pre-existing workplace applications working with collaborative elements at close to 100% functionality, so that others may continue developing the application later with

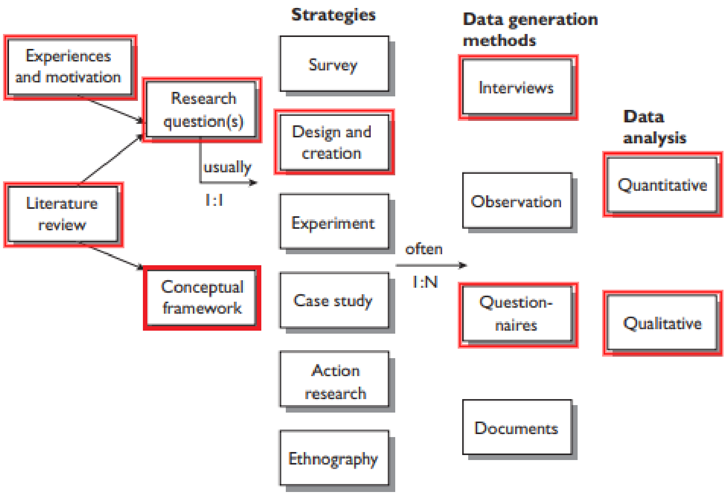


Figure 4.1: Model of the research process adapted from Oates [58]. The red outlined boxes are methods used in this thesis.

relative ease. The most important part is still to see whether or not the end product can heighten the efficacy of the VR career guidance project.

4.2 Development methodology

The primary type of development used in the project can best be described as a variant of agile software development. Agile development refers to certain principles that were written down in the 2001 article *Manifesto for Agile Software Development* [18]. This manifesto decries the old method of rigid development that is very resistant to change. Over the course of this project, feedback is sought at every level, hoping to improve the software both for the customer and the users, which means that it must be open to change when it needs to.

There will be multiple iterations and phases of the project, each building upon the last. Three major phases were roughly planned out at the beginning of the project, with each containing multiple iterations as priorities shift based on feedback. These three phases are discussed in more detail in chapters 5, 6 and 7, respectively. Figure 4.2 outlines the adapted develop methodology.

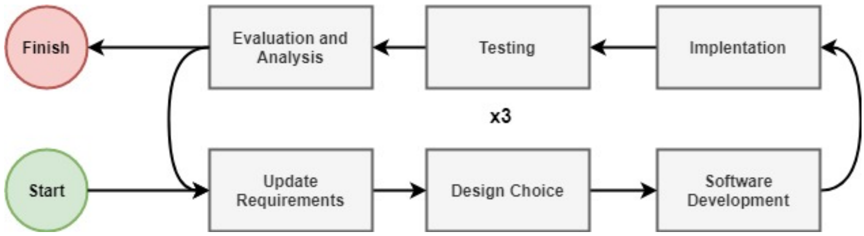


Figure 4.2: The development methodology used in this thesis.

4.3 Methods to Answer Research Questions

The primary goal of the paper is to answer the research questions as formulated by us based on the the previous research. To do that, it is important that there is a clear and structured way to answer them. As the matters they pertain to vary to some degree, so too will the ways to answer them.

First and foremost is the primary research question: *"How does collaboration in virtual reality workplaces contribute to the career guidance of young job seekers?"*. This RQ, along with secondary RQ1 and RQ2, will be answered mostly through traditional data gathering and analysis methods, i.e., surveys, user tests and expert tests. They are multi-faceted questions that need to be looked at from multiple angles, and as such, need multiple runs of data gathering to properly answer. Primarily, this will include user testing and interviews, with a side of surveys and focus groups.

Secondary RQ3 and RQ4, are more technical questions, and will be answered with the information gleaned from the design and creation method. Users are less involved with this, as it pertains more to the process of development and the interests of the IMTEL group as well as NAV. The process of development, needs and requirement will therefore be well documented to enable a comprehensive report as to the conversion process from single user experience to multi user experience.

4.4 User Testing

User tests are an important part of agile development. They are one of the primary means of gathering relevant feedback from the people who will actually be using your product. In essence, a user test is way to test the opinions of users who have had a chance to try the artefact being created. By employing user tests, it is possible to glean more unbiased information from users that do not have knowledge of the artefact or preconceived notions of its quality. A common pitfall when evaluating systems is letting your own knowledge of quirks and the intent, rather than the performance, of a functionality cloud your evaluation. With user testing, you can figure out what a mechanic looks like to those the artefact is intended for, gather data and make the proper adjustments to increase the value of the system.

A lot of care goes into creating the tests and making sure that the data extracted from them is sound and valid. The tests needs to specific enough to showcase or test the aspect you are focusing on, but not so specific that it becomes an unnatural situation that does not represent the actual product.

Most of the tests performed with the target audience have been done in collaboration with NAV. With their help, testers in the target group were gathered, and they could then try out the application collaboratively. The experience would be supervised by us, ready to guide or help if they struggled with the basic VR interactions, as the testers had quite varying levels of familiarity with VR. Once they had finished the tasks that were available to them they were asked questions through either a semi-structured interview or a questionnaire. User testing was planned to happen after each iteration as part of the iterative software development process. Data material gathered from the first two phases was used to iterate on the artefact, while the last user testing phase was used for the final evaluation.

This master thesis is approved by the Norwegian Centre for Research Data (NSD). See appendix A.1 for the consent form given to user before testing.

4.4.1 The Surveys

The purpose of a survey is to obtain the same data from a large amount of people in a systematic way, and then analyse the data, looking for patterns to generalise to the larger population[58]. People often associate surveys with questionnaires, but a survey can consist of many other forms of data gathering. This project has opted to use several of these to be able adapt to the multiple situations.

For surveys, it is important to reach a minimum desired amount of respondents to ensure that you have a large enough sample size. In those situations where we opt to use quantitative data, steps should be taken to increase the response rate where possible. Since the plan is to conduct most of the primary data gathering in person, the response rate will hopefully be quite high. In the situations where we can not gather data in person, questionnaires may be employed instead. For those cases, it is possible to emphasise the importance of the project and thoroughly explain what we hope to achieve in an attempt to appeal to the responder's solidarity and curiosity.

One of the most important parts of research is gathering the data. Often a choice must be made to go for either a smaller quantity of high quality data, i.e., qualitative data, or a larger selection of data points at the cost of the quality, i.e., quantitative data. There are merits to using both, and they will each suit different situations. As such, both quantitative and qualitative data gathering will be used as best suited for the situation.

For this thesis, self-efficacy has been an important measure of the impact collaborative work has on career guidance in VR. According to Bandura et al. self-efficacy refers to one's belief in their ability to execute a task, or more specifically, "Perceived self-efficacy refers to the beliefs in one's capabilities to organise and execute the courses of action required to produce given attainments" [17]. Self-efficacy greatly impacts motivation and is important in one's choice of behaviours, including occupational or social behaviours [17].

Quantitative Data

When shaping the surveys to gather quantitative data, it is necessary to shape the questions accordingly. The way you allow the respondent to answer will also shape your data. If the survey consists mostly of open questions, where the respondent can answer what they want to you may gain a more detailed answer, but the respondent may also be less likely to answer it at all, as you have raised the barrier for answering [58]. Narrow down the possible answers too much, and the respondent may not find an answer they agree with. One of the more common formats for answers called is the *Likert scale*, after psychologist Rensis Likert [45]. It is designed to capture the degree of agreement or disagreement of the respondent, and strikes a middle ground between a simple yes/no question and an open one. Likert items are employed heavily in our surveys.

Qualitative Data

When quantitative data do not quite cover what you need, qualitative data can instead be of use. Sacrificing the possibility of a larger selection of feedback, one can then dig deeper for the answers you seek, as well as open up the possibility for a dialogue with the respondents, in the case of a focus group or similar situations. To take proper advantage of the qualitative data gathered, some work is required to make it usable. This can take on different forms, but a common version is thematic analysis, where responses are checked for recurring keywords and themes, and categorised accordingly [58]. Thematic analysis is one of the main tools that will be used in this paper due to the large amount of variance between responses that qualitative data can produce. Coupled with a significant amount of planned tests and the general size of a transcribed interview, qualitative data can be overwhelming if proper organisation and analysis methods are not used.

Exploratory Work

In the beginning phases of the project, it was deemed important to get an overview of the general attitude of the target audience when it came to VR. As such, plans were made to conduct quantitative data surveys of different parts of the target audience. This included both young job seekers, as well as NAV employees. For the first group, the most significant knowledge to be gained was what young job seekers felt was helpful and what was not when it came to VR. The previously developed applications at the IMTEL lab suited that purpose excellently and could be used to convey the possibilities as well as the limitations of VR, and hopefully evoke useful feedback.

For the second group, NAV employees, it was important to figure out how they usually worked with the job seekers. What did their workflow look like before, and how could the artefact of this project fit into that?

4.4.2 Expert Evaluations

Since most of the work of this project was done at the IMTEL lab, opportunities presented themselves for us to gather feedback and advice. Throughout the year, people from multiple fields and disciplines stopped by the lab for various reasons, and most were quite open to some discussion about the project. The multidisciplinary nature of the project meant that even if they were not necessarily well versed in every aspect, they still had some valuable input for us to consider.

Using the contacts of the lab managers, it was also possible to arrange larger scale information gathering sessions, where the application was demonstrated to people working in the field of career guidance and lifelong learning. Following the demonstration, a discussion was held, questions from the audience were fielded, and the participants were asked to answer a survey regarding the application.

By doing this, we intended to gather many different points of view in an effort to ensure that the artefact was interesting and valuable to use for all users.

4.5 Covid-19 Ramifications

While the methods described in this chapter will still be used, their usage and our ability to gather data has been impacted by the outbreak of Covid-19 [1]. The primary effects of this is felt in the data gathering work. As of the 13th of March 2019, Norway was under a shelter-in-place directive in an attempt to minimise the spread of the virus. This meant that qualitative data could not be gathered in the amounts we had hoped to. Quantitative data is used more than originally planned, specifically in phase three. In that phase, the plan was to conduct several test days at the IMTEL lab with visitors from NAV using our equipment to gather large amounts of qualitative data. With shelter-in-place in effect this became impossible, and alternative means of conducting tests had to be found. Primarily, this took the form of video conferences coupled with remote usage of the developed software system. The specific changes to each phase will be discussed in detail as it becomes pertinent.

4.6 Work distribution

While working on the project, we made sure to play to the strengths and weaknesses of having two authors of the paper. With our different backgrounds within IT, as much of the work as possible was to be handled by the person most suited for it. The combined expertise covers advanced software architecture, networking, graphics, UX and more. We were therefore well equipped to handle almost every part of the project. Table 4.1 shows roughly how the work was distributed. Work was done both individually and together (e.g. pair-programming).

Author	**Task**
Both	Surveys, interviews and tests
Both	PUN2 initialising
S. Ulvestad	Network architecture
C. Røkke	Prototype game design
Both	PUN2 implementation
C. Røkke	Interaction design
S. Ulvestad	Network optimisation
S. Ulvestad	Lobby networking
C. Røkke	Game and lobby UX

Table 4.1: Distribution of work.

4.7 Data Gathering Schedule

Table 4.2 shows the data gathering schedule of all dates where tests where performed and what methods was used.

Date	**Place**	**Method**
27.09.2019	NTNU Gløshaugen	Questionnaire
04.11.2019	NTNU Dragvoll	Expert feedback
25.11.2019	NAV Falkenborg	Interviews
09.03.2020	NTNU Dragvoll	Group discussion / questionnaires
21.04.2020	Video conference	Questionnaire
24.04.2020	Video conference	Questionnaire
14-24.05.2020	Video conference	Interviews

Table 4.2: Data gathering schedule.

Chapter 5

Phase 1: The First Prototype

For phase 1, we first conducted a questionnaire and analysis combined with discussion with stakeholders during an exploratory phase, from which we defined the requirements. Afterwards, design choices, development and implementation was done, followed by testing and evaluation of the analysis.

5.1 Exploration and Planning

The first phase of this project required extensive experimentation and planning as the use of VR technology with collaboration and how it can contribute to the experience of young job seekers is a relatively unexplored area of research. The primary objective for this phase was implementing an immersive and collaborative experience, but how this was to be achieved needed exploration and prototyping. As the aim for this project is to evaluate the collaborative workplace training in VR it first and foremost must support a collaborative environment in the VR world. This meant we had to implement multiplayer capability into existing workplace simulations from the ongoing project financed by NAV. It was decided that we would use Photon Unity Networking (PUN) [4] as it enhances features built into Unity's built-in networking and UNet (Unity's multiplayer framework) will become deprecated within 2021.

5.1.1 Researchers' Night 2019

The last 15 years NTNU has hosted *Researchers' Night* as part of an initiative throughout Europe launched in 2005 as a means to educate and invite the youth inside the research that takes place. September 27. 2019, NTNU invited students and teachers from upper secondary and adult education institutions from Trøndelag, see table 4.2. The IMTEL lab was present with VR and AR application demos and during the testing and talks we conducted a questionnaire with the aim of gathering preliminary data and opinions in relation to VR and collaboration in respect to workplace training, see figure 5.1. The reasoning for choosing this quantitative data gathering method was because quantity offers more universal means and criteria for evaluating key points and making generalised conclusions based on the result set [58]. Also, predefined answers (eg. closed answers) makes the questionnaire easy to complete for participants.

Figure 5.1: Researchers' Night 2019 showing the testing of VR application in action and group members from the IMTEL lab. *Credit: NTNU*

The questionnaire

The questionnaire was comprised of two sections, one with general questions with age, sex and career guidance at school. The second contained questions aimed towards VR and the IMTEL labs' VR internship applications (note that all participants did try a VR application before answering the questionnaire). It was generated using Google Forms, an easy and useful questionnaire tool. Most questions were closed questions meaning they had predefined answers. We constructed the questionnaires in such a way that it produced both nominal, ratio and ordinal data. Most significant questions were ordinal on a consistent ranked/scale questions where the participants were asked to rank their agreement from ”Strongly disagree” to ”Strongly agree” on a scale from 1-5. The full questionnaire can be found in appendix B.1.

Analysis

The questionnaire had 27 answers consisting of 78% males and 22%women with an age distribution from 13 to 32. The mode being 16 years with 37% of the participants. The data results are presented in bar and pie charts using Google Forms own utilities. There was a general agreement amongst the responds that collaborating with peers and mentors would enhance the career guidance. 77% respondents ranked 4 and 5 (on a scale of 1-5) that they strongly agree that having peers would be beneficial, see Figure 5.2.

Figure 5.3 shows the distribution of the applications which participants tried during their visit at the IMTEL lab stand. In regards to the use of these VR applications in relation to career guidance the participants mostly agreed that they should be a part of the guidance at school, see figure 5.4. None of the participants ranked their agreement below 3 (out of 1-5, see figure 5.5) when asked about having a fellow peer in the VR application and that it could be beneficial. Also, 85,2% agreed with 4 and 5 (out of 1-5) that having a mentor or teacher in the VR application could also be beneficial, the mode being a rank 5 (51,9%).

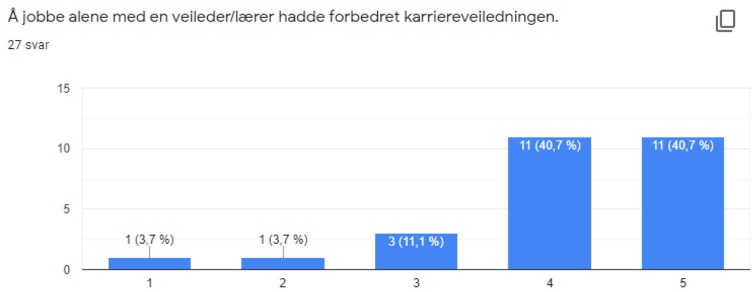


Figure 5.2: Bar chart showing the participants answers with the statement ”Having a similar aged peer would enhance career guidance”.

This shows that the participants (comprised mostly of students at upper secondary school) agree that the use of VR can be beneficial in career guidance, gives them a taste of different jobs and that having multiple players (both peers and mentors) can enhance the learning outcome and thus the experience. Based on evidence from this questionnaire it is clear that this is an interesting field of study and it has gives us gives insight and motivation. However, we must also consider the limitations of this questionnaire which falls a bit short in regards to the number of participants and has almost, but not quite, the correct target audience in respect to age and education. That being said this questionnaire was only meant as preliminary data collection for understanding and getting an overview of the field.

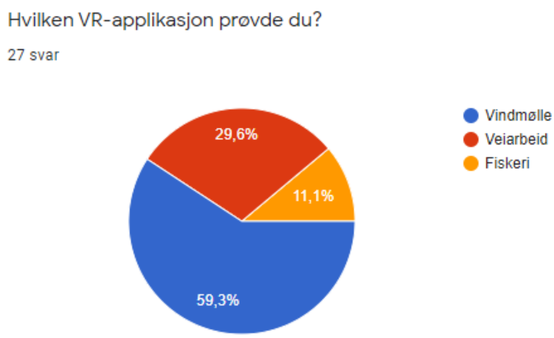


Figure 5.3: Pie chart showing the distribution of the applications which participants tried during their visit at the IMTEL lab stand including Fishfarm, Windmill and Construction.

5.1.2 Requirements

As discussed in section 4.1, the design and creation research method was selected as the most fitting way to conduct this project. Therefore, there was a need to gather information

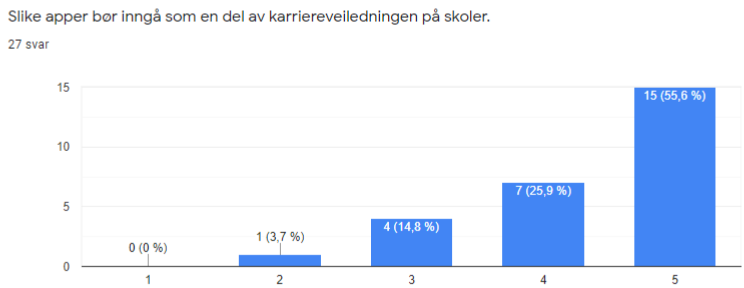


Figure 5.4: Bar chart showing the participants answers with the statement ”Such applications should be a part of the career guidance at school”.

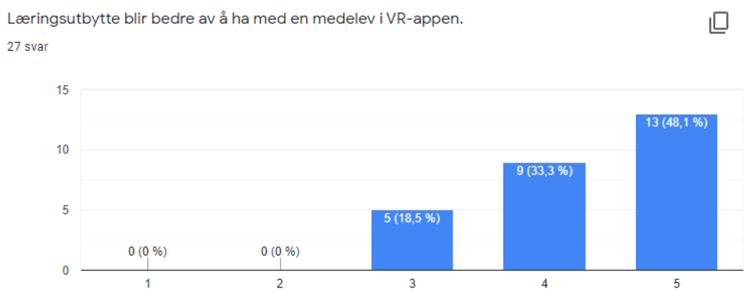


Figure 5.5: Bar chart showing the participants answers with the statement ”Learning outcome is greater when having a fellow peer in the VR application”.

on user needs and specific information abut the problem. Through early conversations with the stakeholders, in this case NAV and the IMTEL lab, the most important user needs were discovered.

After sitting down and discussing the acquired information, a few key decisions were made regarding what was needed, what was possible and what was wanted. At the core of the project is the desire to incorporate multi-user experiences to see whether it is helpful or not to the goals of NAV. It was also important that the application could fit into their workflow and setups, as it was unrealistic that every NAV office had the space for two full VR spaces, necessitating the inclusion of a desktop mode that would allow the mentor to interact with the user from within the same virtual space, even if there only was one VR station.

The final core need for phase 1 is angled more toward the needs of the IMTEL lab. Should it be the case that the multiplayer component is something they wish to bring forward to new workplaces they develop, a general framework or set of guidelines for multiplayer that they can build upon is wanted. With this framework/set of guidelines, a new workplace could be made to work with multiplayer from the get go, drastically reducing the amount of work needed to get multiplayer running for future projects.

Aside from explicit user needs that need to be considered in the project, one must also consider what is necessary to support the user from a theoretical standpoint. As the aim is to create a collaborative experience, there is a need to weigh the options available against the cost of implementing them. Looking back at chapter 2, there are many aspects related to working using groupware, as well as CSCL and presence that can be used to ensure a better experience for the user.

For one, the user should to a high degree be aware of the other user's intention and actions, as well what artefact they are currently interacting with. Their location, motion and field of view are all important to discern this this information, and so it reinforces the need to have a fully tracked avatar that other users can see an infer information from.

The avatar helps support not only the ”What” element, but also the elements of the ”Where” an ”Who” category from table 2.1, and can in general be seen as the strongest contributor to all the categories of workspace awareness introduced in this table. It also acts as a simplification of communication, as seen in table 2.3. Through the use of an avatar in virtual space, it is also easier to coordinate action, as one can easily see what the other user us doing, and when they need assistance or guidance.

From the literature review in chapter 3 we presented table 3.1 which compares related applications and relevant features from them. Using the comparison we drafted additional requirements which aim to include features which the related applications do not.

This leads to the following functional requirements for phase 1:

F1 The applications must allow multiple players to join the same scene.

F2 Interactable objects must be serialised and and synchronised over the network.

F3 A player shall be represented as an avatar with corresponding movement from the real world to the VR world.

F4 The application must offer the option of using VR equipment or desktop mode (mouse and keyboard) for interaction.

F5 The application must contain a scene with tasks enabling collaborative learning.

F6 The multiplayer component must be generalisable and scalable to work with other NAV applications.

5.1.3 Development decisions

Choice of development platform

Since one of the purposes of the project was to heighten the quality and experience of the existing applications developed at the IMTEL lab, the choice of development platform was already locked in. As the projects had used Unity before and due to the substantial support of well integrated frameworks (as detailed in section 2.2.2) we opted to continue doing exactly that.

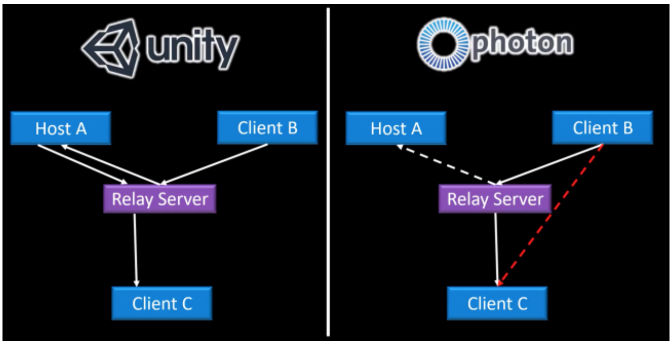


Figure 5.6: Architecture models of UNet and PUN. *Credit: Raywenderlich*

Networking framework

As described in section 2.2.4 the PUN2 networking framework for Unity supports a wide range of useful methods and features. Unity's own UNet multiplayer framework was another option but it was quickly discarded as Unity themselves has deprecated the solution limiting support and updates for several features. Their application programming interface (API) are however fairly similar, with the main difference between Unity networking and Photon networking being their architecture required to use the API. Figure 5.6 illustrates this difference. PUN2 allows peer-to-peer communication, a feature which might become useful in future development. The obvious choice was therefore PUN2 as the IMTEL lab hopes to utilise the networking foundation for existing and future projects.

5.2 Implementation

5.2.1 Implementing VR in Unity

When it comes to developing for VR in Unity, there are numerous tools available. Drawing upon the expertise of the IMTEL lab and discussion with previous master degree students, as well as reading previous IMTEL papers, the choice was made to use SteamVR [10][11]. By targeting SteamVR for development, the application will automatically work on a large range of the most commonly used headsets without needing any further effort from the developer side, as outlined in section 2.2.3. When programming, one uses words like grab and pinch to define the action instead of mapping and action directly to a certain input. SteamVR will then translate that to the correct action for the end user, regardless of what type of controller they are using, so long as it is SteamVR compatible.

Movement

Movement in VR is primarily achieved through two methods. Physical motion of the body in the play area, as well as *teleportation* inside the game. Due to a limited physical area, it becomes necessary to combine these two forms to move efficiently in VR. Teleport

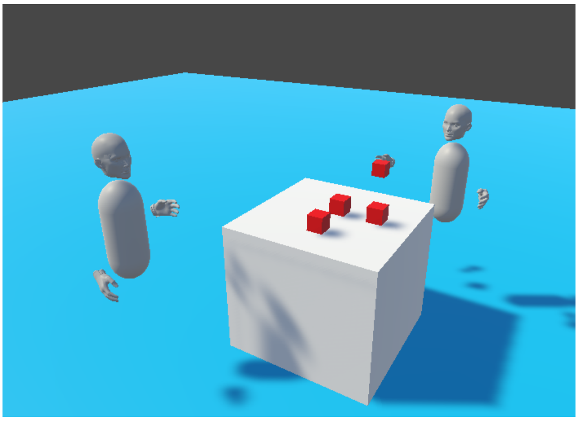


Figure 5.7: The first preliminary scene with networked cubes and players.

for long distances, physical movement for minute and precision movement. Using the SteamVR plug-in for Unity [11], this can all be handled with relative ease. However, due to the inclusion of Photon networking, it becomes necessary to translate these movements onto another object, one which can be networked to other players.

The Steam VR player object functions as a singleton. This means that there can only ever be one of them in any one instance. Many of the key interaction systems of Steam VR rely on there only ever being one Player object, and never more than that. For collaborative purposes, we need more than one player. Therefore, an avatar representing the player is created, see figure 5.8a. This is invisible to the player, but is shown to the other players as it copies whatever the user does. In this way, we can always use the singleton *Player object* on each client, while still showing all the users' movements and actions simultaneously to everyone currently in the room.

Interactable Objects

When working with Photon, numerous features are abstracted and automated. For developers, it becomes a question of figuring out what needs to be networked, and what does not. By adding a few components to a *GameObject*, and instantiating it through Photon's systems rather than Unity's instantiation systems, Photon can track the object's state and synchronise it across all users. The last player to interact with an object becomes its *owner*, the truth source of this particular object. Therefore, once an object is in the hand of a user, other players can observe the actions of the user and the effect on the object. As seen in figure 5.7 we developed a simple test scene to test networked object and players, which would later lay the foundation for future development.

VR and desktop mode

As outlined in section 5.1.2 the application should include both and VR and desktop mode allowing users to participate in the same virtual space even though they do not have VR

(a) Avatar model for a VR user.

(b) Model for a desktop user.

Figure 5.8: Screencaptures of the player models for VR and desktop mode.

Figure 5.9: The launcher start screen.

equipment. A common way to control a non-VR user, i.e a desktop user, is by utilising their keyboard and mouse. This is what we opted for, where their movement (forward, backward, left and right) is decided by the *WASD* keys, replicating the arrow-keys and the angle and rotation of their view is decided by the mouse inputs. A mentioned above we created avatar models for VR users. For desktop users we opted for a simple, but highly visible upside down pyramid with their name above, see figure 5.8b. The idea was that they could use their model as a marker or pointer in the virtual space. As seen in figure 5.9 we created a simple *Launcher* start screen where the user can simply check or un-check VR mode depending on their needs. They can also enter their name and see the network connection progress once they clicked on the *Start* button.

5.2.2 Issues

Ownership transfer of interactable objects

We experienced issues related to the SteamVR player and *PhotonTransformView*. We could transfer objects to each other but the previous owner would not see the other user take the object from their hand until they let go of it, of which there is no clear indication that they must do, aside from some minor jittering of the object. PUN2 allows for different ownership transfer protocols allowing a user to pass control of the networked object to other users. This, alongside a signal of transfer change would be needed to investigated further.

Git and LFS for Unity

During the first months of the development at the IMTEL lab we experienced unexpected crashes of the Unity editor with *"no fix available"* according to the error log. As we did not have permanently assigned desktops at the lab it meant we were completely dependant of using a source control system, e.g. Git. Our first thought was that the PUN2 library did not collaborate well with our Git LFS (large file system) setup as deleting the *Temp* folder sometimes solved the issue. Nevertheless, we managed through the crashes in this phase. At a later time the issue was solved after we discovered a well hidden error in our Unity-specific *.gitignore* settings.

Uncanny valley; representing the player as humanoids

In the first phase, simple low-poly human heads were used for the avatars representing the users, along with a capsule body and hands for the rest of the body. For collaborative VR, it is important to consider the effects of the *uncanny valley*[52]. If the users feel any form of aversion due to the avatars, they may need to be changed for something less human-like. An article from 2017 by Seyama and Nagayama [66] pinpointed that a realistic face is a necessary condition for triggering the *uncanny valley* effect, but is not always enough by itself. Some bizarre facial feature like supersized eyes or off putting motion needs to be present as well. Since the heads of our avatars have no distinct facial features or actual animation, they may elicit no specific response at all.

5.2.3 Result of phase 1 implementation

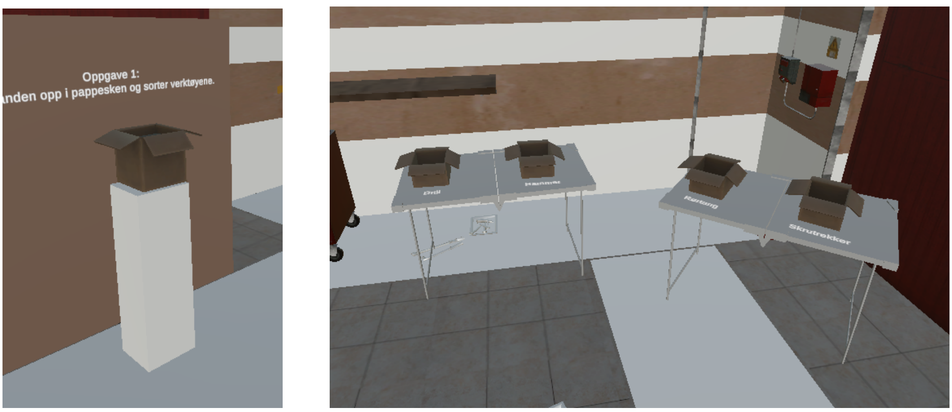
The first phase of the project was focused on features. A plan was made concerning which collaborative features were needed for an minimum viable product (MVP), and these were implemented in a test space made primarily for prototyping and testing purposes. This was made using a garage asset from one of the other projects of the lab, and several objects were placed into the scene with a simple corresponding task for users to interact with, see figure 5.10 and 5.11. While not all features that may prove useful had been implemented, enough was done that we believed a test could be performed to gauge the usefulness of the collaborative features.

Preferably, we wanted to get some data from the users about what features worked well, which ones did not and other things we may have missed.

(a) Two users using different HMDs collaborating on a task simultaneously while being connected over the network.

(b) A more detailed view of the task where users are asked to place the correct tool for a specific job related to cars.

Figure 5.10: Screen captures of the test environment developed for phase 1 showing the first task.



(a) A box which spawns tools if a user puts their hand in it.

(b) The boxes of which the users where asked to sort the corresponding tools based on the box label.

Figure 5.11: Screen captures of the second task.

5.3 First Evaluation

Testing of the first prototype took place with the help of NAV at NAV Falkenborg Jobbhuset, see table 4.2. Two laptops and inside-out MR headsets were brought to a facility where we could test the prototype and interview the participants (see Figure 5.12). Initial results were positive, with the participants offering solid feedback. It is worth noting, however, that since the tests were conducted with the two users in the same room, it may not be completely accurate to every potential usecase of the application, such as long distance collaboration. In such cases, one would need voice chat to be functional, which it is not in the first prototype.

Figure 5.12: Testing in action with two primary users at NAV Jobbhuset Falkenborg.

5.3.1 Expert Test Data

During the development of the first prototype, the opportunity was taken to demonstrate the prototype to experts and interview them collecting data, as they had expertise in at least one of the relevant fields related to the project. See table 4.2. For example, people with a lot of VR experience, welfare workers and other types of expertise. Through these discussions, subtle changes could be made to the prototype and the plans for the next phase to better include the new knowledge. While some of it was new, parts of it simply confirmed what was already planned.

The first time was a visit during a day dedicated to technology enhanced learning. After having tested the prototype so far, some feedback was given. This was mostly related to visual clarity and communication, and could be distilled into three points. First of all, since the fingers of the avatars were not animated, they felt that some other way of displaying accurate deictic gestures were needed, like a laser pointer. This was valuable feedback, and the decision was made to include the feature for the next iteration.

Next was voice, a feature that was already planned, but the importance of it was certainly highlighted. It became quite clear that without voice communication, the artefact was simply not usable for anything but two people with VR gear in the same room, a fairly unlikely occurrence outside of a VR lab.

Finally, some comments were made about the avatar, which was at this point in time a grey capsule with a grey head and hands. There were some suggestions that another avatar would allow the users to immerse themselves more easily.

At another point in time, a presentation was held for the lab courtesy of a leading actor in the field (who preferred not to be named), focusing on collaboration in virtual reality. The company itself has carved out a niche by serving customers with virtual reality meeting spaces where they can share 3D models, inspect and discuss projects while being a country apart. The subject of the avatars was discussed, as the company used full body avatars, as opposed to floating hands, body and a head. Correctly animating and interpolating the limbs and legs of the avatar was apparently quite an undertaking, and needed a lot of time, maths and skilled animators. While implementing an avatar like this was deemed out of scope, it was decided that the avatar should be updated in some manner to more accurately look human for the next phase, while still considering the uncanny valley.

5.3.2 User Test Data

As per the plan, data was gathered in phase 1 through a semi-structured interview. As the raw data for this can be quite large, it can be found in appendix B.1.

5.3.3 Analysis

Qualitative Textual Data Analysis

In order to analyse the textual data from the interviews conducted for phase 1 we utilised multiple techniques to help manage and analyse the interview materials as suggested by Oates in his book *Researching Information Systems and Computing* [58]. First, we prepared the textual data by making a duplicate of the material which ensured that we did not harm our original data. Then we could ensure the same format and similar naming conventions for all data helping us to manage it. Through an inductive approach [58] we conducted *theme analysis* and observed categories in the material by studying them. From there we could get a greater understanding of the feedback from the tests and evaluate the result with its limitations and achievements.

Table 5.1 shows the themes which were determined after the analysis process and their related more refined sub-themes. Table 5.2 illustrates relevant metaphors identified in the interviews by each interviewee and it was a helpful diagram to help manage the interview material. Finally, table 5.3 shows the interviewees satisfaction of the application presented in the test.

Interaction and realism

A few of the participants pointed out the current choice of avatars, and there was a discussion about them. While they felt the simple grey avatars were functional, some wanted to

Theme	Sub-theme
Interaction	Voice communication or voice chat Pointing/marker Personalisation (avatar skins)
Collaboration	Focus on collaborative tasks Tasks which require at least 2 players
Game design	Controller guidance (toggle on/off) Level design Distinction between roles

Table 5.1: The identified themes and sub-themes from the analysis.

	#01	#02	#03	#04	#05	#06
Avatar skin	*					*
Fun	*	*		*		*
Engaging	*		*			
Voice communication	*	*				
Easy			*			*
Gamification	*					
Collaboration focused tasks	*	*	*	*	*	
Natural with multiplayer			*	*	*	
Presence		*	*			*
Controller explanation			*	*		
Habituation		*			*	*
Pointing	*	*				*

Table 5.2: Identified metaphors/keywords from the interview material.

be able to choose avatars or at least do some minor customisation, like the colour of the avatar. As mentioned in section 2.1.3 avatar can provide valuable awareness information. The interaction itself mostly felt normal, and was not intrusive. One, who was not as accustomed to VR, felt that the other person was helpful in realising what was possible and what was not, even if the avatar moved a little strangely.

Visibility and simplicity

Due to the simplicity of the avatars and the general scene, most things were relatively clear, and not too cluttered. Some reported difficulty reading the text, which may be due to the limited resolution of the MR headsets that were used for the tests. Since usability is very important, and increasing text size is quite simple, this may be done for the next version.

Worth noting is that the premade asset used to construct the test scene contains a lot of visual clutter and objects one might assume to be intractable that is not. While not directly related to collaboration, this can confuse and reduce the user's feeling of presence by reminding them of the limitations of the virtual environment. An attempt should be

Role	ID	Satisfaction with the system	Reason
Job seeker	#01	High	Better. More atmosphere and engaging. Fun to work.
	#02	Medium	Enhanced the experience, but need more distinct collaboration tasks.
	#03	High	Increased presence and multiplayer seems better. Has potential and can be more engaging.
	#04	High	Positive experience, especially when more people help each other. More fun.
	#05	Low	Stressful. Not always aware of where the other player is. Better through habituation.
Mentor	#06	High	Exiting to mentor the other less experienced player. Easier to give instructions as one is present in the same world.

Table 5.3: Satisfaction of the application grouped according to the role of each interviewee.

made to reduce visual clutter where possible, and that scenes do not contain misleading objects.

Real content

As identified in the theme analysis (see table 5.1) game design was a common feedback from the testers. Some pointed out that the content in the virtual environment should be more accurate in terms of real world situations.

Considerations for the next survey

There was some back and forth as to what method should be used for the data gathering on the first survey, as we were not certain how many users would be present and available for testing. Therefore the constructed interview guide was slightly rushed. While we consulted with our supervisor, we need to make sure that the next survey is more properly vetted and double checked to remove any possibility of leading questions or bias.

Updated Requirements

The requirements will see some changes. A major part is to implement a accurate virtual workplace. An additional requirement for phase two is that voice chat must be implemented, and preferably some tools the users can use to mark or pinpoint objects or locations that they want to draw attention to.

Chapter 6

Phase 2: Application implementation

After the exploratory phase 1, phase 2 is more concerned with gathering concrete data. Functional requirements have been revised as a result of data gathered in phase 1, and more focus will be placed on creating a solid foundation as one of the major artefacts of the project. As the data in phase 1 indicated strongly toward a preference for multi-user experiences for workplace training, phase 2 can proceed mostly as planned.

By spending a lot of time with the tools selected for the project in the first phase, it has become apparent as to why a general solution is needed. While some custom logic will always be needed, the overarching plan for the NAV project is to create a *workplace experience catalogue* that will allow users to browse workplaces as needed. It is therefore paramount that the experience is the same to satisfy user expectations. A general solution will also produce clearer results that are not muddied by having different parts of the application respond, operate or appear differently. Less time can be spent creating fundamental logic, and more time spent on making sure that the custom logic parts work well.

With this mind, the development work can be said to be split into two parts. One part will concern itself will implementing and creating a fully functional multi-user workplace experience as one of the two primary artefacts of the project. The other artefact and effort will be devoted to creating the general framework and mapping the process needed to convert a workplace experience to multi-user environment. As the artefacts created here will serve as a foundation for further development and research, a significant portion of time has been spent making sure that the artefacts created are up to the IMTEL lab standards, as well as following software architecture principles. In section 6.2 the details of this process will be explained. The following sections will detail the specific changes made to the artefact concerning the fully implemented workplace and an evaluation the artefact created.

6.1 Planning and Changes

6.1.1 Changes

The changes to the application is based mostly on the analysis done in the previous phase. From table 5.1 we presented sub-themes which after some internal discussion resulted in an agreement (which we felt covered the most important aspects) that we should add the following changes to this phase's development and implementation process.

Change 1
A fully functional virtual workplace environment which support multi-user functionality. Meaning objects, avatars, movement etc. should be networked and other data should be serialised in data streams to and from servers.

Change 2
Direct communication so that users has the possibility to talk to each other. With voice chat users should only hear others talk, not themselves, avoiding echo and misinterpretations.

Change 3
Collaborative features should be available for VR users, such as hand gesticulation and a laser pointer to pinpoint or mark objects.

Change 4
More realistic avatars with some aspect of personalisation.

6.1.2 Updated Requirements

As mentioned above this phase adds several changes to the artefact. The requirements outlined in bold are additions for this phase.

F1 The applications must allow multiple players to join the same scene.

F2 Interactable objects must be serialised and and synchronised over the network.

F3 A player shall be represented as an avatar with corresponding movement from the real world to the VR world.

F4 The application must offer the option of using VR equipment or desktop mode (mouse and keyboard) for interaction.

F5 The application must contain a scene with tasks enabling collaborative learning.

F6 The multiplayer component must be generalisable and scalable to work with other NAV applications.

F7 **The application must be a virtual workplace with multi user functionality**.

F8 **Users should be able to communicate through integrated voice chat functionality**.

F9 **VR users should be able use tool(s) to mark or pinpoint objects or locations**.

6.1.3 Development Decisions

The largest difference between phase one and phase two is the environment and the tasks available to the users. While phase one focused on a functional multi-user implementation to showcase possibilities and to see that users could navigate and understand a collaborative VR environment, phase two is about creating a functional collaborative workplace. With this, the goal is to create an artefact that is as close as possible to what would be used in a normal use case, but with multi user functionality.

For the virtual workplace to be used in this phase, a workplace developed at the IMTEL lab was chosen based on several criteria. Due to the time frame of the project, it was decided that a new workplace would not be created. Instead, the choice was made to use one already developed at the IMTEL lab, as that would allow us to ask questions to the developers regarding any issues that might occur.

Secondly was the issue of scope and complexity. To properly test the possibilities of collaboration in VR, there needed to be a proper set of tasks that were neither to small nor too large. Too small, and the testers would finish it in no time, or the space might feel cramped. Too large, and there might be unforeseen issues implementing collaboration elements or for testers navigating the space together. Since the application would not be developed from the ground up, a larger and more complex application could also create issues when trying to serialise all the necessary information and states per task and player. Using more limited application would allow more time to work on individual serialisation to make sure that the application maintained consistency across the clients of all currently connected users.

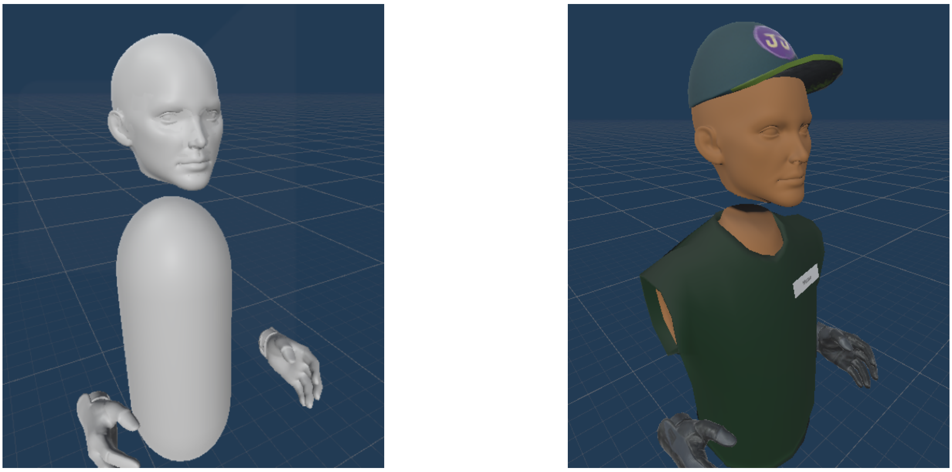
The recency of the workplace was also a concern. Due to the nature of the collaboration between the IMTEL lab and NAV, the developers of the older projects are not necessarily ready, or available at all, to help with issues, even if the application was made at the lab. As such, it would be helpful to use a fairly new workplace.

Considering these criteria, the newly developed car mechanic workplace was chosen. In this workplace, the users can attempt several different tasks in a garage, with the aim of introducing the user to some of the tasks a car mechanic might face in a normal workday [3].

Figure 6.1: Screenshots of the car mechanic workplace application. *Credit: IMTEL lab*

Virtual Reality

In response to feedback, several decisions were made in this phase to enhance the experience of the individual users, and how they could interact in VR. This included altering



(a) The old avatar model from phase 1 with a grey colour schema.

(b) The enhanced avatar model with more realistic colours, hat, gloves and name tag.

Figure 6.2: Iterations of the avatar model.

the avatars to be less grey and dull, so that they would not blend into the environment as much. They were also given a hat so that their silhouette would be more distinct. See figure 6.2. According to Wallach et al. it is possible that users of a VR application often focus on discordant elements in the VR environment rather than accurate element which might indicate that the feeling of presence is influenced by the existence of such discordant elements [75]. A more realistic visual representation for a human as an avatar can therefore, as outlined in section 2.1.2, contribute to an increased feeling of social presence.

Finding a way to let players highlight either their own location or the location of a specific object was also taken into consideration. After some discussion, the decision was made to implement a form of laser pointer that can be activated for each player. The laser has significantly more accuracy than the standard hand, and can be used to pinpoint rather small objects. Example of use cases can be seen in figure 6.3.

Perhaps most important was the possibility of direct communication. To begin with, direct voice chat has been implemented in the application. An important consideration was the that audio quality had to be good with little to no background noise and echo as it can impact both the usability and the feeling of social presence (see section 2.1.2) for the users. The effect on collaboration with voice chat would have to be investigated before adding more features to it, so certain Quality of Life features such as speech indicators or low fidelity animations to indicate speech could be implemented later based on time and further feedback. If users feel that it is hard to figure out who is talking, or where the other users are, the importance of these features can be adjusted to more accurately reflect their perceived value to the overall application.

(a) A user pinpointing a loose hose in the engine compartment with the laser.

(b) A career counsellor highlighting a caliper bolt for the users who need help to complete the task.

Figure 6.3: Laser pointer feature in action during testing.

6.2 Implementation

As the implementation got started, it was obvious that some sort of triage needed to be performed. The overall application was broken into its composite pieces, and to the highest degree possible, components were separated and isolated. Figure 6.4 illustrates the high level architecture of the application. In the case of the car mechanic application, it consisted of two main scenes, one small and one large. First was the wardrobe, where players had to equip the proper equipment before heading into the garage proper, see figure 6.5a.

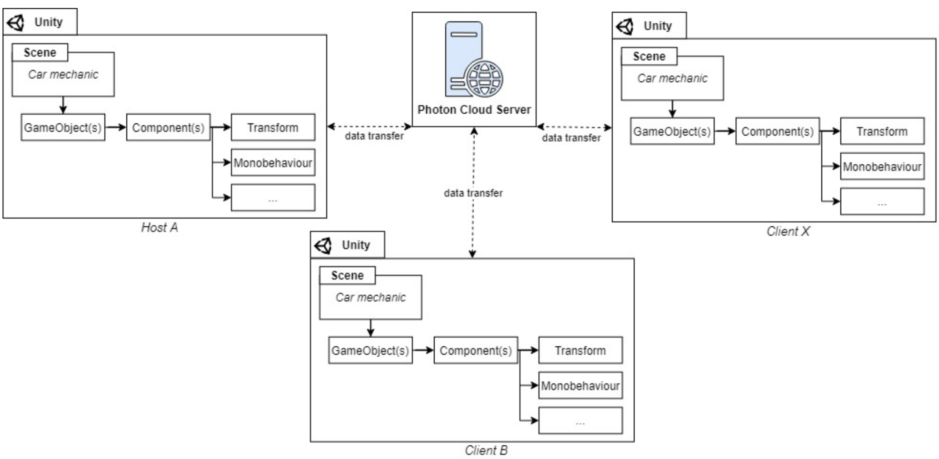
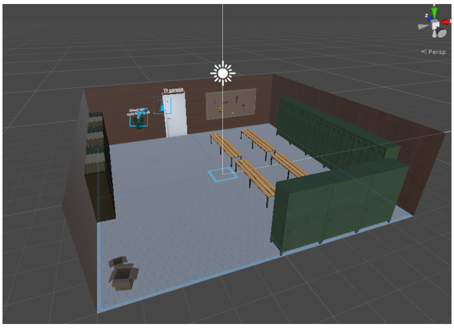


Figure 6.4: High level diagram of the architecture.



(a) Screenshot of the wardrobe model in Unity.

(b) Tool wall with different networked tools.

Figure 6.5: The wardrobe scene.

There was not too much happening here, so to begin with we made sure player instances and avatar representations were instantiated correctly in the room. We also added a simple wall with different tools that the awaiting users could interact with, adapting scripts for object networking and serialisation from phase 1, see figure 6.5b. Other than that the last thing that was implemented was the ability for the multiple players to enter the garage through the door. Generally, in a online multiplayer game the master-client handles scene changes, as was the case with standard PUN2 framework. We added logic in the network code so that whomever opens the door, even though it is not the master-client, and callback is sent to the the master-client telling a scene change needs to happened. It is an adaption of the software design pattern *Observer Pattern*, where if one object is modified dependant objects gets notified.

Once inside the garage, the meat of the matter becomes prevalent. The garage contains four separate cars that all have various tasks assigned to them, see figure 6.6 for an overview. These were from the start designed separately, with no overlap, which made it easy to focus on one of them at a time. Making sure that each task worked over the network had varying degrees of complexity, largely dependant on the tasks' original complexity. For each of the tasks, understanding the code was essential. This led to some time being spent on each task simply breaking down the code and structure of each game object. Once thoroughly understood, the basic networking pieces could then be added, and the necessary components and scripts switched out for new, networked variants created in phase one (see chapter 5). For those tasks that required further networking, or had some state that needed to be uniquely maintained, new scripts were created as required, while still aiming to maintain simplicity. In so far as it was possible, adherence to certain principles was kept a high priority.

In terms of software conventions we followed several design principles which included *modularisation*, *high cohesion - low coupling* and *entity-component*. Unity already provides the entity-component patterns as default, where entities are instances of *GameObjects* and they get their logic (interaction, movement etc.) by classes (scripts) extending the base class *Component*. See figure 6.4. These classes inherits some useful methods and operators. Modularisation refers to the principal of splitting and dividing the system into independent modules which gives the benefit of an easier system to understand and use, while allowing re-usage any number of times. Lastly, we tried to adhere to the high cohesion - low coupling principle which emphasis that classes should only do related things while being as independent of other classes as possible.

As detailed in section 2.2.4 we also used the *client-server architecture* as our computing model.

(a) Screenshot from position of where the player objects are instantiated.

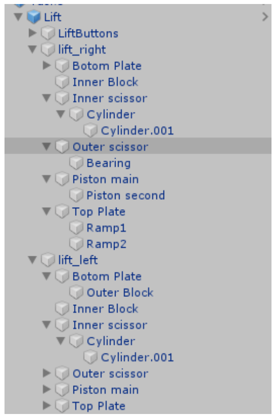
(b) Screenshot from opposite side of the garage. Four cars with unique and realistic tasks.

Figure 6.6: The garage scene.

6.2.1 Improving the serialisation of network objects

For those objects that did not fit neatly into the basic entity types, it becomes necessary to create a *PhotonView* script specific to that object that describes how the object is supposed to transfer its' data over the network to the other clients. When that is done, it is important to remember that since serialisation needs to be done manually, so does other things, like lag compensation. If the object also has triggers or other important changes that depend on user input, remote procedure calls from the Photon API can be very handy. It allows the player to request other clients to perform certain procedures remotely, hence the name. Using these RPCs, the state of the tasks can then be easily maintained across all clients, even with more complex state and triggers. A good example of the usefulness of an RPC method call is how it greatly simplified the serialisation of the complex car lift mechanism (see figure 6.7a). With this callback we could ignore the data serialisation for necessary states of the left and right piston, outer scissor and inner scissor mechanism, top plate and all other *GameObjects* seen in figure 6.7b. Instead we call a method on remote players with one of three states: still (0), up (1) or down (-1). The local player then handles the rest with little alteration to original code.

(a) The car lift mechanism in the application.



(b) Hierarchy of *Lift* prefab.

Figure 6.7: The car lift prefab from the garage scene.

6.2.2 Optimisation

Over the course of the implementation of the artefacts, areas that could be improved and bugs that could be fixed appeared. As they were noticed, or certain parts caused issues, the issues were taken note of and general implementation continued. If a bug or piece of code was hindering the implementation it would be fixed as needed, otherwise left for later. At the tail end of the phase, they were prioritised and ordered, and they could then be fixed, one at a time. Among these were improvements to level loading, missing collision detectors for certain items, incorrectly synchronised objects, etc. Multiple passes were made to make sure that remote procedure calls were not being sent multiple times or being looped by firing other users' event handlers and so on.

A helper method has also been created to help keep the code general. Instead of creating a new remote procedure call every time one is needed, one can simply pass the desired method call as a argument to the helper, and the method will initiate the desired remote procedure call. We also optimised which remote clients gets the RPC call, reducing network traffic and complexity. For instance we could specifically target the *MasterClient*, the *others* (all but the masterclient) or simply every remote client connected.

6.2.3 Challenges

One of the more complex challenges encountered was the fact that the workplace being revamped to function with multiple users was simply not designed from the start with this in mind. This meant that certain scripts needed to be altered to function while networked, and a discussion was had regarding the validity of the tasks as collaborative work. However, as mentioned in section 2.1.4, the act of collaborating in itself can bring about better learning through simply discussing and bouncing ideas off another person. A task need not necessarily be created for multiple users for a group to gain benefits from solving it together.

Covid-19 pandemic

Due to the global corona virus pandemic (Covid-19) and restrictions issued by the Norwegian government as part of their actions to prevent spread of the disease [1] impediments arose. Social distancing, isolation and the considerable risk of transferring the virus from the VR headsets and controllers meant that the VR lab at the university was closed until further notice and that scheduled testing with the primary target group could not be carried out as planned. Although some user testing was completed before the restrictions, we did not manage to get enough satisfactory results. More about this in section 6.3. It became clear that proper data collection to answer Secondary RQ1 (see section 1.4) was not feasible, as it meant we would need both counsellor and job seekers using VR equipment they do not have at home or be localised at the VR lab at the same time which was not permitted. However, we did plan to run test for data collection with both peers and mentors. Further details of plan is described in section 6.3.

As discussed with our supervisors in the preliminary phase of the pandemic we decided to add a research question which shifts focus to remote collaboration as a career guidance tool. However, we consider the RQ1 as potential future work, see section 9.3 for more.

Covid-19 also meant we had continue work from home by setting up temporary VR stations in our apartments. Relatively small areas were not ideal for tracking and movement, but we adapted to the situation. As for the VR equipment, it was borrowed from the IMTEL lab, specifically an Oculus Rift and Rift S. We therefore had to accommodate to new controller bindings and setup as we previously mainly worked on HTC Vive and Index, i.e. non-Oculus devices.

6.3 Second Evaluation

In order to evaluate the usability of the application and collaborative features we developed for this phase we utilised a reliable and well established method called system usability scale (SUS). The scale gives a number representing a composite measure of the overall usability of the system being studied [21]. In order for SUS to have the best result it is important that the test is performed before any discussion around the trial of the system takes place, which we tried our best to ensure.

The SUS questions were translated in the testers' native language (Norwegian) and included in a separate category in a survey, amongst two other likert scale categories related to career guidance/career choice and collaboration mechanisms. This is a popular strategy for user evaluation of a computer system [58]. Some of the questions were adapted and utilised from an evaluation system designed by an associate professor from the Department of Education and Lifelong Learning at NTNU. Questions about career guidance, engagement and self-efficacy measurements aimed to answer the primary RQ. SUS provides answers for usability, e.g. secondary RQ2. Comparing feedback from seeker-seeker vs. seeker-counsellor would provide answers to secondary RQ1. The survey can be found in appendix B.2.

The plan for the user testing was to conduct twelve separate tests with pairs of two. Either seeker-seeker or seeker-mentor would try out the application in VR before answering the survey. This meant we would have 24 answers, half of which was seeker-seeker pairs

Figure 6.8: User testing in progress at the IMTEL lab and the users perspective inside the application.

and the other half seeker and mentor. The mentors would be career counsellors from NAV Jobbhuset Falkenborg. Figure 6.8 shows a job seeker equipped with HTC Vive testing the application and the experience once inside the virtual environment.

6.3.1 User test data

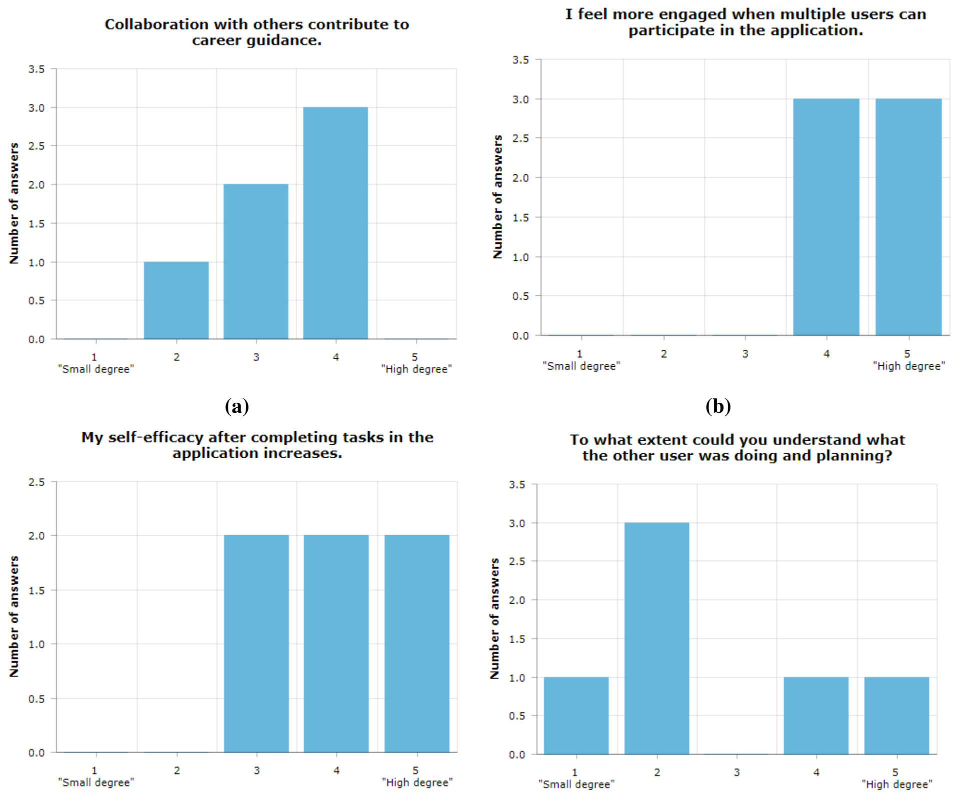
As mentioned in the challenges we faced for this phase, the Covid-19 pandemic meant that we were not able to complete our planned testing. We were only able to conduct six tests, i.e. *3*2* pairs of job seekers, thus missing the other half of counsellors and seekers. Ideally we would have gotten the last half and from there we could compare the data sets of the two halves. Therefore it meant we could not evaluate what the effects of collaborating in virtual reality with another job seeker compared to a counsellor were. At the time of writing, the restrictions are still in effect leaving us unable to properly discuss and answer the Secondary RQ1. The testing started in March 2020, see table 4.2.

6.3.2 Analysis

Although we did not complete the user testing, we still got half of the intended data points, and they will be presented here. An important note is that we cannot definitely conclude or properly discuss using these results as they are incomplete and the number of answers is not enough for quantitative analysis. We will present key and interesting findings, as they still hold some good value for the thesis.

Quantitative Data Analysis

In order to get meaningful information from the quantitative data we utilised different techniques to help manage, view and analyse it. The survey mainly consisted of likert scales, which is an ordinal data type, meaning the numbers are allocated to a quantitative scale [58]. The full survey and answers can found in appendix B.2. In our survey they



(a) (b) (c) (d)

Figure 6.9: Bar charts showing the participants likert scale answers to various statements.

were asked to answer to what degree they agreed with statements regarding VR on a scale from 1-5, where 1 is ”Low degree” and 5 was ”High degree”. The survey had nominal data points as well which describes categories instead of number or scale, such as Yes/No questions. Finally, interval data type was used in regards to the age of the users, where measurement is along a scale but the points on the scale intervals with a fixed number such as the age intervals: 10-20, 21-30, 31-40.

Through organisation of the data by using visual aids and statistics we were able to identify interesting findings. The survey had six answers consisting of one woman and five males with age distribution 18-25 years. Of those, none had tried NAV VR applications before. Data results are presented in bar charts and was constructed using an online graph maker.

There was a general consensus that the addition of collaboration mechanisms in the virtual reality application contributed with a positive effect in terms of increasing the engagement of the users and their career guidance, see figure 6.9a and 6.9b. Figure 6.9b shows that 50% rated 5, ”High degree” (*High degree*) and the other 50% rated 4. Figure 6.9a shows the mode is 4 on the scale. An important aspect according to employees at

NAV is that several young job seekers lack a sense of achievement. The responses from the testing show that they obtain just this after completing tasks in the application, such as adjusting the headlights of a car, increasing the individual's belief in her or him, i.e. their sense of self-efficacy. Figure 6.9c shows that 66.66% (or 2/3) agree or highly agree that their self-efficacy increases. The mean and median being 4 on the scale, which is *Agree*.

There was however divided opinions in regards to whether or not they understood what the other user was doing or planning to do. Figure 6.9d shows that only one third (33.33%) rated 4 or 5, whereas two thirds (66.66%) ranked 1 or 2. The mode being 2. It is therefore clear that the users feeling of social presence in VR can vary from person to person.

We must also consider the limitations of this survey which does not have enough data entries and lacks testing with a career counsellor. It does however have the correct target group which is part of why we included it, since due to the Covid-19 situation it proved difficult to to run such a test again with the desired test audience.

SUS Score

In order interpret the system usability scale (SUS) score we needed to calculate the score for each participant, which gives a number from 0-100. This will result in a score which can be used as an interpretation of the usability performance of the system in the aspects of effectiveness, efficiency, and overall ease of use [5]. However, we wanted to get the average SUS score, which we simply got by adding all individual scores and divided by the number of scores. The following steps is required for each score calculation:

1. Converted each scale into points for all ten answers, see Table 6.1.
2. Calculate X. *X = sum of the points for all odd-numbered questions – 5*
3. Calculate Y. *Y = 25 – Sum of the points for all even-numbered questions*
4. Calculate SUS score. *SUS Score* = $(X + Y) * 2.5$

Scale	Point
Strongly Disagree	1
Disagree	2
Neutral	3
Agree	4
Strongly Agree	5

Table 6.1: SUS scale/point conversion table.

Using this method we calculated the SUS score for each of the participants. The results can be found in table 6.2. This gives an average SUS score of:

$$\overline{SUS} = \frac{68 + 32.5 + 42.5 + 82.25 + 85 + 70}{6} = \frac{379.25}{6} \approx 63.2$$

According to table 6.3 this results in a *Poor* adjective rating of the usability for the collective participants. The average SUS score is 68 [5]. However, due the number of data entries being low (six participants) the average score is highly affected by scores which are very low or opposite. The median SUS score 69, which correlates to a *Good* rating and is above the average SUS score. Also interesting is the number of the SUS scores and their coherent adjective rating. Here we find 2 scores in the *Excellent* rating, 1 in the *Good* rating, 2 in the *Okay* rating, and finally 2 in *Awful* rating. This shows that there is divided opinions about the usability of such an VR application. This may have some correlation with the fact that non of the users had tried had tried NAV VR applications before and that they had limited experience with VR.

Participant ID	**SUS score**
2	32.5
3	42.5
1	68
6	70
4	82.25
5	85

Table 6.2: SUS scores for each participant sorted ascending by score.

SUS score	**Grade**	**Adjective rating**
> 80.3	A	Excellent
68 – 80.3	B	Good
68	C	Okay
51 – 68	D	Poor
< 51	F	Awful

Table 6.3: SUS scores and their rating [5].

Visibility

As presented in the analysis the feeling of presence, e.g. the feeling of being in the VR environment, varied quite a lot, see figure 6.9d. There are a number of factors including technological, user and interaction variables that influences presence [59] [75]. Technical variables such as display resolution or consistent sensor inputs may have an impact on the users and should considered. Also, the degree of interaction in the application can influence the presence as it can focus their attention and result in increased involvement [75]. Some participants pointed out after the testing that the voice communication worked well, but they had some difficulty identifying who talked and when. This may be optimised by speech indicators, such as an speaker symbol over the avatar, or other animations.

Remote career guidance

Due to the new situation regarding the virus pandemic we added a new research question which shifts focus to remote career guidance. As such, a complete lobby system, with hosting, creation and selection of different application should be created for the next phase.

While it may restrict our time and ability to develop other features it provides a unique opportunity for testing and demonstration over the network across the country or even worldwide.

Considerations for the next survey

Due to the fact that our primary testing target group became mostly unavailable for a unknown amount of time we must be wary of the effect on the data generation in the next phase. Considerations should include how the users experienced the application and how the testing is conducted.

Chapter 7

Phase 3: Final Requirements and Finishing Up

The primary targets for the third and final phase of this thesis were to implement additional requirements, complete the artefact as a general multi-user framework to serve as a foundation for future development and analyse user test data. The following sections will describe changes due to Covid-19, development decisions and implementation, as well as an evaluation of this phase's artefact.

7.1 Planning and Changes

Phase 3 was originally meant to contain changes and finishing touches based on the feedback received during phase 2. However, just as the main testing was about to begin, Norway took measures to limit spread of Covid-19 (see section 6.2.3), effectively preventing us from going through with the original plans for this phase. Coupled with an enforced work from home situation, the plan needed to be changed drastically. Primarily, some triage had to be done as to figure out which parts of the application were the most necessary for remote data gathering. Since the application is a proof of concept, it was never that important that it ran without supervision, or that multiple server instances could be run at the same time, since we were always present to run the tests and could manage all of this manually. Now that could no longer be assured. This lead to some significant changes in the planned schedule, and more features needed to be developed. A brief overview of the changes can be seen below.

7.1.1 Changes

Change 1
Support for multiple concurrent rooms must be made.

Change 2
Artefact must be changed to an executable file for end-users so it works with minimal or no input from developers.

Change 3
Features need to be complete and usable, or potentially removed if their unfinished state interferes with normal use of artefact.

Change 4
Modified research questions, as the new circumstances made some of the difficult to answer properly.

7.1.2 Changes to Research Questions

As a direct result of the Covid-19 situation, it became unfeasible to complete the research question looking into the difference between collaborating with a seeker compared to a counsellor, as it was impossible to set up a day for testing the scenarios properly. In order to thoroughly answer this research questions, we concluded we needed more people, and time to test with multiple combinations of seekers, counsellors and experts. As such, secondary RQ1 will not be answered in a way we had hoped to. See *Future Work* in section 9.3 for more on this.

On the other hand, the new circumstances paved the way for an additional research question. During a discussion held with IMTEL and NAV, a need to figure out what parts are essential for remote career guidance to work was expressed. Thus, a new research question (secondary RQ2) was drafted, see section 1.4, with the aim of assessing essentials needed for collaborative VR in order for it to be applied effectively as a remote career guidance tool.

A revised plan for this phase was drafted to handle the new situation regarding the Covid-19 restrictions and adapt to the changes of the research questions. The new plan included testing with NAV clients remotely, online seminars and testing with experts from NAV and Kompetanse Norge. See section 7.3 for more details.

As such, the new topic regarding remote career guidance could be integrated seamlessly into the paper with only some minor adjustments to surveys and plans. Therefore, work began on stabilising features in the application so remote guidance could work smoothly. With the final features in place, the survey could be updated to find out which of them were essential, and whether any features were missing that we had not considered.

7.1.3 Final Requirements

As outlined in section 7.1 this phase saw changes to the artefact and past plans. The requirements outlined in bold are additions for this phase.

F1 The applications must allow multiple players to join the same scene.

F2 Interactable objects must be serialised and and synchronised over the network.

F3 A player shall be represented as an avatar with corresponding movement from the real world to the VR world.

F4 The application must offer the option of using VR equipment or desktop mode (mouse and keyboard) for interaction.

F5 The application must contain a scene with tasks enabling collaborative learning.

F6 The multiplayer component must be generalisable and scalable to work with other NAV applications.

F7 The application must be a virtual workplace with multi user functionality.

F8 Users should be able to communicate through integrated voice chat functionality.

F9 VR users should be able use tool(s) to mark or pinpoint objects or locations.

F10 **The application must support a lobby system allowing multiple concurrent instances of an application to run simultaneously**.

F11 **A room instance should support at least sixteen VR or desktop users to join.**

F12 **A distributable executable file must be made available to users.**

7.1.4 Development Decisions

While the previous phase focused on creating a fully functional multi-user collaborative workplace by implementing network functionality into a car mechanic workplace, phase 3 is about adding remote usage possibilities in the existing artefact while finishing up prioritised features.

Remote Application Use

In order for the virtual internship to be used successfully in remote circumstances, it was decided that the artefact needed updates to the limited *Launcher* logic. Architecture, setup, network related methods and callbacks, as well as optimisation settings needed an overhaul so that clients could seamlessly host, create and join instances of different applications (rooms). The launcher logic should also include multiple selectable applications (scenes) so that it could serve as a foundation for future development and be utilised to demonstrate the basics of implementing multiple workplaces into one lobby.

Usability

User experience have always been considered when developing the application, but it was mainly in relation to the VR aspect, and less focus was placed on other parts such as the user interface for the lobby. For the application to be used remotely by users, this phase's artefact should include a distributable file. Hence, more consideration towards the usability of the software had to be taken. A general rule of thumb while developing software is to have a goal that whomever (young digitally-skilled or elderly with little skill) should be able use it with as little support as possible. With that in mind the development must consider subjective objectives such as intuitiveness, ease of use, feedback, and efficiency to hopefully increase the overall satisfaction for the end users.

Networking

Due to the shift in focus for this phase, many possible challenges were discussed. One of them being an increased number of concurrent users. From previous phases the intention of the artefact was to accommodate collaboration mechanisms by allowing two or three users to work together (possibly more, but with an intended cap at six). Introducing a distributable file we decided that it should at least sustain sixteen concurrent users per room (application instance) to better accommodate different scenarios for remote career guidance. An increase in concurrent users of at least 150%.

The PUN2 framework we opted to use in development uses Photon Cloud to host the server-side of the application. Photon has several subscription plans for this, including a free *Public Cloud*. That was the plan used in phase 1 and 2. At the time it was the obvious choice, being free and providing plenty of capability for the intended use. This plan supports up to 20 Concurrent Users (CCU), i.e., the number of users allowed to connect to the application, eighth thousand monthly activities and 500 messages per second per room. The other subscription plans *Premium Cloud* and *Enterprise Cloud* can handle 50.000+ CCU but has a cost of at least $580 per month. After some network traffic calculations and discussion we decided the *Public Cloud* could still satisfy our needs, but some restrictions in the code was needed to limit the number of users so that it does not exceed the CCU cap.

7.2 Final Artefact

As the development came to a close, and the highest priority requirements were finished up, a final version of the artefact was created and prepared for testing. To be able to test properly, it is important that all testers experience the same artefact. By prioritising the features with the greatest impact on the overall experience, it is possible to create an artefact that captures the essence of the concepts presented in the paper. While not every desirable feature were implemented, the final artefact still stands as a usable proof of concept with a fully functional lobby system, app selection and a network synced VR workplace. Figure 7.1 shows the car mechanic scene from the final artefact. A YouTube video is found at *https://www.youtube.com/watch?v=ZNnK4ohWSag* showing the system in action.

7.2.1 Lobby Supporting Different Applications

Being a part of the larger collaboration project between IMTEL and NAV, it is natural for new projects to build on the older ones, as this one did. To further enable this process, considerable effort went into making sure the artefact is reusable and easy to expand further should the need arise to do so. As part of this, the starting screen of the application received updates, as seen in figure 7.2. All the elements in the user interface were redesigned to support multiple resolutions so that the layout adapts to it. We also included a new feature, where the user can select which application they would like to start as a mean to ease reusability and future development, seen in figure 7.3. This allows future developers to effortlessly target any desired scene (or application) to be created as a public hosted

Figure 7.1: Screencaptures of the final artefact showing both VR users as avatars and desktop users as orange pointers.

instance on the server so that users can join. However, it must be pointed out that this does not serialise or network objects within the scene automatically. Players that join the room are synchronised, but every other interactable object requires some level of PUN2 networking implementation.

Figure 7.2: The redesigned *Launcher* screen the user meets after launching the application.

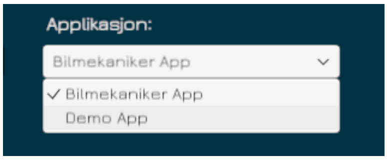


Figure 7.3: Dropdown element for targeting launch of a specific application.

Once a specific application is chosen in the dropdown and the *Next* button is pressed the user is taken to a new *Lobby* screen for the selected application as seen in figure 7.4. Here the users have several options. First, the system automatically connects the user to the Photon network and once connected successfully it joins the corresponding lobby based on the application selected in the previous screen. Then the system fetches all the corresponding rooms (application instances) hosted on the Photon Cloud server. If none are found, meaning no rooms are active or being hosted, a simple textbox notifies the user that no rooms exist and that they can create their own. Otherwise, the rooms are listed in a scrollable list element, see figure 7.5.

Figure 7.4: Lobby screen for a selected application. In this instance the *Auto mechanic app*.

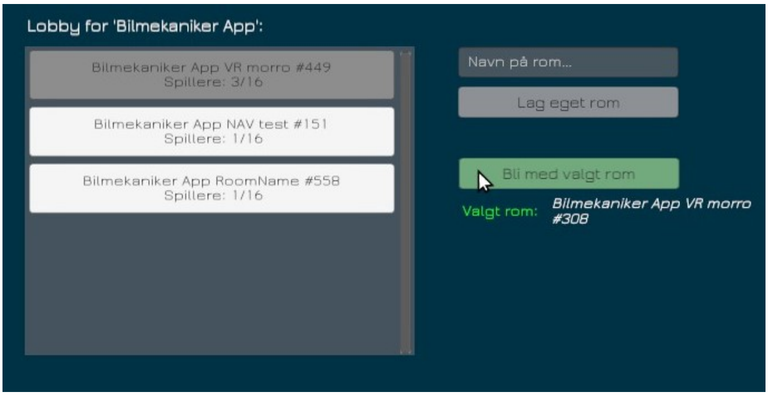


Figure 7.5: Cropped screenshot of the lobby, listing hosted rooms and a user ready to join a selected room.

The process of creating a room was to a large extent simplified (while ensuring functionality is kept) so that most users could perform the operation. Only a name for the room is required. It does not need to be unique, as that is accounted for in the code. Custom logic assigns a unique ID number to a room instance, which is then used as a key identifier when a user wants to join that room. Once a user successfully creates a room on the server, the client joins the room and their local player instance is instantiated. They are now the master client of the room. If they were to leave, and other users are connected to the room, the master client privileges are delegated to another user. Otherwise the room is closed. After the client has created and joined the room, a callback is made to all connected remote clients in the lobby and the room is added and displayed in the list of rooms.

To join a hosted room the user only needs to select the desired one from the list by clicking on it and press *Join selected room*. As a verification that the correct room is selected, a text string below the join button is updated with the corresponding room name, see figure 7.5. Similar to creating a room, the process of joining is automated. The difference being there is no need to create it, just instantiate the client's local player instance.

A player cap of 16 concurrent users are set for each room. The number of connected clients in a room are shown in the list of rooms along the name, type of application and ID. See figure 7.5 for an example.

To demonstrate the new feature that allows multiple applications in the lobby system, a demo application was made. The dropdown menu allows the users to select different applications and see the new feature in action. It also serves to demonstrate how to implement a new scene for future developers who may use the lobby system. This aligns closely with secondary RQ4, as part of the challenge of implementing these features is that they must be general enough to work in a multitude of scenarios. Figure 7.6 is a screenshot of the demo application scene. This is not the early demo from phase 1, but a new barebones scene used as an example of how to manage multiple applications in the launcher, primarily for the benefit of other developers.

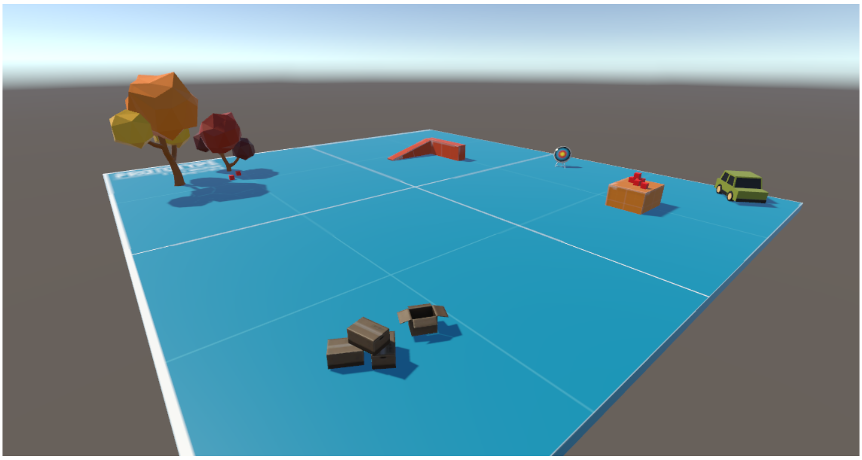


Figure 7.6: The example application with basic collaboration mechanism and networked integration.

7.2.2 Improvements

Identifiable rooms

In the preliminary stage of this phase the primary focus was to implement a functional lobby system as described in section 7.2.1. To begin with, the rooms only had an identification number and the type of application as room name. The ID was set when the room was created. This meant the creator of a room did not know the ID and it was hard for other users to identify which room they were supposed to join. As such we improved the situation by allowing the users to enter a custom name for the room so that other users could identify the room by its name.

Custom keybindings

As mentioned in the previous chapter (see section 6.2.3) we had gotten Oculus devices to support our work from home. We therefore added custom controller binding settings so that features such as laserpointer were supported for Oculus Touch controllers.

7.2.3 Usability

As a measure to increase the users' opinions about subjective objectives related to the artefacts usability we considered and added different heuristics.

First, we added symbols and status text so that the user has visibility of the system status. As an example the lobby displays a loading symbol and appropriate text in the room list while it is fetching data, seen in figure 7.4. To prevent error by the user, some buttons are disabled until the user fulfils the requirements. In our solution the user needs to enter a name for the rooms before the *Create own room* button becomes active and clickable. The use of consistent elements such as colour scheme, size of buttons, text font and other mechanisms were also adapted. For example a mouse hovering over a button yields the same green colour overlay for all buttons to signal that it can be clicked. See figure 7.5.

7.2.4 Challenges

Corrupted Prefabs

The work from home environment presented some issues that were not expected. When work was done at the lab, the computers were kept up to date, programs were updated and things ran smoothly. When setting up at home, a fair bit of time was spent correctly setting up VR headsets on home computers, and importing the project files onto a new install of Unity. One of the issues was related to Unity prefabs and Blender files. During an import, several prefabs stopped working properly due to a lacking blender install. References to these prefabs broke, models did not show up as intended, and related networking components stopped working.

As it turns out, *.blend* files open in Blender in the background, and are exported as *.fbx* files. But even when blender was installed on both computers used during the work from home period, there were still issues with certain *.blend* files not being properly exported. Something about these files in particular must have used a newer function of Blender, as they were finally solved when the Blender version of the second computer was completely reinstalled to make sure the newest version was present on both computers.

GameObject tag - NullReferenceException

During the development on a distributable executable file we experienced a bug in the build process. The application worked as expected when running it from the editor, but running it from the executable after the build process we would encounter a *NullReferenceException*. This exception is raised when the system is trying to access a reference variable which does not refer to anything. It turns out if a tag is removed from the tag index, Unity will not see this change and the build file will try to access a variable which does not exist. In the application we used methods to get GameObjects by their tag, which was what raised the error. After much debugging the issue was solved by simply restarting Unity so that references and metadata was updated.

7.2.5 Unimplemented Features

Due to the unexpected situation and the corresponding changes, some features that were wanted were not implemented.

Speech Indicator

As mentioned in the previous chapter (see section 6.3.2) some users have difficulty identifying who talks and when. One idea was to add speech indicators on avatars which is visible when a user talks in the application as a means to aid the visibility of speech amongst both VR and desktop users. Figure 7.7 shows how such indicators might look.

The addition of speech indicator would be beneficial for the workspace awareness of the users in cases where there are more than two users at the same time. If users have trouble identifying who is currently speaking, the elements of identity and authorship (see table 2.1) are not reinforced enough. This negatively affects the workspace awareness of the user and, as a result, the overall experience suffers.

Figure 7.7: An example of how a speech indicator might look.

Synchronised finger movement

A discussed, but not implemented feature was the synchronisation and networking of the animated hands that Steam VR provides. While the hands of the user is correctly tracked and displayed to other users, the fingers are set in a static position. A user is able to see their own fingers move, but these animations are not played for other users.

When weighing the pros and cons of the feature, simplification of communication (see table 2.3 is the concept that weighs most heavily. Deictic gestures are some of the most basic forms of communication, and any feature strengthening the users ability to communicate is worth considering for implementation. When prioritising different features, finger movement was not considered as important as other aspects of the artefact. To begin with, the avatars as they are now are not accurate or realistic, with missing limbs and little to no animation on the head. The direction, position and rotation of the hands were thought to serve satisfyingly as a representation of deictic gestures. Therefore finger movements were considered unnecessary for the current implementation, but may be considered later in the IMTEL project life cycle.

7.3 Third Evaluation

While evaluation turned out to be more difficult than anticipated, tests were still able to be performed with some effort. As planned, tests with users remain the primary source of data, but the new circumstances placed further importance on expert evaluation to garner additional data sets. Table 4.2 shows how and when data was gathered for this phase, which began with video conferences in April 2020.

7.3.1 Remote User Tests

Since tests could no longer be performed at the lab or at the offices of NAV, they had to be adapted to fit the new circumstances. That meant finding testers who were available who also had VR gear at home. This turned out to be somewhat difficult, and a significant amount of time was spent finding testers so that the project could finish as planned. Due to the collaboration with NAV, the task of finding suitable testers could be at least partially delegated to our collaborators at NAV. Since this would take an undetermined amount of time, time could be spent finishing up other aspects of the artefact that needed work or more polish to ensure the best result.

Finding job young seekers willing to participate turned out to be very difficult. A combination of lacking VR equipment, insecurity and no obligation to attend meant some job seekers first wanted to participate but ended up withdrawing from the testing. Due to the new circumstances, the amount of testers was drastically lower than initially planned for, so the methodology of testing had to be adjusted as well. As a consequence, these tests were conducted remotely over the internet using video conference tools and the remote guidance opportunities built into the artefact for this phase. Furthermore, more focus was placed on the qualitative data with additional quantitative data to support it, to make sure the samples obtained were useful and thorough. In late May, with testers finally secured, testing was conducted as planned. Although the amount of primary target testers were low, we had to proceed as they were the only ones available.

Table 4.2 shows that large parts of April and May was used to prepare for and conduct video conferences and interviews. With the new restrictions in place, the importance of these interviews were further highlighted. By sourcing a template interview guide from another student at the IMTEL and altering it to suit our needs, we could relatively quickly create a high quality interview guide that would touch upon the subjects most important to us. The interviews needed to strike a good balance between length, content and accessibility. Compared to earlier interviews and discussions with users, there was definitely a barrier present when communicating via video conferences that meant conversations were less natural. As such, the interview guide had to maintain a high quality to properly extract the information that was needed. Were the conversation too long or the subject too dry or esoteric, the interest of the respondent might falter, leading to potentially poor data.

The interviews mostly took the shape of semi-structured interviews, which would allow on the fly adaptation if interesting topics sprung up. It also allowed for unsuited pr previously covered topics to be skipped when needed. Room was also left open for the respondents to discuss topics they felt were interesting and relevant to the research. Due to the situation, all of the interviews were conducted with a guidance counsellor from NAV present, which helped keep the conversation going, as the job seeker and counsellor were able to discuss their previous experiences with career guidance compared to this new way of career counselling.

7.3.2 Expert Evaluation

While work was underway in securing testers for the planned remote guidance tests, other avenues for feedback were also pursued. Due to the special circumstances, there was some concern that enough test data could not be secured. By working with various collaboration partners of IMTEL, we could present the project and garner feedback and opinions from experts in the fields of career guidance and mentoring. While this alone is not a satisfactory type or amount of data, it is helpful to see their opinion on what we have made, particularly for the research questions that pertain to remote guidance, i.e., RQ2 and RQ3.

This data was primarily to be gathered using Microsoft Forms, where a survey was created over the course of multiple iterations. A copy of this form can be seen in appendix B.3. Microsoft Forms was selected as it was suggested by the our advisers and complies with concerns regarding general data protection rules (GDPR), as well as being a platform all NTNU students have access to.

The largest opportunity for expert feedback happened in late April, where a possibility presented itself for a presentation and discussion with NAV and Kompetanse Norge, a directorate of the government department of education. While their field of expertise is primarily focused on the education and re-education of adults rather than young job seekers working with NAV, their expertise in the field of career guidance could be useful nonetheless. This opportunity was an academic forum about VR in training and guidance hosted via Zoom, a video conference tool. During the meeting we presented our thesis and the developed artefact. To ease the explanation we made a short video showcasing and demonstrating the potential and features of the artefact. The video is available on YouTube [1].

The survey that was prepared for the final phase consisted of four main sections aimed at providing data related to our research questions. These sections included *Decision Learning and Career Guidance*, *Collaboration Mechanisms*, *SUS - System Usability Scale* and *Remote Guidance*. Since participants of the survey could have different experiences with the application (used it, watched the video etc.) the survey considered all such cases, branching to the correct sections depending of their experience and answers.

The survey was employed after the meeting in an attempt to gain a secondary data source. From the about 50 to 60 people we interacted with, 14 chose to respond to the survey. While the amount of respondents was not entirely as high as hoped considering this was not an entirely random selection for participants, their status as a secondary data source mitigates this somewhat, as this data was always considered secondary to the data gathered from the primary target group, which would be of the qualitative sort. We did however remind the participants of the meeting after some days to take the survey but with little response. More answers were provided by chief advisers in the Norwegian automotive association, who have worked previously with the IMTEL lab on career guidance projects.

7.3.3 Analysis

Due to the challenges regarding user testing as described above data was gathered through both semi-structured interviews and surveys. Interviews were completed with the primary

[1] https://www.youtube.com/watch?v=ZNnK4ohWSag

target users (young job seekers and career counsellors). The amount of interviews was limited and as such we also conducted surveys with experts to support our data gathering.

Qualitative Textual Data Analysis

To analyse the textual data from the interviews conducted we utilised the same method and procedure as previously used in section 5.3.3. See appendix B.3 for interview guide and answers. Using theme analysis we identified themes and related refined sub-themes as seen in table 7.1. Table 7.2 shows relevant metaphors found in the interviews for each participant, and table 7.3 presents the interviewees perceived value of the final artefact developed for this thesis and the underlying concept.

Theme	Sub-theme
Positive effect	Engagement Social skills Self-efficacy
Ease of use	Intuitive Low threshold to get started
Career guidance	Shared virtual environment Conversation starter

Table 7.1: The identified themes and sub-themes from the analysis.

	#01	#02	#03	#04	#05
Positive effect	*	*	*	*	*
Cooperative presence	*	*		*	
Engagement	*	*	*	*	*
Decision learning	*	*		*	*
Collaborative learning		*	*		
User representation	*		*		
Availability		*	*		*
Gesticulation	*				*
Intuitive	*	*	*	*	*

Table 7.2: Identified metaphors/keywords from the interview data.

Role	ID	Perceived value of the concept	Reason
Job seeker	#01	High	Very positive in regards to teaching and showing how things work. You can physically show, instead of talking from outside the app.
	#05	High potential	Yes, I definitively think so. Speaking from previous experience, [...] people motivate each other, and dare to do more, as they can't see other real people looking at them.
Career counsellor	#02	High	In a situation where geographic distances are challenging, the concept is very valuable. The multiplayer concept is very interesting.
Career counsellor	#03	High	Has a lot of potential. Being able to communicate with VR headset on, being able to collaborate like that and being able to work with employers are good things.
Career counsellor	#04	High	In regards to VR as a remote guidance tool it is a very cool way of reaching many people. I thinks multiple users can increase engagement.

Table 7.3: Perceived value of the concept grouped according to the role of each interviewee.

Unlike the previous phases we decided to include direct quotations from participants of the target group as it shows their exact language and helps to point out important points. The following quotes presented below are opinions of participants from the interview process which we found to be both of value and interest. They are translated from Norwegian to English and grouped in corresponding themes.

Engagement

> *"I think VR creates engagement, because I see how gaming how affects how they collaborate and discuss to solve issues."*

> *"Engagement definitely increases, I would say. It is based on what I said earlier about collaboration in a workplace, it becomes more serious."*

Presence

> *"I have not used VR multiplayer too much before, it has mostly been single-user or turn based multi-user. So I have limited experience, but I felt the presence of another VR user as an avatar during testing. Movement, and what he was planning was understandable."*

Collaboration mechanism

> *"A laser pointer is very handy for counsellors, and if a user is wondering about something then you can point at the problem specifically. "*

> *"Voice communication worked really well. Obvious who said what."*

> *"...when people are talking a small talk bubble could appear, I think it would be better, especially if you are more than two users at the same time."*

Ease of use

> *"Downloading and getting started was easy. I think it was pretty clear and quite self explanatory."*

Quantitative Data Analysis

The data from the expert evaluation process was generated through a survey made using Microsoft Forms. See appendix B.3 for the full survey and answers. To get meaningful and interesting information out of it, we used similar techniques as the previous analysis phases to manage, view and analyse the data. The survey mainly consisted of ordinal data types from likert scales, a few nominal data types from categorical questions and finally one interval data type for the age of the participants. A benefit of utilising Microsoft Forms as our survey tool is that the data was automatically organised into visual aids such as bar and pie charts. Using these and the analysis we were able to identify interesting findings. The survey had 17 participants (experts in respective fields) consisting of 10 women and 7 men, all within the age group of 45-64 years.

The participants experience with VR was generally low, with 64,7% ranking it either *Very low degree* or *Low degree*, but this was to be expected as the use of VR in public sectors is not common. 35% experienced (used) the application on their own computer before answering the survey, whereas 65% saw the video presentation as mentioned in section 7.3.2.

Independent of their experience of the application there was common consensus amongst all participants in relation to various statements regarding career guidance and decision learning. Figure 7.8 and 7.9 shows the answers to similar statements but adapted depending on whether they used the application or watched the video presentation. As evident from the bar charts most participants ranked statements *High degree* or *Very high degree*. The mean being *High degree* with an average of 59% ranked for figure 7.8 and 60% for figure 7.9.

Figure 7.8: Bar charts showing participants who used the application ranking to various statements regarding career guidance and career decision.

Figure 7.9: Bar charts showing participants who saw the video presentation ranking to various statements regarding career guidance and career decision.

Most participants agreed that collaboration can contribute to decision learning in regards to career choice as seen in figure 7.10. Here the mode was *High degree* with 83.3% of participants ranking it. However 16,7% of participants were neutral in their opinion. This was the exact ranking received for another statement in regards to potentially increased engagement when there are multiple users present in the application, see figure 7.11. Interestingly, the participant were divided in how they experienced the feeling of presence affected the experience of the application as seen in figure 7.12. Here the mode was *Neutral* with 50%. *High degree* was ranked only 16,7% whereas *Low degree* was ranked 33,3% of the time. A clear spread of data values, illustrating a difference in opinion between the participants.

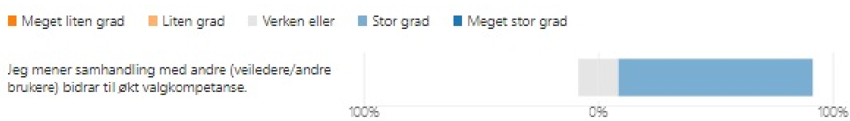


Figure 7.10: Bar chart showing the distribution of how the participants ranked according to the statement: *In my opinion collaboration with others (carer counsellor/other users) contributes to increased carer decision learning*.

Figure 7.11: Bar chart showing the distribution of how the participants ranked according to the statement: *In my opinion the engagement increases when there are multiple users in the application*.

Figure 7.12: Bar chart showing the distribution of how the participants ranked according to the statement: *To what degree do you feel the presence to another user affect the experience of the application*.

Of those who tried the application (total 6 participants) half of them used the VR mode and the other half used the desktop mode. Ranking how different collaboration mechanisms worked according to their experience of using the application 50% thought verbal communication worked to a *High degree*. The other 50% ranked it *Neutral*. Interestingly, as seen in figure 7.13, 33% (or 1/3) ranked the use of hand gesture as a communications method to a *Low degree*, the median and mode being *Neutral*. Also, one third ranked laser pointer to a *High degree*.

As for the participants perceived understanding of what other users in the application did and planned, 16.7% ranked it to a *High degree* and the mode being *Neutral* with 83.3%. One third (or 33.3%) of the participants thought the laser pointer mechanism worked to a *High degree*. Figure 7.14 shows how the participants perceived the subjective feeling of presence (first bar) and their conscious of other users in the application (second bar). Two thirds (66.6%) ranked *High degree* related to presence, whilst half (50%) also ranked *High degree* in regards to their conscious of other users within the application. No one ranked it below *Neutral* or higher than *High degree*.

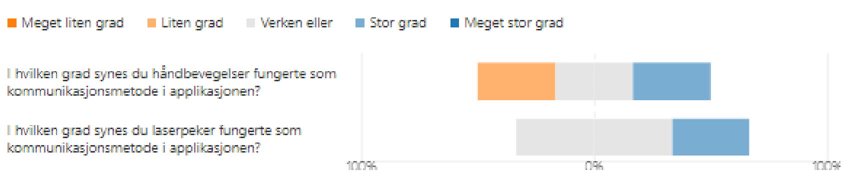


Figure 7.13: Bar chart showing the distribution of how the participants ranked hand gesture and laser pointer as a collaboration mechanism.

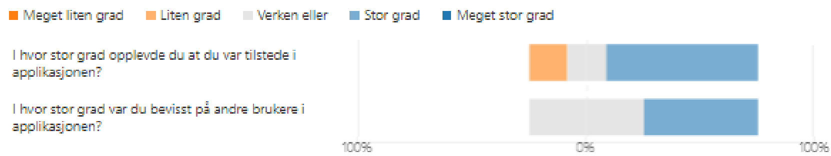


Figure 7.14: Bar charts showing the distribution of how the participants ranked the feeling of presence and their conscious of other users.

In regards to features which can facilitate the use of the application for remote carer guidance and to what degree they could be useful, the participants ranked several of them. These features included for instance verbal or written communication, ability to mark objects, and system intuitiveness. Figure 7.15 shows that participants heavily favoured verbal communication over written as a quality which is important for remote usage. Almost two thirds (64.7%) ranked verbal communication as *Very important* whereas none ranked in *Very important* for written communication. The mode and median being *Neutral*. For qualities related to ease of use and intuitiveness the mode was *Very important* for all, with an average ranking of *Very important* of 72%, which is almost three fourths of all answers. See figure 7.16. Additionally, figure 7.17 shows the distribution of their opinions regarding whether or not the application developed in this thesis can be useful for remote career guidance. 82% ranked either *Strongly agree* or *Agree*.

Figure 7.15: Bar chart showing the distribution of how the participants ranked verbal and written communication as useful qualities.

Figure 7.16: Bar chart showing the distribution of how the participants ranked statements related to intuitiveness and ease of use.

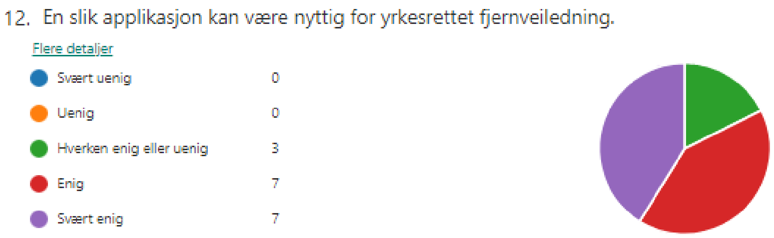


Figure 7.17: Pie chart showing the distribution of how the participants ranked how useful the application can be for remote occupational guidance.

The were also a strong general consensus that remote guidance in VR can be relevant for several use cases, including young job seekers, at school, as a result of geographical distance or due safety measures in workplaces. The mode for all, except one, was *Very relevant* with an average of 62%. The use case in context of unemployed as a cause of Covid-19 had the mode ranking of *Somewhat relevant* being the least ranked relevant use case with 11.8% ranking it *Less relevant*. Se figure 7.18.

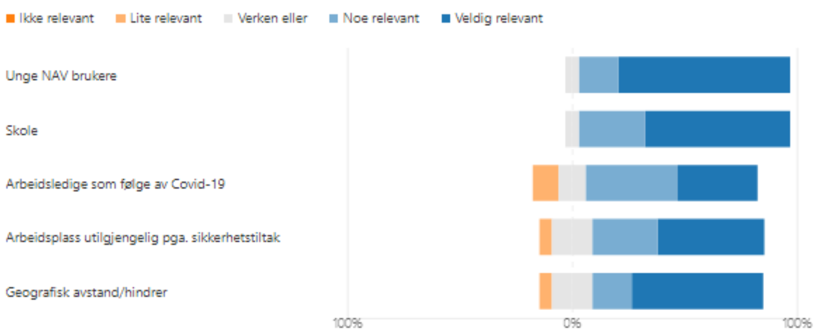


Figure 7.18: Bar chart showing the distribution of how the participants ranked how relevant the application can be for remote VR guidance.

SUS Score

The survey contained a section for a system usability scale (SUS). To interpret the score we used the same procedure as in phase 2 (see section 6.3.2). Firstly, we calculated the SUS score for each participant. There were a total of six scores as these participants were the one who had used the application during testing. The scores can be found in table 7.4 alongside their adjective rating and grade from table 6.3 in phase 2.

Participant ID	SUS score	Grade	Adjective Rating
16	60	D	Poor
2	62.5	D	Poor
1	65	D	Poor
15	65	D	Poor
4	68	C	Okay
17	72.5	B	Good

Table 7.4: SUS scores for participants sorted ascending by score.

This gives an average SUS score of:

$$\overline{SUS} = \frac{60 + 65.5 + 65 + 65 + 68 + 72.5}{6} = \frac{393}{6} \approx 65.5$$

According to table 6.3 this yields a *Poor* rating of the usability of the system. As the number of individual scores are low such scales are generally prone to being volatile and effected by widespread results. However, these score were all fairly close with the range (how far apart the highest and lowest scores where) being 12.5 points. This is just a variation of a single grade in the rating. The median SUS score was 65, which correlates to the rating *Poor*. This shows that there were a general consent that the usability of the system of could be improved according to the SUS method.

Chapter 8

Discussion

The outcome of the Design and Creation research strategy used for this thesis is a combination of the working system, methods, models and constructs. Once combined, these IT artefacts can offer knowledge to the research field [58]. In this chapter we will discuss the research question presented in chapter 1 in relation to the artefacts and the analysis results from the final phase. Limitations of the study is also discussed.

8.1 Discussion

The following sections explain and evaluate the results of the analysis done for the final phase of this thesis in relation to the developed artefacts and research questions.

8.1.1 The artefact

Table 8.1 lists and compares features from the related work applications presented in chapter 3 and the features which were implemented in our artefact supporting a collaborative VR environment aimed at facilitating career guidance. A "$\surd$" symbol indicates the feature is present, while a "$\div$" symbol indicates it is present, but in a limited fashion.

As evident by the table, the artefact supports all the features we identified in the preliminary research study to be important in hopes of answering the research questions set. Although all features provides value to the artefact, some turned out to be more advantageous and useful than others. The ability for remote usage was especially highlighted as a consequence of Covid-19 and stands to be a solution for similar events. While several of the related applications contained features that were useful, they did not have that specific combination that was wanted for this project. The artefact developed for this project contains a fairly unique mix of purpose and features, where multiplayer collaborative features are used to create a different form of career guidance for a different group of people.

Section 3.2 discusses ElectroVR, a collaborative learning tool in VR that is made to explore magnetism and electricity simulations. It uses co-located VR compared to our remote solution, and is such lacking key features such as voice chat. The other papers in

	Related Work				
Features	**Workplace Internship**	**ElectroVR**	**CoVAR**	**VR-JIT**	**Our artefact**
VR	√	√	√	√	√
Multiplayer		÷	÷		√
Workplace training	√			√	√
Collaboration		√			√
Real-world simulation	√	÷	√	√	√
Voice-chat					√
Co-located	√	√	÷		√
Remote			√		√
Symmetric role	√	√	÷		√
Asymmetric role		√	÷	√	√

Table 8.1: Related work applications and their features compared to our implementation.

chapter 3 also have interesting key points, such as *CoVAR*, seen in section 3.3, and its focus on interaction and gestures. There are not, however, many examples of a fully multi-user VR system for education and career guidance. The systems using HMDs are rarely made for multiple users, and the multi-user systems are usually a combination of AR and VR, or just AR.

Comparatively, the system created for this application is made to support remote and co-located multi-user career guidance with a focus on collaborative interaction. Users are encouraged to work together, discuss and reflect on the tasks. As mentioned earlier in section 3.1, this previous project for virtual internships had good results, but more interaction and feedback were some of the more requested features. After implementing precisely that, there is a clear indication that this is positive for the users. The results seen in chapter 7 are positive, and the following sections will look at their effects more in-depth.

8.1.2 Research Questions

Primary RQ: ***How does collaboration in virtual reality workplaces contribute to the career guidance of young job seekers?***

The primary goal of this research paper has been to discover whether or not collaborative VR is conducive to career guidance. Both the primary qualitative data and the secondary quantitative data that was gathered has a high degree of relevance concerning this question.

First and foremost, how did actual NAV clients and NAV employees compare the collaborative VR experience to a single-user VR experience? While the number of respondents and testers were not as high as wanted, even for a qualitative study, the opinions of the actual users of the system were extremely important. Not only had they tested the single-user VR experience already, many of them were currently in or had been in a situation where they needed NAV help to find employment. Looking at the qualitative data, we can see that the responses have been quite positive as the theme analysis in table 7.1 clearly shows.

Section 2.1.4 discusses the effects of CSCL, and the ways in which it can transform learning for the better. As discussed there, CSCL is an inherently social way of learning, and technology must support this concept in a meaningful way if you are to gain benefits from it. When properly employed, CSCL should lead to increased motivation and learning. Greeenwald et al. found that collaborative visual learning increased the understanding of all involved users [30]. Considering the gathered data in this project, one can begin to see somewhat similar results. Table 7.3 shows the perceived value of the concept based on interviews with the testers. One of the points brought up most often here is the concept of *engagement*. Looking at table 7.2 which shows metaphors and keywords that appeared, engagement is one of only three which was used in every interview. Respondents consequently refer to motivation and engagement as one of the biggest factors for successful use of collaborative VR. As shown in section 7.3.3 a counsellor said that *"I think VR creates engagement, because I see how gaming how affects how they collaborate and discuss to solve issues."*.

The engagement of users is an important aspect of learning. During the interviews, one of the most commonly discussed topics were how the inclusion of collaborative tasks would help raise the engagement of users. The NAV employees explained that with current single-user applications, users may grow tired of the VR applications after only a single use, citing boredom or repetitive tasks as the main reasons. They felt that with the inclusion of collaboration in VR, users would be more engaged and serious in their approach to the tasks. The interviewed NAV clients also expressed greater interest in the tasks when they were to be solved alongside someone else. It is also worth noting that the tasks used for the single-user version and the collaborative version did not differ at all, and were originally made to solved by a single person. This points towards collaboration in itself being the interesting and engaging factor, and not because tasks are more complex or engaging in and of themselves.

By collaborating, users are also placed in a position where the experiential learning cycle is more naturally employed. In the section regarding experiential learning in section 2.1.6, the experiential learning model as seen in figure 2.3 is highlighted for its relevancy in regards to self-efficacy and learning. The looping nature of the cycle allows learners to grow and reflect on what they have done before, and may work now. The collaborative aspect further strengthens the cycle by allowing users to discuss and reflect on what they have done so far. By doing this, users are able to proceed through the tasks with a greater sense of self-efficacy and a sense of accomplishment. The application includes light gamification elements such as a score list and checklists detailing what needs to be done. By including some of the aspects seen in 2.1.7 such as *serious games*, an attempt was made to strengthen the experiential learning cycle by providing objective feedback to give direction to users as well as create some discussion hooks for both job seekers and career guidance counsellors.

Interviewees believed that the collaborative aspects would allow the users to push each other to be better in a peer setting, or allow for more hands on motivation and assistance when collaborating with a career counsellor or similar. One user remarked that *"Engagement definitely increases, I would say. It is based on what I said earlier about collabora-*

tion in a workplace, it becomes more serious." as seen in section 7.3.3. This contributes to a higher sense of presence as the users become more immersed in their tasks as discussed by Greenwald in his 2017 paper [30].

The secondary data also seems to support these points. As seen in figure 7.10, 83.3% of the survey respondents believed that collaboration would lead to increased career decision learning with 16.7% responding with *neutral*. The same distribution appears in figure 7.11, mirroring the qualitative data results. Comparing to the literature, this matches the finds of Madathil's 2017 paper [47] as seen in section 2.1.5.

While VR can offer great advantages for learning, there are as outlined in section 2.1.6 several aspects to consider. Table 2.4 showcases some of the aspects one needs to consider for learning in VR. Several, if not all, of these aspects must reach a level of quality in order to provide a good learning environment. While the previous VR workplaces appear to have done well in these aspects, the affective aspect seems to hold a lot of weight when it comes to user satisfaction. The affective aspect is concerned with user engagement and confidence in the virtual environment, and it is specifically these aspects that the data would indicate the collaborative features are improving. Collaborating in VR will however do little to the *orientation*, *cognitive* and *technical* aspects, for example. These must be improved in other ways, while the *pedagogical* aspect is more dependent on *who* you are collaborating with and how they work with you.

Furthermore, there generally appears to be a positive outlook on the possibilities of the concept. Figures 7.17 and 7.18 showcase a majorly positive result for remote career guidance, highlighting another avenue in which the collaboration in VR can contribute to the career guidance of young job seekers. This is also the case for social skills. Throughout the interviews, respondents agreed that the artefact could function as a safe way to introduce workplaces to those struggling socially, allowing for a safe environment where they can speak to either employers or career counsellors. Adding collaboration into a Virtual Internship application means that it inherently receives an social aspect. As outlined in the background, see section 2.1.4, this social aspect influences the learning, and vice verse. The learning outcome from the application is inherently different from the knowledge which a user would gain from a single-user application lacking collaboration. Although according to our analysis CSCL seems to be a good fit for the VR workplace applications, that may not be the case for every type of career guidance application, and its use needs to be considered on a case-by-case basis.

Secondary RQ1: ***How is career-guidance affected by seeker-seeker collaboration compared to seeker-counsellor collaboration in virtual reality?***

Several features were implemented and numerous aspects were considered so that the artefact could support a wide range of different use cases. This includes a traditional career guidance situation with one seeker and a counsellor, but is not limited to it. The application system can handle any number of seekers and counsellors (up to 16) at any given point, using either VR equipment or a traditional desktop. This means users can utilise the application in a great number of different circumstances. For instance, four young job seekers situated in Trondheim can join a virtual workplace environment from their NAV facility or at home, while a business manager situated in Oslo can show how they operate whilst at the same time a counsellor observers the situation. Since the application supports both symmetric and asymmetric roles, plus remote or co-located usage, which based on our research of other applications does not exist for career guidance cases, it would be very interesting to see how this could affect young job seekers and their self-efficacy.

As previously described, the Covid-19 pandemic heavily impacted our ability to collect data material in regards to this research question. Described in section 6.2.3 the restrictions by the Norwegian government meant proper data collection was not feasible. We were not able to collect the desired amount of interviews from both seeker-seeker and seeker-counsellor pairs. The sample size meant the data material was not suitable for making generalisations of the target group, which generally requires a larger sample size [58]. We could there not justify any valid discussion or conclusions related to the research question since we did not possess reliable and rich data.

This research question will thus become a suggestion for future work. See section 9.3.

Secondary RQ2: ***Which features are effective at facilitating collaborative virtual reality for remote career guidance?***

There are many concepts which are important to consider and contemplate when regarding the use of collaborative VR for remote applications. First and foremost, the subjective feeling of presence, especially social presence, should be considered the bedrock for VR if it is to be applied effectively for collaboration. Explained in section 2.1.2, a low feeling of social presence greatly impacts the overall experience of the application amongst its users. Factors such as visual representations of users (avatars), interaction with other agents and more behaviourally realistic visual representation has been shown to increase both involvement and engagement [68] [59].

Interestingly, as shown in our analysis, figure 7.12 illustrates that the experts evaluation regarding the affect of social presence on the experience is divided and does not directly align with the research theory. This might be a direct result of experts lack of knowledge in the VR field, as the concept of presence is often misunderstood as being immersed. However, if we look at figure 7.9 we can see that a very similar statement: *To what degree do you feel the presence of another user is useful for developing career decision learning?* was ranked *High degree* by 63.6%. Although not similar, these statements are concerned about the same concept (social presence), but they show different results depending on how they experienced the application. It is evident they perceive the value of presence differently, and should be taken into consideration. The being said, these data results are regarded as support material due to the circumstances explained before and in an ideal world all testing would have been conducted using VR headsets or desktop mode so that they get a proper feel for the artefact. Noticeably, figure 7.14 shows experts perceived a relatively high degree of presence and social presence from the artefact. Although a few rankings were sub neutral there is a clear common consensus that they feel access to another intelligence and its intentions. This is further strengthened by the mentioned experience of a user shown in section 7.3.3, *"I have not used VR multiplayer too much before, it has mostly been single-user or turn based multi-user. So I have limited experience, but I felt the presence of another VR user as an avatar during testing. Movement, and what he was planning was understandable."*.

As we described in the background, workspace awareness is important for how users can collaborate efficiently [35]. Thus elements presented in table 2.1, 2.2 and 2.3 are all especially vital to consider for any application to be used in a remote setting. If a user lacks awareness of another user's intentions then they have trouble understanding what goal and outcome actions they execute is part of. Resulting in a disorienting experience for both users. The awareness of present actions is particularly crucial for counsellors observing other seekers in the workspace. Also, the ability to to explain how tasks work in order to provide assistance within the same virtual environment is a clear benefit compared to existing NAV applications where instructions was coming from the outside environment, resulting in a disconnected and difficult experience. With the artefact created for this thesis counsellors can effortlessly communicate with all users (e.g job seekers) using the built in voice communication component while simultaneously being present in the same virtual environment, which according to table 2.3 benefits the workspace awareness. Experts heavily agreed that verbal communication is a useful quality if the artefact is to be used for remote guidance as seen in figure 7.15. One user said that *"Voice communication worked really well. Obvious who said what."*, see section 7.3.3. This strongly indicates that the voice communication implemented is at a sufficient quality level to support the needs of the users.

How developers utilises the advantages of VR embedded in the technology is decisive, as it can cater to and empower users that are not situated in the same geographical area to collaborate, share and learn about a workplace or career direction. During the development of artefact we included the ability to apply mechanisms of deixis to demonstrate and collaborate. Section 2.1.3 discusses in length what can be done to increase the awareness of users participating in groupware. Mechanisms of deixis fall under the term *simplification of communication*. By enabling communication and coordination, users are able to work together more efficiently. Table 2.3 describes the most important activities of collaborating in a workspace, and can be used to strengthen remote collaboration. This is important as it increases the learning effect [71] and should work seamlessly despite any geographical or networking hindrances. If not, this could heavily distort the artefact's ability to facilitate remote guidance.

For any artefact to be effective for remote usage, we assumed the the process of installing, setup and application use must be easy so that as little as possible of technical support is needed. No one wants to use a system which is hard or difficult to use. It simply becomes too much of a burden so that other solutions such as video conferences are used. As such, during the development we put considerable effort into making sure the artefact could be as intuitive and easy to use as the time-frame allowed. Table 7.1, 7.2 and figure 7.16 show that both survey participants and interviews generally agree that the artefact is intuitive and has a high degree of ease of use. Notably, a young user said during the interview that *"Downloading and getting started was easy. I think it was pretty clear and quite self explanatory."*, see section 7.3.3. However, there are inconsistencies with the survey rankings and the SUS score, which provides a scale on the usability of the artefact. The average SUS score yielded a poor rating of the usability, meaning there is potential for improvement. An important note is that all participants of the survey (which gave the SUS score) was all in the age group of 45-64 and 65% of those had little to none experience with VR. This could have impacted the results but there is no way of conclusively knowing without doing further studies.

Although VR has become more readily available to consumers, there is still a large percentage who does not have the means to access the equipment needed to experience a VR environment. With the inclusion of the desktop mode in the artefact and through gamification principles we attempted to lower the threshold for the artefact to be used in remote settings. From the survey (where half used desktop mode) it was quite evident that this was supported by the experts as there was a high agreement that such an application could be useful for remote occupational guidance (see figure 7.17). This reasoning is also supported by career counsellors in the interview as seen in table 7.3. However, the desktop mode does not have the functionality VR mode has, meaning interaction with the environment is very limited, and might impact the experience. The intent of the desktop mode was primarily to let counsellors observe seekers in the workplace so that not much functionality was put into the feature. Seeing its potential this could be improved further and perhaps become part of a future IMTEL project.

Secondary RQ3: ***What type of collaborative features are technologically feasible for virtual reality workplaces?***

The use of VR as Virtual Internships as a mean to inform and educate young job seekers with the added element of multi-user functionality opens up a whole new challenge for developers. What features can be added so that it supports and enhances collaboration amongst users (e.g. seekers and counsellors) is difficult to answer conclusively, but some are explored in this thesis.

Throughout this project we developed several features based on feedback and analysis of data materiel. The very first collaboration mechanism was gesticulation, specifically hand gesticulation, using the avatar representations of the users. This is a common and effective technique for adding presence and identity in relation to workspace awareness as outlined in section 2.1.3. Virtual 3D environments natively provides opportunities for this and can thus contribute with valuable awareness information according to Dyck and Gutwin [25]. Later, voice communication and laser pointer was added as it was deemed necessary for collaboration to be effective and would satisfy the needs of the counsellors and seekers which was not present in the first prototype. A counsellor remarked that *"A laser pointer is very handy for counsellors, and if a user is wondering about something then you can point at the problem specifically. "*, as seen in section 7.3.3. By our analysis, see figure 7.13, these features were mostly able to fulfil their objective aimed towards collaboration and workspace awareness. Gesticulation and user representation where also keywords found in the theme analysis, see table 7.2.

While the difficulty of implementing them into a multi-user project varies, they are technologically feasible. Both gesticulation and voice communication logic was abstracted away and put into reusable prefabs so that little work has to be done for new developers to utilise these collaboration mechanisms. Using the prefabs should exclude the need for data serialisation and synchronisation, while being customisable if the need should arise. This means future developers do not need to be concerned with the underlying client-server architecture as described in section 2.2.4. The implementation of laser pointer could, depending of what HMDs are used for the workplace experience, need some configuration to support the same action (press to enable laser) due to differences in controllers and thus different buttons amongst suppliers.

When developing a single-user VR application there is no need to consider how the user is represented, just the hands are visible to the player. This changes for multi-player applications. There is a distinct need to translate real world movement into corresponding actions represented by an avatar. It provides elements of presence, identity and awareness such as where they are looking or what they are doing. Our solution was simple, a clear and common avatar with a torso, head and hands. This could perhaps be improved by implementation a full body avatar. However it is extremely difficult to implement without using sensors placed on a users body in the real world to translate position data. There was also no mention of this from either the interviews or survey, so this is a feature we would deem not necessary as it also provides little additional value. One must also consider drawbacks such as uncanny valley, yielding an unsettling feeling for the users. Section 2.1.2 discusses the role of an avatar and how the possible different depictions and behaviours can impact a user's feeling of presence. While a full body avatar may be more realistic than a floating head, hands and a body, the increase in presence is not going to be linearly dependent on the realism. As mentioned in the *Social Presence* section in chapter 2, a commensurate increase in realistic behaviour is needed to prevent it from becoming detrimental to social presence instead [59].

The most common VR HMDs today cannot track eye positions, so there no definite way of knowing where users are looking. We can only assume it based on their head position. Gazing, the principle of looking at something for a period of time, is an feature which was not implemented in the artefact. However it could provide some value for collaboration as users could stare at objects and actions could be triggered (change colour etc.). Using ray-casting this could implemented, allowing users to either mark objects, or perhaps career counsellors could see summaries of what objects caught the attention of job seekers.

An important aspect to consider when implementing collaborative features is that they must be visible and clear for all users. Different resolutions and FOV in HMDs could all impact the success of the features. Table 2.5 outlines that the number of pixels used in the HMD effects the details in the application so that small text or objects can be experienced differently for the users depending on their VR hardware. It is therefore important to keep it in mind so that features does not differ to such an extent that they become useless.

The artefact developed contained both a VR mode and a desktop mode. The collaboration features was mainly implemented for the VR mode. The desktop mode had only voice communication and the ability to use their position as a marker. Due to the different circumstances, the limited amount of time meant that this was a low priority. However, as testing was done in the final phase we experienced that it would be very useful to at least include one or two more collaboration mechanisms. That way this mode could be used to a greater extent than just observation for career guidance. Using gamification principles, one could adapt common video game features and thus lower the threshold for its use. This could also help improve the ease of use which was an identified theme in the analysis, see table 7.1.

Secondary RQ4: ***What challenges arise when implementing collaborative features in an ongoing single-user virtual reality project?***

As described in the chapter 1, this thesis could be regarded as a branch project of the Virtual Internship project. No previous projects have been develop with multi-user capabilities or with that in mind. There was therefore a wide range of obstacles and challenges which was encountered during the three phases of software development. First of all, it is the fact that single-user VR projects do not need to be concerned with anything related to networking. Described in section 2.2.4 and illustrated in figure 2.6 and 6.4 a multi-user application such as ours often uses a client-server architecture. Hence, every action in the application done by one user needs to transferred to all other users with matching data so that state is synchronised. This means the foundations of a single-user project are often not suited for it be evolved into a multi-user application which supports collaborative features.

What we found during the development was that there were little to no project structure or followed code standards. It was obvious the application selected was a students bachelors project where Unity and VR development was new for most of them. Thus the lacking structure and inconsistencies should be considered an expected consequence. In the case of IMTEL's future Virtual Internship projects we recommend that they create a basic template for how development should be done and code should be structured. This is however difficult to adhere to as projects differ, but should at least provide some level of similarity between projects resulting in a better foundation if they were to be further developed as multi-user applications.

There a few technical prerequisites that need to be in place before development can begin to implement collaborative features. However, some aspects determine the intricacies of implementation. These include the complexity of the application and underlying game elements, cohesion of code, numerous elements which needs networking and game state. With respect to technical requirements, there needs to be at least four things in place. First, (1) a client-network architecture for data transmissions, (2) a lobby system for joining or creating instances of scenes, (3) code (scripts) to handle networked objects and finally (4) managers for for keeping track of game state and general network related requests. A partial goal of this project was to create a general framework (including prefabs, scripts and lobby system) for future use. With this framework the difficulty of accommodating collaborative features drastically reduces. To further reduce difficulty we created a demo application in our artefact so that it could be used as a guide for development and implementation.

Consideration must also be made towards what type of project benefits and is suitable for collaborative features. As an example is the *Wind turbine electrician* application [38]. Here there are limitations in regards to virtual space within to the wind-turbine so that having multiple users could present a crammed feeling for the users resulting in a negative experience. Also, the PUN2 cloud service used in the project has a limit of 16 concurrent users (CCU). If an application needs to support more than that there are basically two options: pay for more capacity in the Photon cloud or change framework. However, having more than 16 CCU is an unlikely use case for career guidance, the aim of the Virtual Internship is not to be a massively multiplayer online game (MMO).

From experience there should also be at least two developers devoted to the task as it is very challenging to test collaboration features, or any other networking solutions with one developer. Additionally, for implementation purposes there should be an agreement of utilising a common VR SDK. Outlined in section 2.2.3 SteamVR is a great choice as it enables support for building applications for major VR headset brands with little change. This yields a higher degree of users which can utilise the collaborating features, although some configuration could be needed. Another consideration could be OpenVR.

8.2 Limitations

While the overall project has been successful and produced a functional artefact as planned, testing was impacted by Covid-19. As a direct result of the pandemic, the amount of testers decreased, which also may have lead to some selection bias.

Originally, the plan was to test with NAV clients, which would allow for a good distribution of testers. This would include people from the entire spectrum of familiarity with technology and make sure that the artefact was usable to everyone, not just those who have used VR before. With the stay-at-home situation, testers were significantly harder to gather. Those that agreed to join us for remote testing already had VR headsets at home, or at least an interest in the technology, which introduces bias in the tester pool on top the already small selection. While it is hard to pinpoint the exact reason for this, and most likely it is simply based on the low amount of testers, we were not able to test the final application with female job seekers. On the other hand, female career counsellors were over represented compared to males. There was also no opportunity to test the artefact in schools, as was originally planned.

Chapter 9

Conclusion

In this chapter we present our contributions, conclusions and recommendations for future work.

9.1 Conclusion

This master thesis has looked at several aspect including the effects of collaboration and remote career guidance, but also more technical aspects related to development and challenges. There is a clear benefit and value of having collaboration possibilities in virtual environments for career guidance. It yields positive effects in regards to engagement of the users and decision learning. Collaboration also impacts young job seekers self-efficacy and social skills.

For remote career guidance we found the most important features to be the ones that help simplify communication such as deictic gestures, laser pointers and voice communication. Avatars must be behaviourally realistic, not necessarily visually. The application must also be easy to install and intuitive to use to make sure that users do not quit before getting started. These features are also technologically feasible for VR workplaces.

Single-user VR applications are to begin with not developed for collaboration. This means that you can make a number of assumptions and rules that no longer work in a collaborative environment. Depending on how much code is based around there only ever being one player is made, significant challenges may arise. If the code is not documented, a lot of time may need to be spent understanding the old code. However, it is quite possible to add multi-user functionality with varying degree of difficulty. Complexity, clean code and the number of elements which needs networking all impact this. As such a framework such as the one we have developed can help accommodating collaborative features. In essence, the most important part is to adhere to principles such as high cohesion - low coupling and other similar coding practices. Avoid shortcuts where you can and make sure artefacts are well documented.

9.2 Contributions

This project has achieved positive results in regards to the hypothesis. The previous section outlines the answers to the research questions discussed in chapter 8. In addition to the findings themselves, the research has also produced artefacts usable for later research. They will serve as additions to the research so that research about multi-user and collaboration aspects can be made easier for future projects.

- Extensible lobby system
- PUN2 network prefabs
- Prototype collaborative VR career guidance system
- Strong support for collaboration in career guidance

9.3 Future Work

Future work and suggestion for future projects is given here. These suggestion are based on the authors experience from the research project presented in this paper.

9.3.1 Secondary RQ1

While our research found collaboration in VR impacts career guidance, this thesis can not provide valid discussion or conclusions on whether or not this changes depending on the use of seeker-seeker collaboration or seeker-counsellor collaboration. We therefore suggests that future work could investigate the self-efficacy gained from of seeker-seeker collaboration compared to seeker-counsellor. The artefacts from this thesis could be used as platform for testing.

9.3.2 New Hardware

In order to make it easier to test quickly and efficiently, we recommend making use of hardware such as the Oculus Quest [39] in order to minimise the amount of hardware needed to run the applications. Such hardware does not rely an a separate computer to contain the VR engine, meaning they are standalone VR devices (see section 2.2.5). Our experience while testing showed that many schools and corporations had bought Oculus Quests in large numbers, but had relatively few standard VR headsets, much less computers to run them on.

Alternatively, more can be done to make use of the more expensive ”standard” VR headsets, such as the Valve Index, with increased feedback and detailed hand gestures to increase realism and user presence.

9.3.3 Desktop Mode

While the desktop mode was not originally planned, its inclusion garnered positive feedback and a desire to see more functionality added to it. Expanding its features and allowing greater interaction with the scene while in this mode could increase the availability and usability of the artefact, and allowing a larger variation of use scenarios. The time allotted for this project did not allow for a thorough examination of potential features, but preliminary feedback would indicate that the most desired features are a laser pointer, the ability to interact with objects and more highlighting opportunities.

Depending on the extension of this mode, it may also be relevant to change the avatar and movement mode to something more akin to the VR players, i.e., a humanoid avatar with movement affected by physics constricted to ground level. It would be interesting to see how this affected collaboration and whether or not it is jarring for a VR user to collaborate with a humanoid avatar with less natural movement and behaviour like a desktop avatar would bring to the table.

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Appendix A

Concent Form

A.1 Consent form

A.1.1 Consent Form and Information Letter

Virtuell praksisplass VR/AR: videreføring og utprøving

Prosjektleder: Professor Ekaterina Prasolova-Førland, ekaterip@ntnu.no, tlf 99440861
Koordinator NAV: Heidi Fossen heidi.fossen@nav.no tlf 916 27 606

Informasjonsbrev og samtykkeskjema

Forespørsel om deltagelse: utvikling av virtuelle praksisplasser/virtuelle jobbsmaker med spill-baserte elementer i virtuell og utvidet virkelighet (VR/AR)

I dette prosjektet vil vi utvikle forskningsbaserte 'virtuelle praksisplasser' ved hjelp av innovative virtuell og utvidet virkelighet (VR/AR) teknologier med spill-elementer. Vi vil finne ut om disse teknologier og spill-basert læring kan benyttes som verktøy som motiverer og informerer brukere på vei mot arbeid. Gjennom simulering av en arbeidsplass får brukeren et innblikk i hva de driver med, og prøver selv: for eksempel hva det innebærer å drive med oppdrett. NTNU er behandlingsansvarlig institusjon for studien.

Basert på resultatene fra en kartleggingsrunde blant NAV-brukere og ansatte og input fra arbeidsgivere har vi utviklet VR/AR app-prototyper med spill-elementer som representerer arbeidsplassene/bransjene Oppdrett, Helse/Velferd og Kontor og senere Jobbintervju. Vi testet disse appene med brukere og ansatte i NAV i 'lavt-nivå' VR (Google Cardboard) november-desember 2017. Basert på tilbakemeldinger laget vi en ny versjon av Oppdrett/Fiske-appen (FiskeVR) med 'høyt-nivå' VR (f.eks HTC Vive og Mixed Reality headset), en jobbintervjuapp i VR, pluss prototyper i VR som representerer nye yrker. Disse er elektriker/vindmølleoperatør, vei/anleggsarbeider, bilmekaniker og blikkenslager og varianter av disse (f.eks med samhandlingsfunksjon), pluss en VR 'yrkeskatalog' der alle appene er samlet. Vi skal nå teste disse appene. DIN tilbakemelding er veldig viktig for oss for å lage innovative spill-løsninger i VR/AR!

Eksempel Bilverkstedapp

Hva innebærer det å delta?
Du vil først få prøve VR/AR appene. I prosessen kan vi be deg 'tenke høyt' og kommentere det du gjør. Etter utprøvingen vil vi be om tilbakemeldinger i form av deltakelse i fokusgrupper, spørreskjemaer og evt. i intervjuer. De som ønsker å delta i videre runder, vil være med og evaluere mer avanserte spill-prototyper som vi utvikler.

Hvilke data samles inn?
Det samles inn lydopptak (under intervjuene og evt. under testingen), bilder og svar på spørreskjema. Det kan bli tatt bilder av deg og de andre deltakere under demoer for å dokumentere hvordan utstyret brukes. Dette vil være delvis anonymisert, da bildene vil for det meste bli tatt bakfra og ansiktene vil være skjult bak VR briller under mesteparten av utprøvingen. Diskusjonen i fokusgruppene/intervjuer

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og kommentarer under testingen skal tas opp med lydopptaker. Spørreskjema skal fylles på papir eller nettbrett/datamaskin/online. Disse dataene skal behandles konfidensielt. Det kan være aktuelt å foreta videoopptak med ansikt skjult bak VR/AR briller samt samle inn bruksdata fra selve spillene, f.eks. oppnådd poengsum, målt puls under spillsesjoner, tidsbruk, opptak av spillsesjoner (screencapture der brukere framstår som avatarer) osv.

Oppbevaring og bruk av data
Alle personopplysninger vil bli behandlet konfidensielt. Deler av opptakene vil bli transkribert (skrevet ned) og lagret elektronisk. De skriftlige dataene vil bli avidentifisert, slik at opplysningene ikke kan knyttes til enkeltpersoner. Alle data vil bli oppbevart i henhold til gjeldende regler for forsvarlig lagring av personopplysninger og kun personer knyttet til prosjektet vil ha tilgangs til disse. Alle data vil bli anonymisert ved prosjektslutt (31.12.2021), og det er kun anonyme data som kan bli gjort tilgjengelig etter prosjektets avslutning. F.eks. lyd og evt. videoopptak vil bli slettet når transkribering og analyse av dataene er avsluttet og senest ved prosjektets slutt bortsett fra utvalgt video- og fotomateriale der ansikter ikke er synlige. Disse og opptak fra innsiden av spillene vil kunne bli brukt for demonstrasjoner i forskningssammenheng på en slik måte at ingen informasjon vil være knyttet til enkeltpersoner. Avidentifiserte data kan bli brukt i vitenskapelige publikasjoner og i arbeid med å videreutvikle innovative løsninger for brukeroppfølgning.

Dine rettigheter
Så lenge du kan identifiseres i datamaterialet, har du rett til:
- innsyn i hvilke personopplysninger som er registrert om deg, og å få utlevert en kopi av opplysningene,
- å få rettet personopplysninger om deg,
- å få slettet personopplysninger om deg, og
- å sende klage til Datatilsynet om behandlingen av dine personopplysninger.

Hvor kan jeg finne ut mer?
Hvis du har spørsmål til studien, eller ønsker å benytte deg av dine rettigheter, ta kontakt med:
- Prof. Ekaterina Prasolova-Førland (NTNU), ekaterip@ntnu.no, tlf. 99440861.
- Vårt personvernombud: Thomas Helgesen, thomas.helgesen@ntnu.no, tlf 93079038.

Frivillig deltagelse
Deltagelse i utprøvingen er frivillig og samtykke kan trekkes tilbake når som helst. NAV-ansatte får ikke tilgang til råmaterialet med personopplysninger, men kun aggregerte anonymiserte data. Det vil ikke få noen innvirkning på NAV-brukernes forhold til NAV dersom de velger å takke nei til deltakelse. Prosjektet er meldt til Personvernombudet for forskning, Norsk samfunnsvitenskapelig datatjeneste AS.

Erklæring om samtykke

Jeg samtykker i at dataene fra studien kan lagres og brukes til forskning- og utviklingsformål slik det er beskrevet ovenfor

Navn_ Sted/dato _

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Virtuell praksisplass VR/AR: videreføring og utprøving

Prosjektleder: Professor Ekaterina Prasolova-Førland, ekaterip@ntnu.no, tlf 99440861
Koordinator NAV: Heidi Fossen heidi.fossen@nav.no tlf 916 27 606

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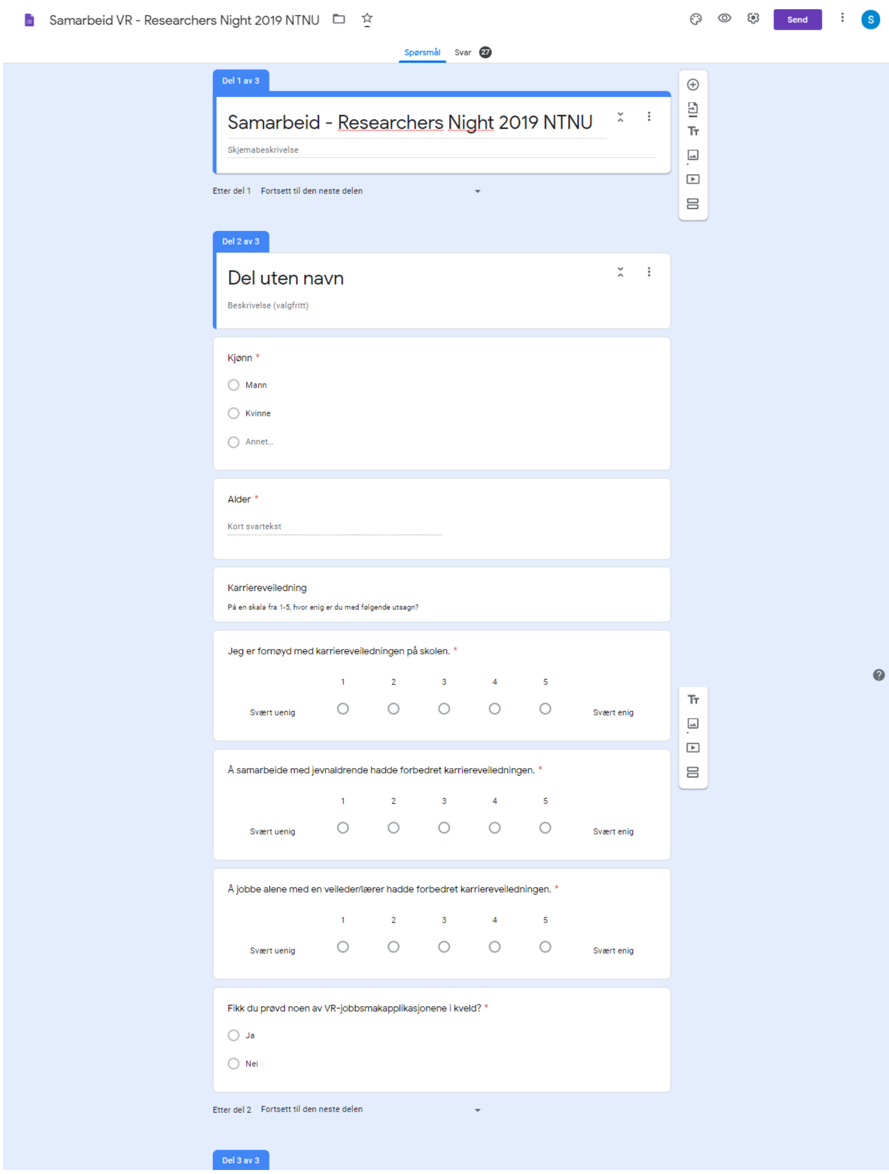
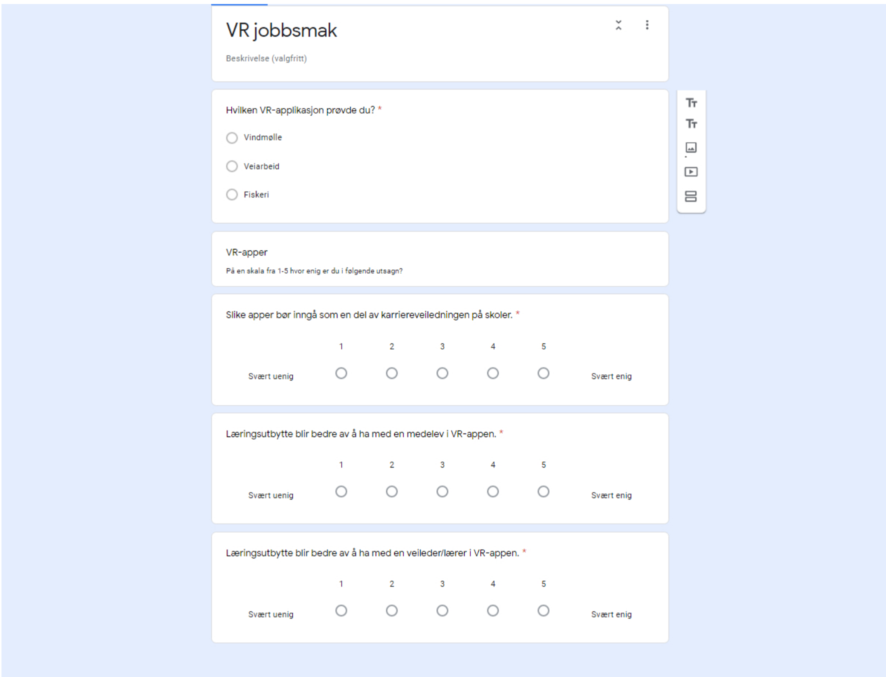
Appendix B

User Test Results

B.1 Phase 1

B.1.1 Researchers Night 2019 Full Survey





VR jobbsmak

Beskrivelse (valgfritt)

Hvilken VR-applikasjon prøvde du? *

- Vindmølle
- Veiarbeid
- Fiskeri

VR-apper

På en skala fra 1-5 hvor enig er du i følgende utsagn?

Slike apper bør inngå som en del av karriereveiledningen på skoler. *

Svært uenig 1 2 3 4 5 Svært enig

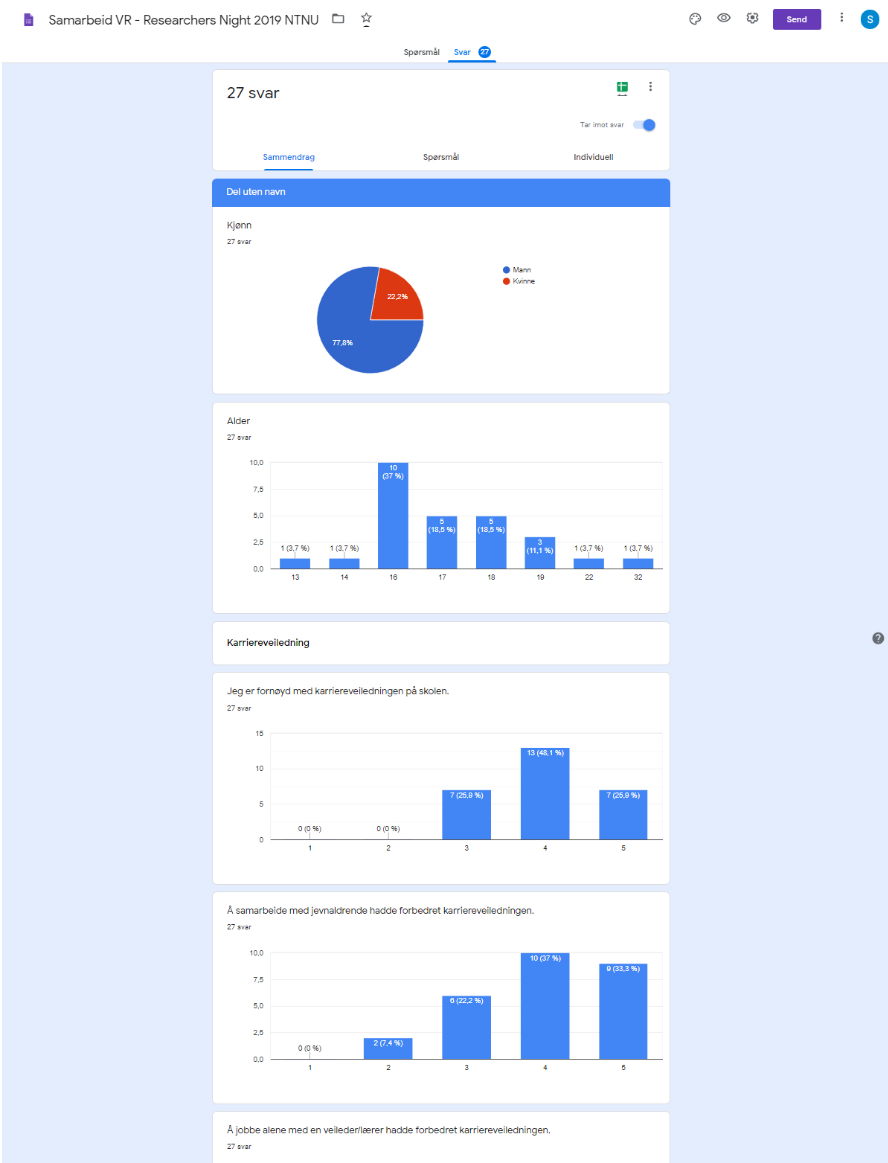
Læringsutbytte blir bedre av å ha med en medelev i VR-appen. *

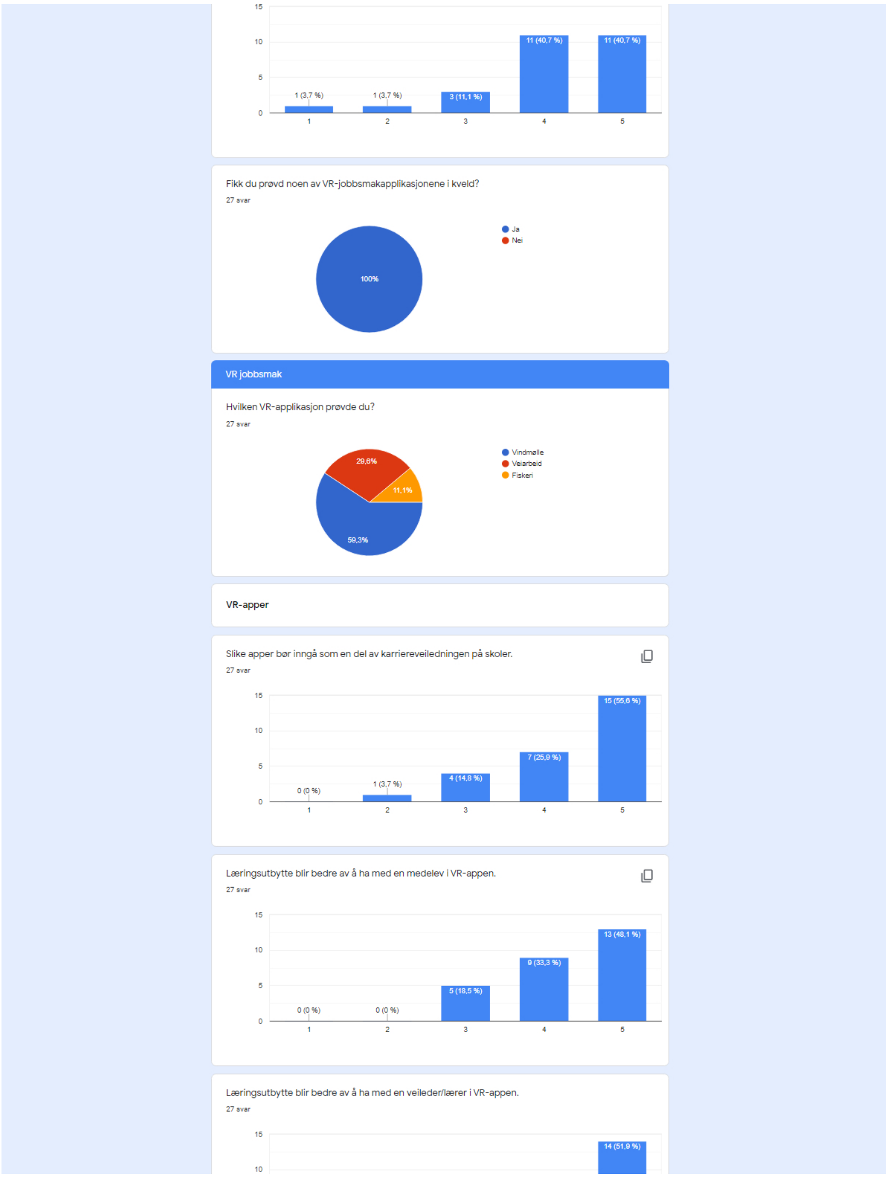
Svært uenig 1 2 3 4 5 Svært enig

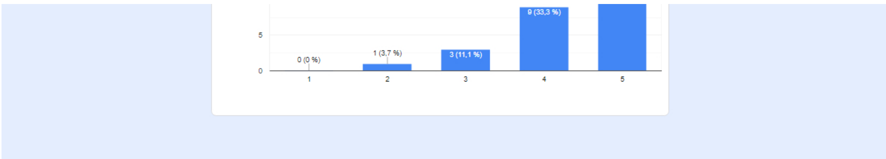
Læringsutbytte blir bedre av å ha med en veileder/lærer i VR-appen. *

Svært uenig 1 2 3 4 5 Svært enig

B.1.2 Researchers Night 2019 Survey Answers




15
10
5
0
1 (3,7 %)
1 (3,7 %)
3 (11,1 %)
11 (40,7 %)
11 (40,7 %)
1
2
3
4
5
Fikk du prøvd noen av VR-jobbsmakapplikasjonene i kveld?
27 svar
100%
Ja
Nei
VR jobbsmak
Hvilken VR-applikasjon prøvde du?
27 svar
29,6%
11,1%
59,3%
Vindmølle
Veiarbeid
Fiskeri
VR-apper
Slike apper bør inngå som en del av karriereveiledningen på skoler.
27 svar
0 (0 %)
1 (3,7 %)
4 (14,8 %)
7 (25,9 %)
15 (55,6 %)
Læringsutbytte blir bedre av å ha med en medelev i VR-appen.
27 svar
0 (0 %)
0 (0 %)
5 (18,5 %)
9 (33,3 %)
13 (48,1 %)
Læringsutbytte blir bedre av å ha med en veileder/lærer i VR-appen.
27 svar
14 (51,9 %)



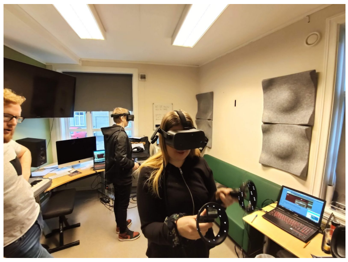
9 (33,3 %)
5
1 (3,7 %)
3 (11,1 %)
0 (0 %)
0
1
2
3
4
5

B.1.3 Semi-structured Interview at NAV Jobbhuset Falkenborg

Fokusgruppe

Forord

Denne testingen ble utført 25. november 2019 på NAV falkenborg. Dette er samfunnshus NAV drifter og holder forskjellige arrangementer for ungdommer som står utenfor arbeidsmarkedet. Vi fikk allokert et rom for utprøving av applikasjonen (fase 1 av prosjektet) hvor to og to testet. Deretter ble det kjørt semi-strukturert intervju etter at personene hadde signert et samtykkeskjema. Aldersgruppe var 20 - 24 år.
Vi stilte med utstyr for å gjennomføre testingen. Dette inkluderte to MSI laptops, og to MR(mixed reality) headset at typen HP (generasjon 1 og 2). Rommet var av begrenset størrelse, men vi fikk likevel gjennomført og testet tilstrekkelig. Se bilder.

Nedenfor er notatene for innsamlinger strukturert i en tabellform. Ettersom testing krever flerspiller for samarbeid ble det kjørt tester i par. Tabellen viser testpar, tabell ID og tilhørende rolle under testing

	Skjema ID	Rolle
Testpar	#01	Jobbsøker
	#02	Jobbsøker
Testpar	#03	Jobbsøker
	#04	Jobbsøker
Testpar	#05	Jobbsøker
	#06	Veileder

ID: #01
Hvem snakker vi med? NAV-ansatt/jobbsøker 1/jobbsøker 2 etc. Kombinasjon desktop/vr/jobbsøkere/veiledere?
Kjønn: Mann Rolle: Jobbsøker To unge voksne menn i 20-årene. Begge er jobbsøkere. Ingen NAV-ansatt tilstede under utprøving eller intervju. Kombinasjon med to VR headset med rolle som jobbsøkere i VR modus.
Erfaring med VR?
Har prøvd Playstation VR (PSVR) før på egenhånd. Utenom det har jeg bare brukt utstyret NTNU har stilt med.
Erfaring virtuell praksisplass?
Ja, har jobbet med det før. Har testet lakseoppdrett applikasjonen.
Hvordan var opplevelsen av å være flere sammen i VR?
Blir bedre uansett, mer stemning, savner skins
Hva var inntrykket ditt av innlevelsen ("immersion") av å være flere sammen?
Det ble mer engasjerende
Ser du verdi av samarbeid i vr for NAV-veiledning?
Artigere å jobbe. Vil gjerne jobbe med oppgaver som KREVER/MÅ være flere. Tidsbasert. Fokus på ikke utfordrende, men ikke for vanskelig for litt tidspress. Justere for eventuelt nye søkere.

Savner du noe spesifikk funksjonalitet?
Snakking er kanskje all kommunikasjon man trenger. Flere muligheter for å peke utenom bare hånden. Kanskje en laserpeker eller noe sånt.
Andre kommentarer?
Knusbare vindu

B.2 Phase 2

B.2.1 Full Survey

Spørreskjema for brukere

ID:

Hovedintensjonen for dette for intervjuet er å utforske potensiale og begrensninger for virtuell virkelighets arbeidsplass med samhandlingsmuligheter som en del av masteroppgaven hos IMTEL labben på Dragvoll NTNU. Vi har et samtykkeskjema for å delta i dette forskningsprosjektet som beskriver hva prosjektet omhandler og hva det vil si at du deltar.

Bakgrunn

Kjønn:

Aldersgruppe (år):

Under 18	**18-21**	**22-25**	**26-29**

I hvor stor grad har du erfaring med VR?

1	**2**	**3**	**4**	**5**
I Liten grad				**I Stor grad**

Har du jobbet med NAV jobbsmak applikasjoner før?

JA	**Nei**

SUS - System Usability Scale

1. Jeg tenker at jeg ville brukt systemet regelmessig.

1	2	3	4	5
Veldig uenig				**Veldig enig**

2. Jeg synes systemet er unødvendig komplekst.

1	2	3	4	5
Veldig uenig				**Veldig enig**

3. Jeg synes systemet var enkelt å bruke.

1	2	3	4	5
Veldig uenig				**Veldig enig**

4. Jeg tror at jeg ville trenge støtte fra en teknisk person til å kunne bruke dette systemet.

1	2	3	4	5
Veldig uenig				**Veldig enig**

5. Jeg synes systemets funksjoner er godt integrert.

1	2	3	4	5
Veldig uenig				**Veldig enig**

6. Jeg synes det var for mye inkonsekvens i systemet.

1	2	3	4	5
Veldig uenig				**Veldig enig**

7. Jeg kan tenke meg at de fleste ville lære å bruke dette systemet svært raskt.

1	2	3	4	5

Veldig uenig **Veldig enig**

8. Jeg synes systemet er veldig tungvint å bruke.

1	2	3	4	5

Veldig uenig **Veldig enig**

9. Jeg følte meg veldig trygg på å bruke systemet.

1	2	3	4	5

Veldig uenig **Veldig enig**

10. Jeg trengte å lære mye før jeg kunne komme i gang med dette systemet.

1	2	3	4	5

Veldig uenig **Veldig enig**

Valgkompetanse

I hvilken grad føler du applikasjonen ga deg innsikt i en arbeidsplass?

1	2	3	4	5
I Liten grad				**I Stor grad**

I hvor stor grad føler du at nærværet til en annen person påvirket din opplevelse av applikasjonen?

1	2	3	4	5
I Liten grad				**I Stor grad**

Jeg har fått innsikt i arbeidsplassen slik at jeg kan avgjøre om yrke passer meg eller ikke:

1	2	3	4	5
I Liten grad				**I Stor grad**

Jeg opplever mestring i å utføre arbeidsoppgavene i «jobbsmak»:

1	2	3	4	5
I Liten grad				**I Stor grad**

Samhandling med andre bidrar til økt valgkompetanse:

1	2	3	4	5
I Liten grad				**I Stor grad**

Samhandling med andre har stor betydning for at jeg likte «jobbsmak»:

1	2	3	4	5
I Liten grad				**I Stor grad**

Jeg opplever å blir mer engasjert når man kan være flere sammen i «jobbsmak»:

1	2	3	4	5
I Liten grad				**I Stor grad**

Samarbeidsmekanismer

I hvilken grad synes du håndbevegelser/laserpeker fungerte som kommunikasjonsmetode i applikasjonen?

1	2	3	4	5

I Liten grad **I Stor grad**

I hvilken grad kunne du forstå hva den andre brukeren gjorde og planla?

1	2	3	4	5

I Liten grad **I Stor grad**

I hvor stor grad synes du at du hadde kontroll på hvor den andre brukeren var til enhver tid?

1	2	3	4	5

I Liten grad **I Stor grad**

B.2.2 Survey Answers

Bakgrunn

Kjønn

ID	Kjønn
1	Mann
2	Mann
3	Mann
4	Kvinne
5	Mann
6	Kvinne

Aldersgruppe

ID	Under 18	18-21	22-25	26-29
1		X		
2			X	
3			X	
4		X		
5			X	
6		X		

I hvor stor grad har du erfaring med VR?

ID	I liten grad/1	2	3	4	I stor grad/5
1		X			
2	X				
3	X				
4	X				
5				X	
6		X			

Har du jobbet med NAV jobbsmak applikasjoner før?

ID	Ja	Nei
1		X
2		X
3		X
4		X
5		X
6		X

SUS - System Usability Scale

1. Jeg tenker at jeg ville brukt systemet regelmessig.

ID	Veldig uenig/1	2	3	4	Veldig enig/5
1			X		
2		X			
3		X			
4				X	
5				X	
6		X	X		

(ID6 krysset midt på 2 / 3 streken)

2. Jeg synes systemet er unødvendig komplekst.

ID	Veldig uenig/1	2	3	4	Veldig enig/5
1			X		
2				X	
3				X	
4	X				
5	X				
6	X				

3. Jeg synes systemet var enkelt å bruke.

ID	Veldig uenig/1	2	3	4	Veldig enig/5
1			X		
2		X			
3			X		
4				X	
5					X
6					X

4. Jeg tror at jeg ville trenge støtte fra en teknisk person til å kunne bruke dette systemet.

ID	Veldig uenig/1	2	3	4	Veldig enig/5
1		X			
2			X		
3					X
4			X		
5		X			
6				X	

5. Jeg synes systemets funksjoner er godt integrert.

ID	Veldig uenig/1	2	3	4	Veldig enig/5
1				X	
2			X		
3			X		
4				X	
5			X		
6				X	

6. Jeg synes det var for mye inkonsekvens i systemet.

ID	Veldig uenig/1	2	3	4	Veldig enig/5
1		X			
2			X		
3			X		
4		X			
5			X		
6	X				

7. Jeg kan tenke meg at de fleste ville lære å bruke dette systemet svært raskt.

ID	Veldig uenig/1	2	3	4	Veldig enig/5
1				X	
2		X			
3			X		
4					X
5					X
6				X	

8. Jeg synes systemet er veldig tungvint å bruke.

ID	Veldig uenig/1	2	3	4	Veldig enig/5
1		X			
2			X		
3				X	
4	X				
5	X				
6	X				

9. Jeg følte meg veldig trygg på å bruke systemet.

ID	Veldig uenig/1	2	3	4	Veldig enig/5
1			X		
2		X			
3				X	
4					X
5					X
6				X	

10. Jeg trengte å lære mye før jeg kunne komme i gang med dette systemet.

ID	Veldig uenig/1	2	3	4	Veldig enig/5
1	X				
2					X
3		X			
4		X			
5	X				
6			X		

Valgkompetanse

I hvilken grad føler du applikasjonen ga deg innsikt i en arbeidsplass?

ID	I liten grad/1	2	3	4	I stor grad/5
1			X		
2		X			
3		X			
4				X	
5				X	
6			X		

I hvor stor grad føler du at nærværet til en annen person påvirket din opplevelse av applikasjonen?

ID	I liten grad/1	2	3	4	I stor grad/5
1					X
2		X			
3					X
4				X	
5					X
6				X	

Jeg har fått innsikt i arbeidsplassen slik at jeg kan avgjøre om yrke passer meg eller ikke:

ID	I liten grad/1	2	3	4	I stor grad/5
1			X		
2	X				
3	X				
4			X		
5				X	
6				X	

Jeg opplever mestring i å utføre arbeidsoppgavene i «jobbsmak»:

ID	I liten grad/1	2	3	4	I stor grad/5
1				X	
2			X		
3				X	
4					X
5					X
6			X		

Samhandling med andre bidrar til økt valgkompetanse:

ID	I liten grad/1	2	3	4	I stor grad/5
1				X	
2			X		
3		X			
4				X	
5				X	
6			X		

Samhandling med andre har stor betydning for at jeg likte «jobbsmak»:

ID	I liten grad/1	2	3	4	I stor grad/5
1				X	
2		X			
3				X	
4	X				
5			X		
6				X	

Jeg opplever å blir mer engasjert når man kan være flere sammen i «jobbsmak»:

ID	**I liten grad/1**	**2**	**3**	**4**	**I stor grad/5**
1					X
2				X	
3				X	
4					X
5					X
6				X	

Samarbeidsmekanismer

I hvilken grad synes du håndbevegelser/laserpeker fungerte som kommunikasjonsmetode i applikasjonen?

ID	**I liten grad/1**	**2**	**3**	**4**	**I stor grad/5**
1				X	
2			X		
3		X			
4			X		
5			X		
6					X

I hvilken grad kunne du forstå hva den andre brukeren gjorde og planla?

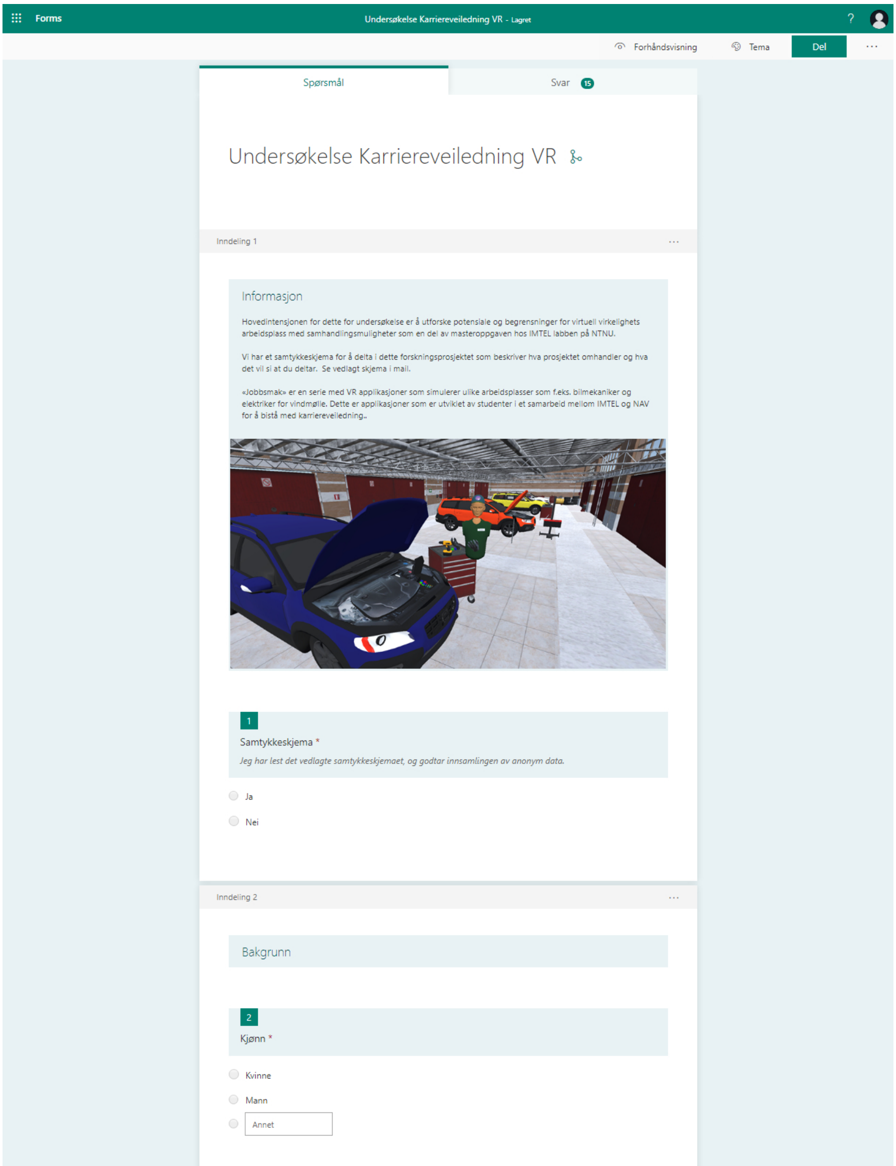
ID	**I liten grad/1**	**2**	**3**	**4**	**I stor grad/5**
1				X	
2	X				
3		X			
4		X			
5		X			
6					X

I hvor stor grad synes du at du hadde kontroll på hvor den andre brukeren var til enhver tid?

ID	**I liten grad/1**	**2**	**3**	**4**	**I stor grad/5**
1				X	
2	X				
3		X			
4	X				
5				X	
6				X	

B.3 Phase 3

B.3.1 Full Survey


Forms
Undersøkelse Karriereveiledning VR - Lagret
Forhåndsvisning
Tema
Del
Spørsmål
Svar 15

Undersøkelse Karriereveiledning VR

Inndeling 1

Informasjon

Hovedintensjonen for dette for undersøkelse er å utforske potensiale og begrensninger for virtuell virkelighets arbeidsplass med samhandlingsmuligheter som en del av masteroppgaven hos IMTEL labben på NTNU.

Vi har et samtykkeskjema for å delta i dette forskningsprosjektet som beskriver hva prosjektet omhandler og hva det vil si at du deltar. Se vedlagt skjema i mail.

«Jobbsmak» er en serie med VR applikasjoner som simulerer ulike arbeidsplasser som f.eks. bilmekaniker og elektriker for vindmølle. Dette er applikasjoner som er utviklet av studenter i et samarbeid mellom IMTEL og NAV for å bistå med karriereveiledning..

1

Samtykkeskjema *

Jeg har lest det vedlagte samtykkeskjemaet, og godtar innsamlingen av anonym data.

Ja

Nei

Inndeling 2

Bakgrunn

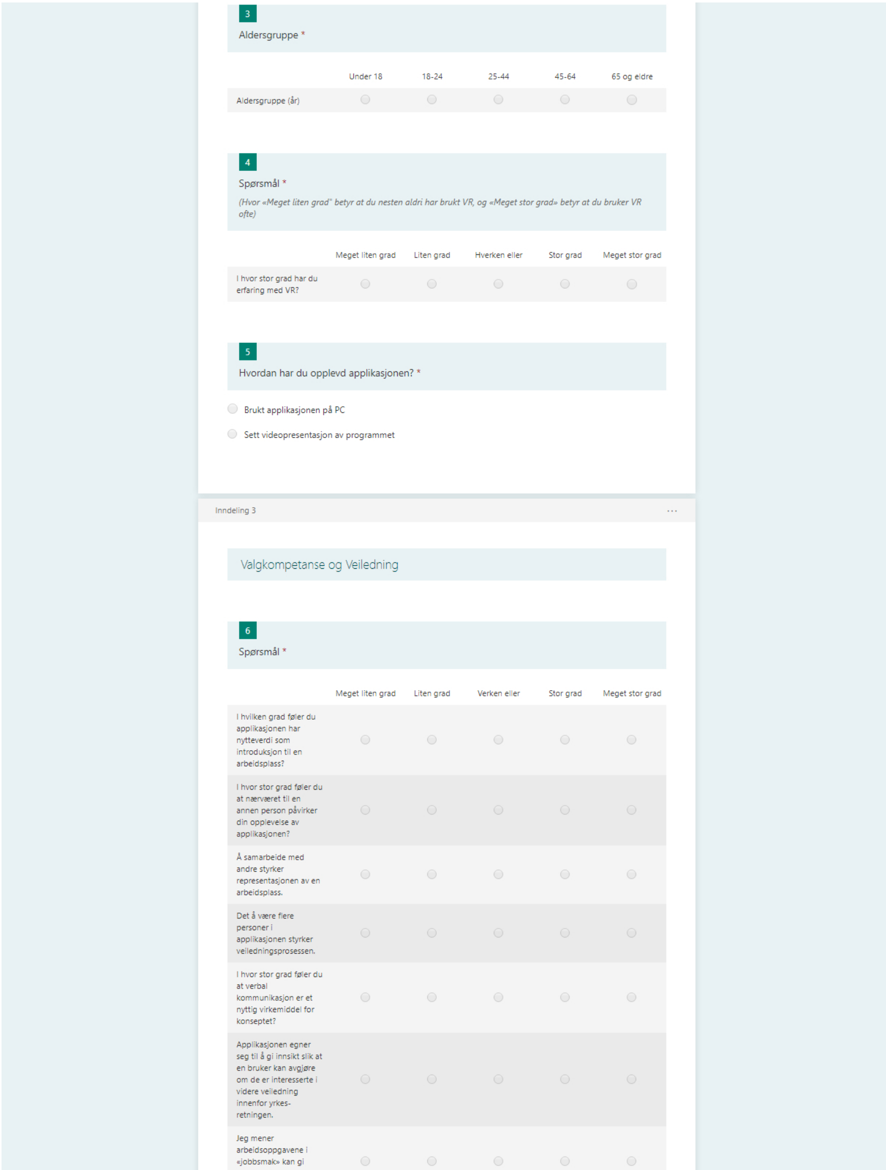
2

Kjønn *

Kvinne

Mann

Annet


3

Aldersgruppe *

	Under 18	18-24	25-44	45-64	65 og eldre
Aldersgruppe (år)					

4

Spørsmål *

(Hvor «Meget liten grad" betyr at du nesten aldri har brukt VR, og «Meget stor grad» betyr at du bruker VR ofte)

	Meget liten grad	Liten grad	Hverken eller	Stor grad	Meget stor grad
I hvor stor grad har du erfaring med VR?					

5

Hvordan har du opplevd applikasjonen? *

- Brukt applikasjonen på PC
- Sett videopresentasjon av programmet

Inndeling 3

Valgkompetanse og Veiledning

6

Spørsmål *

	Meget liten grad	Liten grad	Verken eller	Stor grad	Meget stor grad
I hvilken grad føler du applikasjonen har nytteverdi som introduksjon til en arbeidsplass?					
I hvor stor grad føler du at nærværet til en annen person påvirker din opplevelse av applikasjonen?					
Å samarbeide med andre styrker representasjonen av en arbeidsplass.					
Det å være flere personer i applikasjonen styrker veiledningsprosessen.					
I hvor stor grad føler du at verbal kommunikasjon er et nyttig virkemiddel for konseptet?					
Applikasjonen egner seg til å gi innsikt slik at en bruker kan avgjøre om de er interesserte i videre veiledning innenfor yrkes-retningen.					
Jeg mener arbeidsoppgavene i «jobbsmak» kan gi					

brukere en mestringsfølelse.					
Jeg mener samhandling med andre (veiledere/andre brukere) bidrar til økt valgkompetanse.	○	○	○	○	○
Samhandling har funksjonell verdi for «jobbsmak» som konsept.	○	○	○	○	○
Jeg mener man blir mer engasjert når man kan være flere sammen i «jobbsmak».	○	○	○	○	○
Verktøyet kan bidra i min jobb for å få brukere til å utforske muligheter i arbeidslivet.	○	○	○	○	○
Bruken av «jobbsmak» applikasjonen åpner opp for samtale med brukerne.	○	○	○	○	○
Samarbeid som konsept er en viktig egenskap å tilegne seg i «jobbsmak» fordi oppgaver arbeidslivet ofte involverer flere personer.	○	○	○	○	○

Inndeling 4 ...

Valgkompetanse og Veiledning

7

Spørsmål *

	Meget liten grad	Liten grad	Verken eller	Stor grad	Meget stor grad
I hvilken grad føler du applikasjonen har nytteverdi som introduksjon til en arbeidsplass?	○	○	○	○	○
I hvor stor grad føler du at verbal kommunikasjon er et nyttig virkemiddel for konseptet?	○	○	○	○	○
I hvor stor grad føler du at nærværet til en annen person er nyttig for utvikling av valgkompetanse?	○	○	○	○	○
Konseptet egner seg til å gi jobbsøkere innsikt slik at de kan avgjøre om yrket passer de eller ikke.	○	○	○	○	○
Arbeidsoppgavene i «jobbsmak» kan gi en mestringsfølelse.	○	○	○	○	○
Samhandling med andre (veiledere/andre brukere) bidrar til økt valgkompetanse.	○	○	○	○	○
Samhandling har betydning for nytteverdien til «jobbsmak».	○	○	○	○	○
Jeg tror man blir mer engasjert når man kan					

være flere sammen i «jobbsmak», enn å være alene.	○	○	○	○	○
Verktøyet kan bidra i min jobb for å få brukere til å utforske muligheter i arbeidslivet.	○	○	○	○	○
Bruken av «jobbsmak» applikasjonen åpner opp for samtale med brukerne.	○	○	○	○	○
Å bruke samarbeid under veiledning gir en mer realistisk representasjon av arbeidslivet.	○	○	○	○	○

Inndeling 5 ...

Samarbeidsmekanismer

8

Prøvde du applikasjonen med VR-briller eller via en vanlig skjerm? *

○ VR

○ Vanlig skjerm

9

Ranger hvordan forskjellige samarbeidsmekanismer fungerer. *

Dersom du benyttet desktop modus, vurder din forståelse av VR brukeren(e).

	Meget liten grad	Liten grad	Verken eller	Stor grad	Meget stor grad
I hvilken grad synes du håndbevegelser fungerte som kommunikasjonsmetode i applikasjonen?	○	○	○	○	○
I hvilken grad synes du laserpeker fungerte som kommunikasjonsmetode i applikasjonen?	○	○	○	○	○
I hvor stor grad opplevde du at du var tilstede i applikasjonen?	○	○	○	○	○
I hvor stor grad var du bevisst på andre brukere i applikasjonen?	○	○	○	○	○
I hvilken grad kunne du forstå hva den andre brukeren gjorde og planla?	○	○	○	○	○
I hvor stor grad synes du at du hadde kontroll på hvor den andre brukeren var til enhver tid?	○	○	○	○	○
I hvor stor grad føler du at verbal kommunikasjon er viktig for opplevelsen?	○	○	○	○	○

Inndeling 6 ...

SUS - System Usability Scale

10

Hvor enig eller uenig er du i følgende utsagn? *

	Veldig uenig	Noe uenig	Verken eller	Noe enig	Veldig enig
Jeg tenker at jeg ville brukt systemet regelmessig.	○	○	○	○	○
Jeg synes systemet er unødvendig komplekst.	○	○	○	○	○
jeg synes systemet var enkelt å bruke.	○	○	○	○	○
Jeg tror at jeg ville trenge støtte fra en teknisk person til å kunne bruke systemet.	○	○	○	○	○
Jeg synes systemets funksjoner er godt integrert.	○	○	○	○	○
Jeg synes det var for mye inkonsekvens i systemet.	○	○	○	○	○
Jeg kan tenke meg at de fleste ville lære å bruke dette systemet svært raskt.	○	○	○	○	○
Jeg synes systemet er veldig tungvint å bruke.	○	○	○	○	○
Jeg følte meg veldig trygg på å bruke systemet.	○	○	○	○	○
Jeg trengte å lære meg mye før jeg kunne komme i gang med dette systemet.	○	○	○	○	○

Inndeling 7 ...

Fjernveiledning

11

For at fjernveiledning skal kunne bli brukt effektivt er det en rekke kvaliteter som på forskjellig vis har noe å si for nyttighetsgraden til applikasjonen. Ranger de følgene kvalitetene fra "ikke viktig" til "veldig viktig". *

	Ikke viktig	Lite viktig	Verken eller	Litt viktig	Veldig viktig
Verbal kommunikasjon	○	○	○	○	○
Gestikulering/håndbevegelser	○	○	○	○	○
Hjelp til markering (F. eks. laserpeker)	○	○	○	○	○
Skriftlig kommunikasjon	○	○	○	○	○
Objektive rangeringer (Poengsystem, sjekkliste, osv.)	○	○	○	○	○
Systemet er enkelt å installere	○	○	○	○	○

Systemet er enkelt å starte	○	○	○	○	○
Tilgjengelig teknisk støtte ved behov	○	○	○	○	○
Systemet er intuitivt	○	○	○	○	○

12

En slik applikasjon kan være nyttig for yrkesrettet fjernveiledning. *

- ○ Svært uenig
- ○ Uenig
- ○ Hverken enig eller uenig
- ○ Enig
- ○ Svært enig

13

I hvilke sammenhenger mener du en slik fjernveiledning i VR kan være relevant? *

	Ikke relevant	Lite relevant	Verken eller	Noe relevant	Veldig relevant
Unge NAV brukere	○	○	○	○	○
Skole	○	○	○	○	○
Arbeidsledige som følge av Covid-19	○	○	○	○	○
Arbeidsplass utilgjengelig pga. sikkerhetstiltak	○	○	○	○	○
Geografisk avstand/hindrer	○	○	○	○	○

Inndeling 8 ...

Annet (gi gjerne forslag)

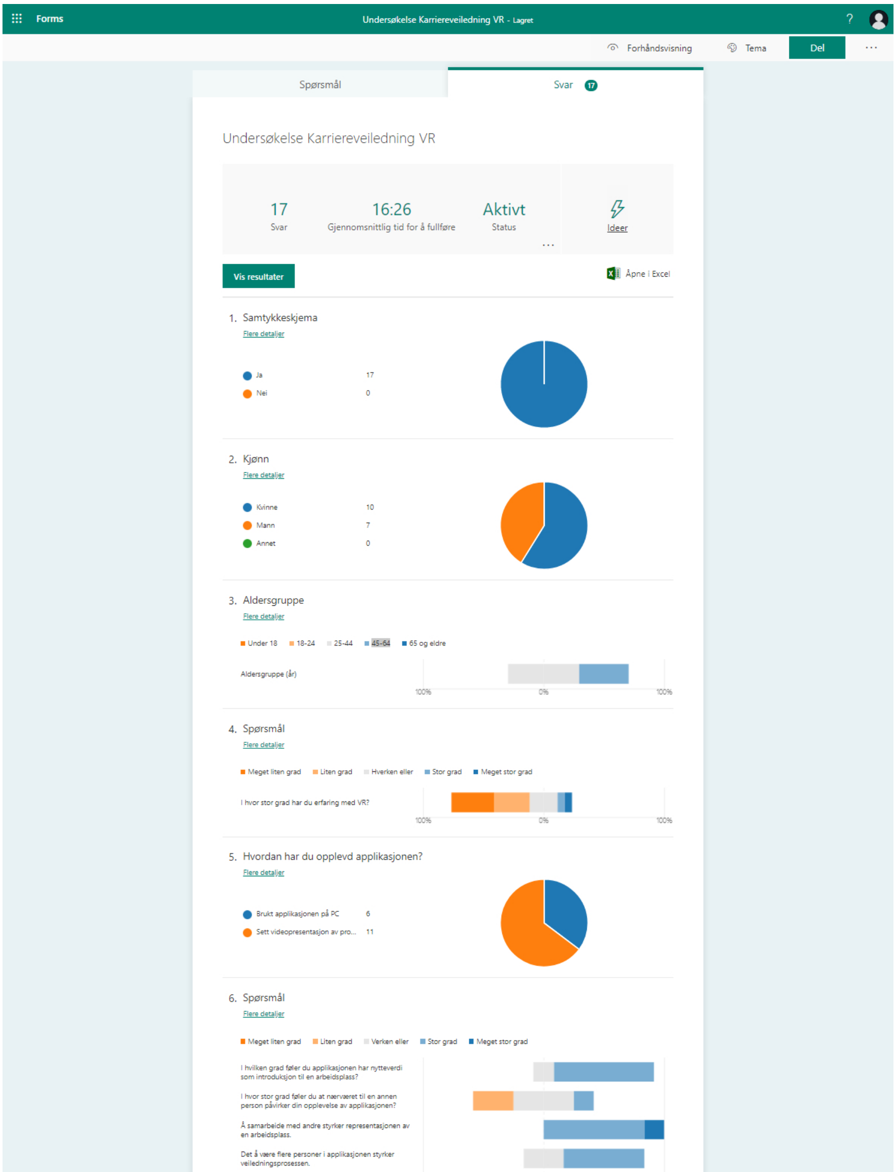
14

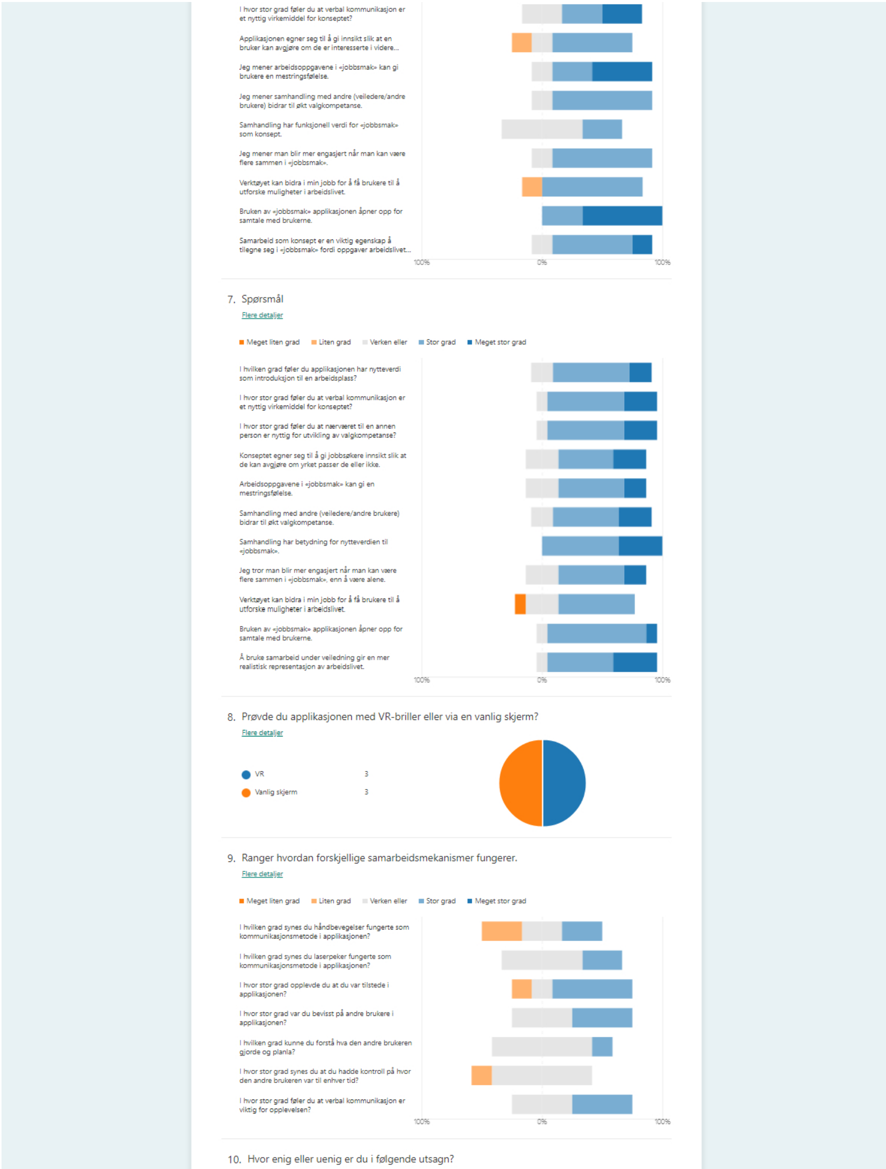
Har du andre kommentarer?

Skriv inn svaret

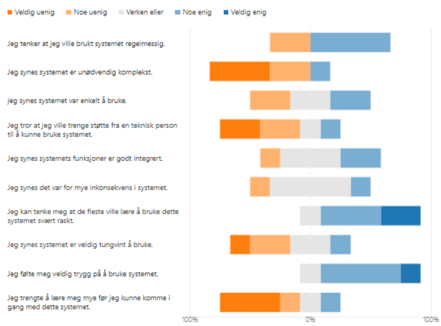
+ Legg til ny

B.3.2 Survey Answers



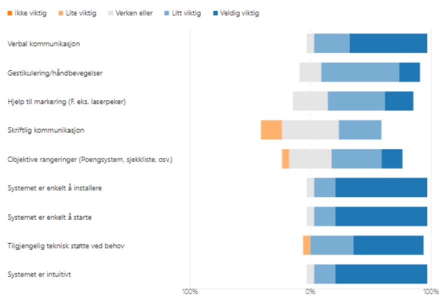

I hvor stor grad føler du at verbal kommunikasjon er et nyttig virkemiddel for konseptet?
Applikasjonen egner seg til å gi innsikt slik at en bruker kan avgjøre om de er interesserte i videre...
Jeg mener arbeidsoppgavene i «jobbsmak» kan gi brukere en mestringsfølelse.
Jeg mener samhandling med andre (veiledere/andre brukere) bidrar til økt valgkompetanse.
Samhandling har funksjonell verdi for «jobbsmak» som konsept.
Jeg mener man blir mer engasjert når man kan være flere sammen i «jobbsmak».
Verktøyet kan bidra i min jobb for å få brukere til å utforske muligheter i arbeidslivet.
Bruken av «jobbsmak» applikasjonen åpner opp for samtale med brukerne.
Samarbeid som konsept er en viktig egenskap å tilegne seg i «jobbsmak» fordi oppgaver arbeidslivet...
100%
0%
100%
7. Spørsmål
Flere detaljer
Meget liten grad
Liten grad
Verken eller
Stor grad
Meget stor grad
I hvilken grad føler du applikasjonen har nytteverdi som introduksjon til en arbeidsplass?
I hvor stor grad føler du at verbal kommunikasjon er et nyttig virkemiddel for konseptet?
I hvor stor grad føler du at nærværet til en annen person er nyttig for utvikling av valgkompetanse?
Konseptet egner seg til å gi jobbsøkere innsikt slik at de kan avgjøre om yrket passer de eller ikke.
Arbeidsoppgavene i «jobbsmak» kan gi en mestringsfølelse.
Samhandling med andre (veiledere/andre brukere) bidrar til økt valgkompetanse.
Samhandling har betydning for nytteverdien til «jobbsmak».
Jeg tror man blir mer engasjert når man kan være flere sammen i «jobbsmak», enn å være alene.
Verktøyet kan bidra i min jobb for å få brukere til å utforske muligheter i arbeidslivet.
Bruken av «jobbsmak» applikasjonen åpner opp for samtale med brukerne.
Å bruke samarbeid under veiledning gir en mer realistisk representasjon av arbeidslivet.
100%
0%
100%
8. Prøvde du applikasjonen med VR-briller eller via en vanlig skjerm?
Flere detaljer
VR 3
Vanlig skjerm 3
9. Ranger hvordan forskjellige samarbeidsmekanismer fungerer.
Flere detaljer
Meget liten grad
Liten grad
Verken eller
Stor grad
Meget stor grad
I hvilken grad synes du håndbevegelser fungerte som kommunikasjonsmetode i applikasjonen?
I hvilken grad synes du laserpeker fungerte som kommunikasjonsmetode i applikasjonen?
I hvor stor grad opplevde du at du var tilstede i applikasjonen?
I hvor stor grad var du bevisst på andre brukere i applikasjonen?
I hvilken grad kunne du forstå hva den andre brukeren gjorde og planla?
I hvor stor grad synes du at du hadde kontroll på hvor den andre brukeren var til enhver tid?
I hvor stor grad føler du at verbal kommunikasjon er viktig for opplevelsen?
100%
0%
100%
10. Hvor enig eller uenig er du i følgende utsagn?

Flere detaljer



11. For at fjernveiledning skal kunne bli brukt effektivt er det en rekke kvaliteter som på forskjellig vis har noe å si for nyttighetsgraden til applikasjonen. Ranger de følgene kvalitetene fra "ikke viktig" til "veldig viktig".

Flere detaljer



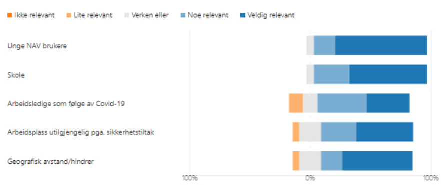
12. En slik applikasjon kan være nyttig for yrkesrettet fjernveiledning.

Flere detaljer

Svært uenig	0
Uenig	0
Hverken enig eller uenig	3
Enig	7
Svært enig	7

13. I hvilke sammenhenger mener du en slik fjernveiledning i VR kan være relevant?

Flere detaljer



14. Har du andre kommentarer?

Flere detaljer


8
Svar
Siste svar
"kontakt med verktøy og gjenstander trenger arbeid. gjerne automatis...
"Hvis vi investerer i dette utstyret må vi ha en ordning på support og t...

B.3.3 Interview Guide

Intervju Karriereveiledning VR

Bakgrunn

Kjønn

Alder

Hvilke erfaringer har du med spill og VR og AR?

Har du brukt NAV VR applikasjon før?

Samarbeid og valgkompetanse (RQ)

Føler du applikasjonen har nytteverdi som introduksjon til en arbeidsplass?

Hvordan opplever du at å samarbeide med andre brukere påvirker representasjonen av en arbeidsplass?

Kan et slikt verktøy bidra til at du finner ut hva du ønsker å gjøre?

Hvordan opplever du at det å være flere sammen i applikasjonen påvirker engasjementet?

Hvordan opplever du at det å samhandle med andre i VR påvirker din valgkompetanse?
- Blir lettere å ta valg for deg for å komme inn i arbeidslivet?

Tror du samarbeid i VR kan hjelpe personer som sliter i sosiale situasjoner med å finne jobb?
- Tror du samarbeid i VR kan brukes til sosial trening?

Veiledning / Veileder

Hvordan var opplevelsen å motta veiledning fra en NAV ansatt i VR?
- VR modus (avatar)
- Desktop modus (trekant)

Hvordan kan dette sammenlignes med en tradisjonell veiledningssituasjon?
- Ulemper / fordeler?

Hvordan var opplevelsen av å veilede andre brukere i VR, i motsetning til tidligere hvor det har foregått i samme fysiske rom?

Fjernveiledning (RQ2)

Hadde du noen problemer med å komme i gang med programmet?

- Var det intuitivt? Lett å bli med i et rom?

Føler du at samarbeid i VR kan være nyttig for fjernveiledning?

- Hvorfor/hvorfor ikke? (utdyp)

Hva mener du er viktigst for at fjernveiledning skal fungere godt?

- Hvor nyttig oppfatter du at den er?
- Kvaliteter som snakking / avatarer / bevegelser osv.

Hvordan tror du opplevelsen ville vært om du hadde møtt en ansatt fra en arbeidsplass som er et stykke unna i VR?

- Ville du benyttet det?
- Tror du at du hadde følt deg trygg på situasjonen?

Samarbeidsmekanismer (RQ3)

Hvordan er din opplevelse av gestikulering (håndbevegelser/peking) som kommunikasjonsmetode?

Hvordan fungerte snakking i applikasjonen?

- Var det tydelig hvem som snakket?
- Fikk du med deg hva de andre sa?

Følte du at de andre brukerne var tilstede?

- Nærvær?
- Hvordan var din bevissthet på andre spillere / forståelse av hva de gjør eller planlegger?

B.3.4 Interview Answers

Intervju Karriereveiledning VR

Bakgrunn

Kjønn

Mann

Alder

25

Hvilke erfaringer har du med spill og VR og AR?

Bruker: "Spilt det meste av det beste. Hatt Vive i 3-4 år.

Har du brukt NAV VR applikasjon før?

Bruker: Ja, er godt kjent med de. Testet alle nåværende NAV applikasjoner.

Samarbeid og valgkompetanse (RQ)

Føler du applikasjonen har nytteverdi som introduksjon til en arbeidsplass?

Bruker: Ser absolutt fordelen med å være en veileder og en bruker. Så klart man kan ha utfordringer med mange brukere og sånn, da spørs det på media eller om det skal være framvisninger og sånn, men jeg ser fordeler med det mot å være alene. Veileder: uten tvil om det. Nok en arena hvor man kan prate om det. I stedet for å fysisk møtes så hvis folk har utstyr så er det jo en gevinst i det og. Enklere for folk å møte opp digitalt enn fysisk.

Hvordan opplever du at å samarbeide med andre brukere påvirker representasjonen av en arbeidsplass?

Bruker: Jeg vil si at det hvertfall er veldig positivt i forhold til å lære opp eller å vise

Hvordan ting fungerer. Du kan faktisk fysisk vise, i stedet for å prøve å forklare fra utenfor appen. Da blir det bare snakking, og det kan skape forvirring. Kunne brukt bots, men det å ha ekte folk er bedre for å lære bort.

Kan et slikt verktøy bidra til at du finner ut hva du ønsker å gjøre?

Bruker: Ja, tror jo at det er et steg som vil få de videre, for du kan prøve vindmølle app, og tenke at det ikke er for meg. Da slipper du å dra på en lang tur for besøke arbeidsplass. Da har du spart pengene og turen. Så jeg ser stor verdi i det. For jeg tror det har en effekt i steget for å finne hva som passer deg. Enten for å utelukke eller åpne nye tanker.

Hvordan opplever du at det å være flere sammen i applikasjonen påvirker engasjementet?

Bruker: Spørs vel hvor godt man kjenner hverandre, de som er med. Med noen du kjenner blir det nok større engasjement. Kan bli vanskelig med ukjente, spørs hvor lenge man tenker å holde på.

Veileder: Det kan trygge(triggere?) hvis det en som er kjempegod og en som ikke er like god, så er det interessant å se samarbeidet. For de som jobber akkord får du lønn ut fra hvor fort du produserer ting, som kan skape irritasjon/frustrasjon hvis noen er trege. Så ved å jobbe sammen kan man se hvor man er. Denne evnen til å samarbeide når man ikke er på samme nivå, hvordan man håndterer det.

Hvordan opplever du at det å samhandle med andre i VR påvirker din valgkompetanse?

- Blir lettere å ta valg for deg for å komme inn i arbeidslivet?

Dette spørsmålet ble besvart i andre spørsmål

Tror du samarbeid i VR kan hjelpe personer som sliter i sosiale situasjoner med å finne jobb?

- Tror du samarbeid i VR kan brukes til sosial trening?

Veileder: I jobbintervju appen har vi har vi hatt folk med store utfordringer til angst, har jo syntes det er fryktelig skremmende å ha på seg brillene og snakke med den personen som er virtuelt til stedet i brillene, og får følelesen av å være i samme rom. Og det tror jeg jo for en del på jobbhuset som blir trygge der, så kan det uansett trigge frykt og angst å møte nye ukjente mennesker på en ny jobb. Så det å få på seg VR briller og kanskje få Snakke med noen du ikke ser men skal løse oppgaver med, kan det si oss noen ting om

Hva vi må jobbe med for å håndtere det om det skaper frykt. SÅ kanskje er det en forberedelses fase på hvordan blir det når de skal avslutte hos oss og inn i en ny ukjent setting hvor det er ukjente mennesker. Kanskje får vi en reaksjon.

Bruker: Bare i dag, så føler man ikke samme presset som når man er i et rom fullt av andre mennesker. Det er jo en grunn til at det er så mye netthets, for man ser jo ikke ansiktet til den man hetser. Det gjør det enklere, men det folk har jo sine problemer, det vil jo alltid være vanskelig for folk, men det vil kanskje gjøre det lettere.

Veileder: Det er spennende hvertfall å teste ut hypoetesen om det senker terskelen i overgansfasen når man går fra noe trygt til noe utrygt, og det å da bruke denne appen for å venne seg til å kommunisere med folk man ikke kjenner. Det hadde vært spennende å teste om folk kunne rett og slett øvd seg på å kommunisere med ukjente, på en måte, og spille sammen. Selv om du sitter hjemme må du snakke med noen andre og løse oppgaver sammen. Det er en interessant tanke å få testet hvertfall. For noen har det ikke betydning, men for en gruppe er det spennende tanke.

Veiledning / Veileder

Hvordan var opplevelsen å motta veiledning fra en NAV ansatt i VR?

- VR modus (avatar)
- Desktop modus (trekant)

Bruker: Tror det er positivt med bruker og veileder i appen samtidig. I motsetning til at det skal forklares (fra utsiden). Trenger jo dobbelt utstyr, så det er jo en kostnad, men er absolutt en fordel med det. Avataren fungerte greit nok. Eneste er vel hvordan verktøy brukes som er litt pirk. Veileder i desktop burde hatt en peker, det hadde utgjort en del.

Hvordan kan dette sammenlignes med en tradisjonell veiledningssituasjon?

- Ulemper / fordeler?

Veileder: Nei, det er jo litt sånn hvis jeg skal veilede en dreven VR-bruker, så tror jeg samtalen om dette yrket og bransjen ville vært en annen samtale om han var uerfaren, for da ville fokuset vært på å få de til å skjønne hvordan de opererer og løser oppgaver, og beveger seg i VR-rommet, før man egentlig kunne gått på det som handler mye mer om den jobbrelaterte tingen, om bransjen og yrket, hvorfor det her er eller ikke er en Interessant jobb, hva er det som trekker deg, så det er litt to ulike prosesser. For normalt

For en dreven VR-bruker så vil jo de bli veilederen min i hvordan bruke utstyret. Så det blir litt sånn at ting tar lengre tid hvor man må lære opp og bli trygg på appen, og det er jo min erfaring med de som ikke har spilt mye før, så trenger man tilvenning og spille det litt før før man egentlig kan snakke om det man skal snakke om. Det er erfaringen min hvertfall. Så kanskje trenger å gjøre det to ganger rett og slett for å egentlig kom i posisjon for å diskutere om yrket er interessant.

Bruker: Det kan vel kanskje bli en litt mer sosial samtalemåte, at man kommer enklere opp med naturlige måter å prate med hverandre i stedet for at det er en veileder og en VR-bruker og at det blir litt sånn stivt. Enklere å gå over til en mer menneskelig samtalemåte.

Veileder: Stor fordel hvis veilederen har VR og, for da tror jeg bruker og veileder kommer i en likeverd situasjon, der vi kunne løst en oppgave sammen, eller kunne trått inn når det trengs. Mer verdi enn å bare sitte på desktop.

Hvordan var opplevelsen av å veilede andre brukere i VR, i motsetning til tidligere hvor det har foregått i samme fysiske rom?

Dette spørsmålet ble besvart i andre spørsmål

Fjernveiledning (RQ2)

Hadde du noen problemer med å komme i gang med programmet?

- Var det intuitivt? Lett å bli med i et rom?

Bruker: Det var enkelt å laste ned og komme i gang. Jeg synes det var fint oversiktlig og ganske selvforklarende.

Veileder: Det var greit, så lenge man kom seg forbi brannmurer på jobb pc osv. For folk som er dreven og holder på med data og sånn så er det kurant. For dem som ikke er så datakyndig hos NAV så kan det være greit å en telefon ved siden av for å hjelpe folk, alternativ kanal som support. NAV veilederen må være trygg på programmet og kjøring slik at det ikke stopper opp der.

Føler du at samarbeid i VR kan være nyttig for fjernveiledning?

- Hvorfor/hvorfor ikke? (utdyp)

Bruker: I en drømmeverden der alle har VR utstyr tilgjengelig så er det helt supert. Da har man flere muligheter.

Veileder: Det må være kjempepositivt.

Hva mener du er viktigst for at fjernveiledning skal fungere godt?

- Hvor nyttig oppfatter du at den er?
- Kvaliteter som snakking / avatarer / bevegelser osv.

Bruker: Jeg tok med jo med meg VR utstyret nedover på besøk til svigerforeldre. Da måtte jeg bare ta med sensorer og sette de i vinduskarmer og få det til å fungere her. Det er litt mer arbeid enn nyeste utstyr som Quest. Da ville jo kanskje gjort ting litt enklere og bedre for fjernveiledning.
Vil si at det er viktig å ha avatarer, man føler at man får mer kontakt med en person som beveger seg i den virtuelle verden enn det man gjør med en trekant eller bare i samme fysiske rom.

Veileder: Det er den utfordringen med utstyr, kostnad og tilgjengelighet. Å få dette til å fungere på en Oculus Quest må være en kvantesprang i forhold til å bruke en spill-pc og mixed reality hodesett. Vil øke tilgjengeligheten stort vil jeg tro.
Når det gjelder avatar og snakking så får man helt klart større samvær når man er i samme virtuelle verden. Øker opplevelsen. Sånn at det er viktig det med avatar og stemme, samt bevegelser. Helt enig det “Bruker sier”.

Hvordan tror du opplevelsen ville vært om du hadde møtt en ansatt fra en arbeidsplass som er et stykke unna i VR?

- Ville du benyttet det?
- Tror du at du hadde følt deg trygg på situasjonen?

Bruker: Det kunne vært interessant, men om det ikke er så langt unna så kunne man like godt bare tatt en tur på verksted. I en situasjon hvor arbeidsplassene er så langt unna så er det sikkert lurt. Kunne sikkert fungert godt.
Jeg tror også at jeg vill vært trygg i en slik situasjon hvor en ekspert er med i VR, fordi man ville fått mer innsikt. Man kan få mer informasjon og detaljer, ettersom en slik VR app som nå er jo litt forenklet slik at det ville vært interessant.

Veileder: I en situasjon hvor man geografiske avstander er utfordrende er det nok gull verdt. I et bilverksted kunne en ekspert blitt med i VR og vist hvordan man skulle fikse noe på en best mulig måte.

Samarbeidsmekanismer (RQ3)

Hvordan er din opplevelse av gestikulering (håndbevegelser/peking) som kommunikasjonsmetode?

Bruker: Sånn når det gjelder håndbevegelser så savnet jeg pekefinger. Men jeg synes det er veldig viktig med hender fordi det er en stor del av kommunikasjonsdelen i VR. Laserpeker er veldig praktisk mot veileder, og hvis bruker skal si at man lurer på noe så kan man peke så problemet spesifikt. Når deg gjelder å ta på ting på en skjerm så er enten pekefinger eller laserpeker bra. Veileder: Det er kjempeviktig å kunne bruke hender, holde opp objekter og peke på ting.

Hvordan fungerte snakking i applikasjonen?

- Var det tydelig hvem som snakket?
- Fikk du med deg hva de andre sa?

Bruker: Jeg slet litt i starten med å få mikrofonen til headsettet å fungere, så jeg brukte mikrofonen på pc. Det blir litt dårligere med det, men tror det mer har med teknisk utstyr på gjøre. Nå la jeg ikke merke til om det lyste opp noe når folk prata, eller en liten snakkeboble, så tror jeg det ville vært bedre, spesielt om man er flere en to stykker sammen. Dersom det står en person i andre siden av rommet så kan det være vanskelig uten noe indikasjon å se hvem som snakker og hva du lurer på. Kan fort tro det er nærmeste person. Veileder: En forutsetning er jo at man benytter mikrofon fra headsett slik at lyden blir bedre, for mikrofon fra pc er mer begrenset. Enig med bruker at man kan se hvem som prater når man er flere med i applikasjonen.

Følte du at de andre brukerne var tilstede?

- Nærvær?
- Hvordan var din bevissthet på andre spillere / forståelse av hva de gjør eller planlegger?

Bruker: Jeg har ikke brukt så mye multiplier VR før, det har mest vært singleplayer eller turn based multiplayer. Sånn jeg ikke veldig erfaring med det, men at opplevelsen av nærvær var mer tilstede når man var med en annen VR bruker som avatar slik som i testingen, da følte jeg nærværet til den andre personen med avatar. Det gjorde jeg. Bevegelser, og hva han planla å gjøre hva forståelig. Kan se for meg at det er litt kaotisk om det er 6-67 stykker som teleporterer seg fram og tilbake. Da ville det nok blitt vanskeligere å få oversikt. Veileder: Multiplayer konsept er veldig interessant. Som desktop bruker fikk vi litt oversikt over de andre VR brukerne sånn at man kunne følge med. Vil jo si at dette er et kjempesteg i riktig retning i forhold til hva vi har hatt tidligere. Enda mer realistisk vil det bli om man er med inn i applikasjon med VR headsett, det gjelder alle NAV VR apper. Da tror jeg også følelsen av nærvær blir forsterket.

Christian Bernard Bouwhuis Røkke

Career Guidance in Collaborative Virtual Reality

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