UiA University of Agder

Master

Virtual reality supported simulation training for healthcare personnel

Investigating Active Learning Through 360-degrees Video Based Interactive Scenarios.

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Abstract

Sørlandet sykehus helseforetak suggested a thesis to design a virtual reality (VR) application with 360-degree videos to be used as an educational tool for training psychiatric healthcare personnel in handling aggressive and suicidal patients. This study aims to find the advantages of using interactive VR scenarios as a supplement to simulation training by developing an application using human-centred design. The article explores how an educational VR application can be designed using human-centred design, the advantages and challenges of using it as a tool for learning, and nurses' satisfaction with the application.

Simulation training is used in healthcare education and training because it allows participants to actively train in challenging situations while remaining in a safe environment. However, because of the time investment and organisational constraints related to simulation training, the use of VR as a possible supplement is currently being researched and explored by Norwegian hospitals.

The present research study utilised a mixed-method approach comprised of the usability testing method, combining observations and interviews, and a survey to answer the research questions. The observations and interviews mainly focused on exploring the design, advantages, and challenges of the application in healthcare training. The survey focused on exploring satisfaction levels. This resulted in two interactive VR scenarios that train psychiatric healthcare personnel in handling a suicidal patients and threats from an aggressive patients.The application was developed using Premiere Pro, Audition, and Unity, which resulted in an active learning environment where users directly affect the outcomes of scenarios.

The advantages of the application are related to its affordability, its use as a learning tool for experiential and affective learning, and its use as a mediator for peer learning. The disadvantages of the application are related to the immersion of experienced healthcare personnel in the topics, the time investment for developing such an application, and the fact that it may not adequately sufficiently replace physical scenarios. Lastly, the application was satisfying based on the healthcare workers' responses.

Future research could explore the research's advantages and challenges in depth to re-evaluate their importance in healthcare training or in other fields. For example, future research could directly test interactive VR simulations in simulation training or test whether it promotes peer learning. Exploring interactive VR scenarios in different cultures and professions could also result in different satisfaction levels.

Sammendrag

Sørlandets sykehus helseforetak foreslo en avhandling om å utforme en virtuell virkelighet (VR) applikasjon med 360-graders videoer, til bruk som utdanningsverktøy og trening av psykiatrisk helsepersonell i håndtering av aggressive pasienter og pasienter med selvmordstanker.

Studiens mål er å finne fordelene ved å bruke interaktive VR senarioer som supplement til simuleringstrening ved å utvikle en applikasjon ved bruk av human-centred design.

Artikkelen utforsker hvordan en pedagogisk VR-applikasjon kan designes ved bruk av human-centred design, fordelene og utfordringene ved å bruke dette som et verktøy for læring og hvor fornøyde helsepersonellet vil være med applikasjonen.

Simuleringstrening blir brukt ved opplæring og trening i helseforetak da det gir deltakerne mulighet for trening i utfordrende situasjoner, men allikevel i et trygt miljø. Men, på grunn av tidsbruk og organisasjonsmessige begrensninger relatert til simuleringstrening blir bruk av VR undersøkt og utforsket av norske sykehus.

Forskningen benytter en mixed-method forskningsmetode som består av usability testing metoden som kombinerer observasjoner og intervjuer og en undersøkelse ved bruk av spørreskjema som skal gi svar på forskningsspørsmålene.

Observasjonene og intervjuene fokuserer i hovedsak på å utforske designet av produktet og for å utforske fordelene og utfordringene ved bruk av applikasjonen i trening. Undersøkelsen fokuserer på å utforske tilfredshets-nivåene. Dette resulterte i to interaktive VR senarioer som trener psykiatrisk helsepersonell i håndtering av en pasient med selvmordstanker og trusler fra en aggressiv pasient.

Applikasjonen ble utviklet ved bruk av Premiere Pro, Audition and Unity som resulterte i et aktivt læringsmiljø hvor brukerne direkte påvirket resultatet av senarioene.

Fordelene ved applikasjonen er overkommelig pris, bruken som lærings-verktøy for experiential og affective læring, og for å promotere samarbeidslæring. Ulempene ved applikasjonen er relatert til muligheten for innlevelse for erfarne helsepersonell, tidsbruk ved utvikling av applikasjonen og det faktum at det ikke tilstrekkelig vil erstatte fysiske senarioer. Til slutt -applikasjonen var tilfredsstillende basert på helsearbeidernes besvarelser.

Fremtidig forskning kan undersøke forskningens fordeler og utfordringer mer i dybden og revurdere deres betydning for trening av helsepersonell, eller innen andre områder. For eksempel, fremtidig forskning kan teste interaktiv VR simulering i simuleringstrening direkte, eller teste hvordan det fremmer samarbeidslæring. Utforske interaktive VR senarioer i forskjellige yrker og kulturer kan også resultere i ulike tilfredstillings nivåer.

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List of abbrevations

VR	Virtual Reality
VARK	Visual, Aural, Read and Kinesthetic
XR	Extended Reality
UI	User Interface
PACT	People, Activities, Context and Technology
SSHF	Sørlandet Sykehus Helseforetak
OKL	Overordnet Kriseledelse
HMD	Head Mounted Display
HCD	Human-Centered Design
UIA	Universitetet i Agder
SBL	Scenario-Based Learning
GP	Group participants
UX	User Experience

Chapter 1

Introduction

Virtual reality (VR) as a tool for learning in healthcare is currently one of the larger fields of VR research being conducted [84], as the technology has great potential to provide contextualised immersive learning for healthcare professionals [30]. As VR technology has become more affordable, Norwegian hospitals have started exploring the possible benefits of VR for educating healthcare professionals [11, 80, 110]. VR technology shows potential as an economical option to educate psychiatric nurses [37, 82] compared to traditional simulation training, which often involves a high cost in time, preparation and execution [36, 63].

In cooperation with Sørlandet sykehus helseforetak (SSHF), this thesis will develop an educational VR application that focuses on training psychiatric nurses in handling aggressive and suicidal patients [87]. As the current limitations of using virtual reality in healthcare education relate to the participants' minimal interaction with the VR application, the application will tackle this by creating an active learning environment [84]. Furthermore, the possible advantages, challenges and satisfaction levels of using a VR application for learning will be explored with the VR application.

1.1 Background

This master thesis is a research project in collaboration with SSHF. The hospital has thirteen departments relating to psychiatric work that treat patients within many different specialisations [105]. Nurses at SSHF participate in educational training to increase their competencies in handling difficult situations [87, 102]. A traditional and effective method for training healthcare professionals has been to use simulation training, as it allows personnel to engage in realistic simulations in safe environments [19, 29, 36, 102].

As employees have to perform optimally in complex and unpredictable situations [36, p2], the use of simulation training to increase the competency of nurses has become a good learning method for improving performance [102, 114]. SSHF, however, wanted to increase the use of VR scenarios for use in simulation training as part of training staff to better handle violent, threatful and suicidal patients [87]. The motivation is to provide employees with access to prevalent scenarios in the healthcare field [110]. The idea is to incorporate virtual scenarios in simulation training by preparing the participants before exposing them to the VR scenario and then debriefing, reflecting and discussing the training afterwards. This should provide healthcare professionals with an immersive learning tool that does not require the same time and financial investment usually connected to simulation training [37, 36].

1.2 Problem statement

Simulation training is a good way to educate healthcare professionals in many different areas and can potentially increase employees' decision-making, communication, interaction and teamwork abilities [34]. However, challenges to incorporating simulation training include time investment and organisational and economic issues [37]. These may be some of the reasons for the lack of available simulation training for healthcare professionals worldwide [68].

In Norway, VR technology has been explored by using 360-degree recorded videos as scenarios in simulation training [11, 80, 110]. The hospitals hope this will provide employees with prevalent scenarios to be used in training [110]. These videos have, however, been passive video experiences without interaction, as is the standard for 360 learning content [84]. This contrast with the usual active engagement used in simulation training, and likely diminishes the learning experience [16, 84]. This is in contrast to the usual active engagement used in simulation training, which probably diminishes the learning experience [34, 61, 112]. Simulation training allows participants to experience difficult situations in safe environments [19, 29, 36, 102]. Without simulation training, healthcare professionals may be confronted with challenging patients without previous exposure and reflection.

The aim of this study is to find the advantages of using interactive VR scenarios as a supplement to simulation training by developing an interactive VR scenario using a human-centred design (HCD) [50]. The application will be used to discover the challenges and advantages of using VR to train healthcare professionals and will explore their satisfaction with using the virtual application. This will be performed using mixed methods [42] by combining usability testing [71] with a survey.

1.3 Scope

The VR application will contain a maximum of two scenarios. These will be created using the human-centred design process to accommodate users' and stakeholders' needs [33]. The interaction will be designed using a branching narrative where the participant will be responsible for the outcome of the scenario. The first scenario is related to an angry patient who is threatful toward the participant. Here, the participant selects how to behave while interacting with someone aggressive. The second scenario is related to a suicidal patient. As in scenario 1, the participant will choose the interaction that determines the outcome of the scenario.

1.4 Research questions

Based on meetings with SSHF, data collection from the early phases of HCD, and the problem statement, the following research questions were created:

- How can effective VR scenarios of hospital simulations be designed for nurse training?
- What are the advantages and potential challenges of using VR scenarios for training nurses in psychiatric wards?
- What are nurses' levels of satisfaction after using the VR simulation?

1.5 Constraints and limitations

Constraints were put on the research due to the pressure of Covid-19 on the hospital and the limitations of Unity's Android builds and Oculus file size limits.

1.5.1 Constraints

Two significant constraints affected the development and research. These were hospital restrictions because of Covid-19 and the Oculus file size support.

Covid-19

Covid-19 created some problems relating to the number of participants who could attend user tests during the early development of the VR application. The first design iteration process was to be performed at hospitals in Arendal and Kristiansand. Ten participants were recruited to participate in the user study. Unfortunately, during the same week when all user tests were supposed to be conducted, a friend contracted Covid-19. Because of this, all user tests had to be postponed due to a mandatory quarantine that went into effect at the time [51]. A few days after the quarantine began, a mandatory isolation went into effect due to a positive test result. The isolation ended the day before Christmas eve. Due to this, all user tests were put on hold until after the New Year.

After New Year's Eve, Covid-19 infections in Norway were at an all-time high. Because of this, the hospital's established Senior Crisis Management team (Norsk: Overordnet kriseledelse (OKL)) decided that all courses, meetings and gatherings not strictly necessary for the operation of the hospital had to be cancelled for the duration of January. This made it difficult to perform new user tests at the hospital. Fortunately, due to the immunity of staff members previously infected with Covid-19, and because the user test requirements were limited to observation and one-on-one interviews, the hospital in Arendal allowed for continued testing. However, the hospital in Kristiansand could not allow this. As such, the user tests in Kristiansand were moved to the University of Agder (UiA) instead. The decision from OKL was posted on the intranet. As such, it is difficult to source the origin of the decision. However, a screenshot of the article is presented in appendix A.

Covid-19-related restrictions resulted in a lot of time and resources being squandered in organising user tests, meeting with the hospital, and finding facilities to perform the user tests. This also resulted in a loss of participants, wherein two participants could not attend the second interview session or and did not respond to emails. It also prevented the use of new 360-degree video recordings for scenario one. These new recordings would have elevated the quality of the application, as users critiqued parts of the video quality. The recording of the second scenario was also postponed to 28 February because some essential participants had contracted Covid. Moreover, the recordings on 28 February had to be cut short because participants needed to return to work due to the nurse shortages.

File size support

The Oculus Quest 2 has a 4Gb [79] game size limit compared to Android's 2Gb limit [6]. The 360-degree videos exported in recommended 60-80Mbps bitrate [104] often result in a file larger than 1Gb. The Android binary then had to be split to allow the application to run on the quest [126]. However, only the first scene was visible due to the large file size. Unity complained that the OBB file was larger than the androids size limit. When the source of the issue was found, the video quality was reduced through transcoding until the file size became under 4Gb. This allowed the program to run natively on the Oculus. Unfortunately, this made it necessary to manually import the OBB file when installing the program to a Quest 2, and the visual quality of the scenarios were reduced to allow two scenarios in the application. This is further explained in chapter 4.2.4.

1.5.2 Limitations

Two main limitations affected the research conducted during the thesis.

Regarding the survey, the number of respondents was less than what is normally needed for a meaningful result [25]. The number of participants was lacking due to hospital-related constraints and lack of available hardware. Only the VR headsets used during user testing had the VR application installed. Moreover, the hospital limited the product's availability to only be used when a VR expert was present, removing the possibility of placing HMD with the application in the different departments, as it would be challenging to ensure that the participants would find the correct application and perform the simulation without oversight. Because of this, available healthcare professionals who could complete the survey were limited to the participants from the interviews and nearby available healthcare professionals who could try the application at work.

Focus group interviews, alongside individual interviews, were used for this study, as the number of participants who wished to participate in the study became significant. This was done to save time and to include as many participants in the research as possible. However, some focus group interviews likely resulted in social desirability bias. This might have carried over to the survey, as it is likely that a majority of the group participants responded to the survey.

1.6 Thesis outline

|The thesis of this paper is introduced in chapter 1. This is followed by chapter 2 state-of-the-art, where the current use of physical and VR simulation training is presented. The chapter also presents strengths and limitations in relation to the use of 360-degree videos in VR for learning, as well as presenting the different learning theories related to the development and research. Chapter 3, methodology, will outline the data gathering methods used to answer the research questions, how the data was analysed, and the approach used to develop the application. This includes an exploration of who the users and stakeholders are and a review of their needs and requirements. Chapter 4, VR application design and development, presents the tools, software and process used to develop the application. Chapter 5, results, showcases the results gathered through the user testing and survey. Here, themes are presented, quantitative data is introduced, and the recorded data from observations are demonstrated. Chapter 6, discussion, will present the data in relation to the State-of-the-Art and the research questions to explore how the results answer the thesis questions. Lastly, chapter 7, conclusions and future work, will summarise the findings and suggest future work.

Chapter 2

State of the art

The state-of-the-art chapter details the current use of simulation training both with and without VR technology. It presents both the strengths and weaknesses of the current utilisation of VR technology and lays the groundwork for how the existing ultilisation of VR simulation can be improved upon. This chapter also presents the learning theories relating to simulation training and highlights how Norwegian hospitals have transformed their trainings to include VR scenarios instead of physical scenarios.

2.1 Simulation training

Simulation training is an essential part of nursing education [131]. It allows nurses to explore and experiment with situations they might experience in real life. The main purpose of simulation training is to provide nurses with realistic simulations in safe environments [19, 29, 36, 102], which allows them to increase their competencies when supporting patients [83]. The use of simulations has become one of the main methods of educating students and nurses in Norway [93]. It is used as an instrument for finding mistakes and learning from them [4]. It also positively affects patient outcomes [21] and is a useful way to integrate theory and practice [22].

A chronicle written by Farbu et al.[36] went into details on the benefit of using simulations in healthcare training. They write that employees often work in complex and varied environments while collaborating with others. At the same time, all their work is expected to be of high quality and efficiency. Expectations are ever-increasing as nurses work with patients who need to be treated as safely and comfortably as possible [76]. The complexity of their workplace also demands that employees be flexible in their daily tasks and demands that they respond to varied situations in a high-quality manner [36]. Simulation trainings help prepare employees to create quality results by allowing them to engage in safe simulations [102] that closely replicate real-life scenarios [114]. A simulation training in progress can be seen in Figure 2.1.

Farbu et al. state that simulation training contributes to a better understanding of situations through improving participants' abilities to formulate and anticipate possible consequences and to practice decision-making, communication, interaction, and teamwork [36, p. 2]. They also state that such simulations show the extent to which participants can translate theory into practice. This makes it an enticing educational method to prepare and educate both people and teams in relevant healthcare situations and to evaluate healthcare employees' performances in solving emergencies [102, 114]. The structure of how simulations are performed is explained in detail in chapter 2.4.2. However, to summarise, it involves a combination of simulation with reflection. The use of reflection will help participants develop new mental models that will, hopefully, increase the quality of their work [34].

While simulation training is used for its apparent benefits, its effects are being researched with mixed results. Authors in *Effect of simulation training on the development of nurses and nursing students' critical thinking: A systematic literature review* carried out a systematic literature review with the

Figure 2.1: From Farbu et al.[36]. Simulation training in Stavanger by Bernt-Erik Rossavik.

objective "..To gain insight into the existing scientific evidence on the effect of simulation on critical thinking in nursing education" [1, p. 17]. Critical thinking in nursing is defined as "reflective and reasonable thinking about nursing problems without a single solution and is focused on deciding what to believe and do" [137, p. 257]. The 2017 literature review concluded with inconsistent results, but it was pointed out that this may be because of the heterogeneity that occurred across the studies. Another literature review by Piot et al.[83] explored the effectiveness of simulation in psychiatry for nurses, discovering that the simulations positively affected skills, learner attitudes, learner behaviours, and mental health.

There are some limitations to performing simulation. It can, for example, be expensive to plan, train people, and gather materials for the simulation which could have been used elsewhere [37]. Farbu et al.[36, p. 4] state that simulation training take time and demand organisation and investment. The simulation quality also depends on the organisers' experience, where lack of experience might negatively affect the overall quality. These issues might be why nurses sometimes have limited access to simulation training [68]. Aside from the organisational and economic elements, the participants might not enjoy participating in a simulation. Moreover, re-experiencing situations might cause discomfort or be humiliating, depending on the case [36].

However, there has been a steady growth in adopting technology in healthcare education [131]. As immersive technologies have become common and affordable, research into their use in education has become more frequent [84]. A prevalent immersive technology is virtual reality, which allows for immersive and active learning experiences through head-mounted displays [53].

2.2 What is virtual reality

The definition of virtual reality (VR) has shifted over the years. *The VR Book: Human-Centred Design for Virtual Reality*[53] presents multiple definitions of virtual reality. However, it concludes with the definition that virtual reality is an interactive, computer-generated environment that is experienced as if it were real-life [53, p. 9]. According to Merriam-Webster, virtual reality is "an artificial environment which is experienced through sensory stimuli (such as sights and sounds) provided by a computer and in which one's actions partially determine what happens in the environment" [69].

360-degree video is a less resource-intensive and economical method of archiving an immersive experience than a fully computer-generated environment [9]. Also known as immersive and spherical videos, 360-degree videos allow users to experience videos in a more immersive format compared to regular videos [84].

Head-mounted display, VR, and 360-degree videos have been of interest to researchers the 19th century. During the 19th and early 20th century, researchers tried to find new ways to experience immersive environments by exploring video displays and 3D images [53]. During the 1950s, Morton

Heilig created a device called the Sensorama [20] which was one of the earliest forms of immersive video and simulated a motorcycle ride through Brooklyn. It included 3D visual, audio, haptic, and wind simulation to create a unique and immersive experience. In the 1960s, head-mounted displays, which included head tracking systems that identified the head's position, began to emerge. These would eventually evolve to become the HMD technology we currently use. These include the Oculus, and the HMDs provided by HTC, Valve, and Sony [12].

It is disputed whether 360-degree videos can be classified as virtual reality, as the user's movement is restricted to head movement [90]. This prevents real-time interaction with the environment, as there are no 3D interactable objects. However, opponents to those statements express that the user can look in any direction [90] and that movement is possible through the loading of scenes that are fixed in the environment [9].

360-degree videos are a medium that can be experienced on several devices. Essentially, it is only necessary to have a video player, since 360-degree videos only need a video player to allow playback [84]. This allows the technology to run on low-powered devices like mobile phones. This is, however, a new phenomenon, as VR technology has historically been restrictive and expensive [82].

2.3 Virtual reality in healthcare education

VR and 360-degree video simulations have been researched in multiple fields, including healthcare, geography, history, computer science, language learning, engineering, natural science, teacher education, and finance. Of these, according to *The Potential of 360° Virtual Reality Videos and Real VR for Education—A Literature Review*, Medicine and healthcare is the largest field of research in relation to VR technology and 360-degree videos [84]. One of the reasons for the popularity of studying virtual reality is the apparent learning benefits that are unique to the technology, including the potential for contextual and collaborative learning [30]. However, these are only a few of VR technology's potential strengths.

Over the last several years, the cost of head-mounted displays has been reduced [82]. This marks VR displays as cost-effective educational products that will increase the sense of presence in an educational environment to a greater degree than computer monitors or screens [13, 84, 132]. This can also be particularly useful in simulation training, as the materials and equipment needed to perform the simulation will not be squandered. This will reduce the waste produced from each simulation session [81]. Moreover, the use of VR simulations compared to physical simulation reduces the need to hire or prepare actors [37, 63]. For example, suppose a simulation is already recorded as a 360-degree video; then the video can be used as an alternative instead of inviting actors to perform more simulations [37]. Moreover, VR training is often used to reduce injury or equipment damage in safety-critical industries [74, p. 353]. Seymour et al. [100] found that VR simulation training resulted in improved quality of surgery and resulted in fewer mistakes.

The use of standard videos provides, in of itself, some educational advantages. This includes their availability any time of the day, providing access to rare situations and complex interpersonal interactions, without the need to be present at an educational establishment [8, p. 2]. Converting the video material to 360 VR experiences provides similar benefits while including a few others. HMD, in contrast to monitors and screens, reduces potential distractions, as the user becomes separated from the outside world [58]. This increases their sense of presence in the virtual learning environment and can potentially lead to better learning. In addition, this increased presence might result in an emotional experience that will motivate further use [13]. The last point of providing a positive emotional experience is a common conclusion among researchers [7, 8, 44, 81, 117, 130].

The mobile benefits of using videos in education does apply to 360 virtual experiences to some degree. For example, it allows students to attend classes when they are located someplace else [44]. It also allows for meaningful learning contexts that are useful in a wide range of educational establishments [81]. In addition to the aforementioned benefits, improved concentration and critical thinking were also reported when learners were immersed in a VR learning environment [81, p. 4].

On account of these benefits, 360 and VR technology is likely a useful e-learning investment for educational institutions [117, p. 107].

2.3.1 Virtual reality supported training of healthcare personnel

The use of VR technology as part of educational trainings at hospitals has been researched for some time [110] in hopes of providing better training and education for healthcare professionals and, thereby, provide better services to patients [11, 80, 110]. This is currently explored by providing 360-degree recorded scenarios as VR simulations, which has been stated to provide some benefit concerning how the simulation is played out to ensure it affects what is supposed to be learned. VR-simulated scenarios have been incorporated into the simulation-based training currently performed at the hospital [110]. This includes three steps: preparation, exposure to a 360-degree VR scenario simulation, and finally, debriefing, reflection, and discussion. In this approach, the 360 video replaces performing a physical simulation wherein the participants immediately encounter an emergency when they put on the VR headset [80]. One such emergency could be, for example, being greeted by a threatening psychotic patient or arriving at an accident site.

With VR technology, the hospitals would like to provide employees with easy access to prevalent scenarios that affect employees [110]. This could include, for example, preparing psychiatric health professionals against violence, threats, and suicidal behaviour from patients [87], but it is also prevalent in other hospital facilities [11].

2.3.2 Limitations of using virtual reality in healthcare education

One of the major issues concerning VR in education is the lack of active engagement in the learning environment. Generally, the participants are expected to do minimal interaction with the application [16] and usually take the role of a passive observer that views the material without affecting what is happening [84, p. 4]. This reduces the potential learning benefits provided through active engagement in simulations [136]. Pirker and Dengel's literature review noted that through the 64 articles included in the meta-analysis, "the interaction within 360° videos is often minimal" [84, p. 84]. The ability for students to actively involve themselves in the VR environment through, for example, changing the storyline or using point and click was rare. The literature review reflected that the vast majority of the research passively used VR technology in education [7, 8, 13, 88, 111, 117, 130]. One example is Ulrich et al.'s [117] research testing the effectiveness of using 360-degree videos as lectures. They concluded that the 360-degree videos' effect was on par with traditional videos but "less effective than traditional teaching in student' learning satisfaction" [117, p. 84]. This adds to the notion that replacing videos and lectures with passive 360-degree recordings might not be effective, especially as students usually are not passive with physical educational environments [31, p. 411].

Other limitations include the lack of focus on the developmental aspects of creating VR applications for education. The use of frameworks or research-backed design models is lacking exchange with intuition and common-sense development [30, p. 25]. This might cause confusion while interacting with the application. For example, the learners might get lost while navigating the VR interface [8, p. 7].

2.4 Learning theories and approaches

Learning theories are hypotheses that explore how knowledge is received, processed, and stored by learners [118]. Different learning theories that explore different learning methods have emerged as learning theorists started moving away from behaviourism. According to the International Bureau of Education, behaviorism is understood "as the step-by-step or successive approximation of the intended partial behaviours through the use of reward and punishment" [118]. Two theories that challenge behaviorism are constructivism and socio- constructivism, where constructivism states that learners are not passive entities but are active participants. Socio-constructivism emphasizes the role of context, especially the social learning context.

2.4.1 Active learning

Active learning involves engaging students in learning activities, for example, through role-play, case simulations, and problem-solving [112]. This is in contrast to traditional learning, where the students are passive entities that receive knowledge from an educator [27]. Instead, active learning focuses on "how" the students learn, emphasising that it is not possible to "tell" the student all they need to know [26]. Teachers should challenge the students' thinking, who are themselves important in their own learning process. Figure 2.2 showcases different active learning strategies, including peer learning which is further explored in chapter 2.4.4, and roleplaying and experiential learning, which are further explored in chapter 2.4.2.

Active learning theory is based upon a learning theory called constructivism [26], which posits that students should construct their knowledge based upon their own previous experiences [127]. In addition, constructivists believe that students learn best when they actively participate in learning, that learning is a social process between the teacher and student, and that the learning process should facilitate the construction of knowledge since learning cannot be given to the students[127].

Active learning has been shown to affect student learning. A meta-analysis by Freeman [39, p. 8410] indicated that students' scores improved by 6% while engaging in active learning. It also indicated that students were 1.5 times more likely to fail a class if it used a traditional lecturing focus. Prince [86] did a study to explore the benefits of active learning, concluding that, although they varied in strength, active learning methods positively affected learning.

2.4.2 Experiential learning

Experiential learning is based on social and constructivist learning theories [118] and is a learning concept presented by professor David Kolb [56]. In essence, experiential learning is the knowledge gained from experience[35]. A participant gets immersed in an experience and learns new skills or attitudes. This is an active learning theory, as users learn by physically engaging in the learning material, which is also called "learning by doing" [61, p. 5].

Figure 2.3 showcases an experiential learning cycle, which typically includes:

- Concrete experience.

  The participant experiences a new situation or concept.

- Reflective observation.

  Reflection on the outcome of the experience and points of interest or particular importance.

- Abstract conceptualisation.

  The reflection conceptualises new theories. The participant has learned something new based on their experience, reflection, and observation.

- Active experimentation.

  Repeating the activity based upon the insights gained from the previous steps. The learner applies their ideas to their work environment to test their experience, promoting future experimental learning [35, 66].

Scenario-based learning

A learning method used to experience experiential learning is scenario-based learning (SBL) [14, p. 105]. SBL, also known as case-based learning [65], uses interactive simulated scenarios. It is often used to engage learners in realistic situations while they remain in safe and supportive environments [19, 34]. This is usually preferable when the actual situation is either not desirable or appropriate to engage in training [54, p. 367]. The scenarios are not entirely real-life situations but mental

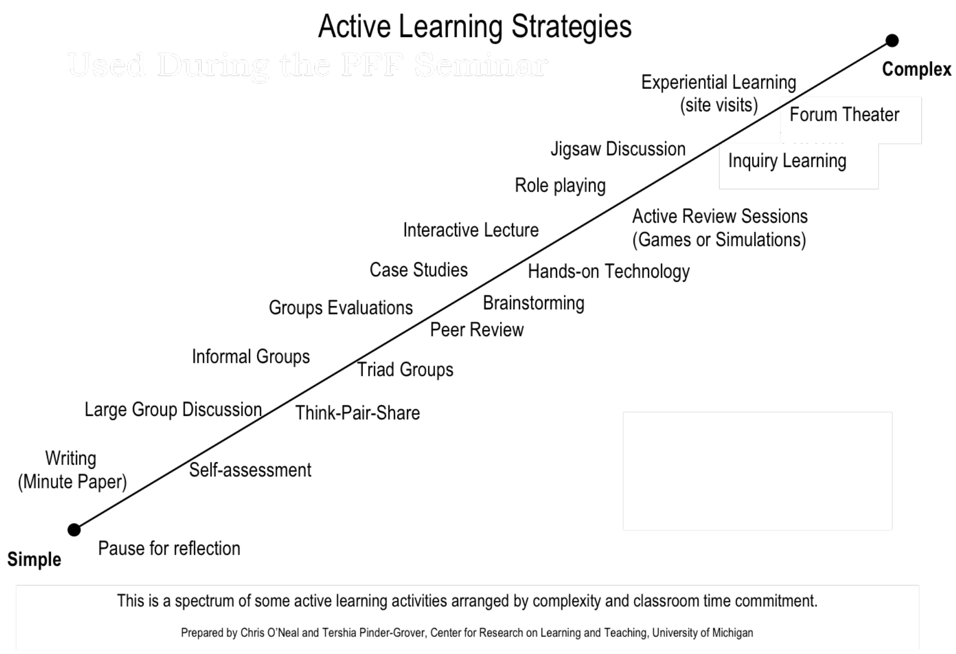

Figure 2.2: A list of active learning styles arranged by complexity [27]

Figure 2.3: The four stages conceptualised by Lewin [35]

fabrications that replicate aspects of real life[34]. This allows them to be dissected and reused without considering time and place.

Scenarios are often enhanced by combining them with techniques like discussions, role-play or periods of reflection [34, p. 2]. For example, role-play has a history of being used in psychiatric education [67], allowing nurses to link theory and practice in authentic psychiatric-related experiences [55, p. 2]. The SBL process usually involves introducing students or professionals to the scenario by receiving a description of the setting [34]. After completing the simulation, the participants have a discussion where they reflect on their choices and actions during the simulations. The last part might be important to allow the participant to reflect on the experience, which helps analyse their assumptions and beliefs [99].

2.4.3 Affective learning

The affective domain is one of three learning domains that are used to classify educational learning [41]:

- The cognitive domain, which is knowledge-based.
- The affective domain, which is emotion-based.
- The psychomotor domain, which is action-based[135, 41].

The affective domain is structured into five levels of learning. These are:

- Receiving - Being willing to listen and be aware.
- Responding - Actively participating.
- Valuing - Attaching value to the learning environment.
- Organisation - Comparing values to resolve conflicts.
- Characterization - Lets the value system control behaviour [135].

The author of *Affective Learning in General Education* explains the different levels [41, pp. 4-5]. The first label on the taxonomy is **receiving**. This is achieved when the learner is aware of the teaching or is attending something learning-related, like lectures or class meet ups. In this step, learners uncover new concepts and are willing to learn more about them. The second level is **responding**. In this step, the learner is, to some degree, committed to responding to the information they are receiving. In addition, they show some willingness to engage in activities. At this level, participants engaged with the course's material by participating in class and completing assignments. **Valuing** occurs when the learner is involved or committed to a phenomenon or behaviour. They demonstrate this when they prioritise academic obligations. **Organisation** occurs when the learner adds new value to their set of values. In other words, learners prioritise values and resolve conflicts between them. Examples of organisational learning include accepting ethical standards and formulating a life plan that balances work and personal values. Lastly, **characterization by a value or value set** occurs when the learner accepts professional standards and commits to them daily. This occurs when students are self-reliant and have the ability to solve problems independently.

2.4.4 Peer Learning

Peer learning is a procedure where participants learn from each other [32]. It involves students being responsible for identifying their learning needs and exploring how to address these needs [23, p. 416]. This teaching method has become more popular as the quality of teaching has gained importance, as well as teachers' needs to educate an ever-increasing number of students [115]. Peer learning is an effective learning method for students, as they learn by explaining their ideas to their peers [89]. Students acquire skills while working collaboratively with coequals, providing and acquiring feedback from peers, and assessing their understanding of topics. Peer learning allows participants to engage in reflection and exploration without having an educational authority present in the learning environment [23, p. 415]. This has been shown to provide outcomes on par or better than group tutoring by faculty, and participants' feedback is generally approving [115, p. 338].

2.4.5 VARK

The VARK (acronym for visual, aural, read and kinesthetic) learning styles are popular concepts concerning how best to educate students based upon their preferred learning type. The VARK model suggests that students learn best when their education matches their learning style [28].

Learning Styles	Strengths	Strategies
Visual	Process viewable information best	Graphs, flow charts, pictures, and other illustrations
Aural	Learn best when they can hear the learning material	Listening to lecture tutorials and listening to recorded playbacks
Read/Write	Learns best when they see written words	Reading text, taking notes, rereading
Kinesthetic	Learns best through experience	Physical interaction, practice, learning information connected to reality

Table 2.1: Strengths and strategies of the different learning styles [64, p. 118]

The table 2.1 and shows the different strengths and strategies relating to the different learning styles. Strengths refers to the main points that represent the learning style. Strategies refers to methods students should use to maximise the effectiveness of their learning style.

The academic literature relating to VARK provides mixed signals concerning the effect VARK has on education. Ania-Popoola's literature review concluded with the necessity to consider VARK, especially in nursing education by saying, "This ensures their achievement and retention in the profession" [5, p. 8]. However, Aina-Popoola does state that, in general, learning styles have not conclusively indicated academic success. Mozaffari [72] explored the relationships between learning styles and academic achievements among dental students, and Husmann [48] checked whether course performance is related to VARK learning styles. Both studies concluded with little correlation between VARK and academic success. However, they shed light on how people are different and learn differently [48, p. 17]. It is likely because of this that VARK remains widespread among students and educators, as students may feel pulled towards a certain learning style [28].

2.4.6 VR and Education

The VR technology can well use the mentioned learning theories and approaches. The VR technology includes the capabilities needed to provide a visual, audial, written and kinesthetic learning experience through its display, speakers and direct interaction using controllers [133]. This allows the participants to actively engage in the learning environment directly. This relates well to the simulation training performed at the hospital, where they explore and experiment in safe environments [29, 102]. Concerning experiential and scenario-based learning, VR technology allows participants to experience new concepts in virtual role-plays relevant to psychiatric situations at work [35, 65]. The technologies are also a good way to provide a positive emotional experience to the learning environment [11, 117] and promote empathy [13]. This makes it relatable to the affective learning domain, creating an emotional-based learning environment [41].

2.5 Technology

Kourtesis et al. [57] conducted a technological review and meta-analysis to discover what technical requirements HMD needed for optimal user experience. They explored and analysed display technologies with different specifications, sound, motion tracking ability, process power, and external hardware. The results of the analysis are presented in table 2.2, which explains the suggested standard for the specific features and the reasoning behind it.

Feature	Suggested standard	Reasoning
Display-screen	Good quality (Oled or LCD)	CRT might cause adverse symptoms
Display-resolution	960 × 1,080 sub-pixels per eye minimum	Low-resolution image
Refresh rate	75hz or higher	To safeguard health and safety
Field of view	110 degrees or higher	Reduces immersion

Table 2.2: Kourtesis et al.'s [57] suggested standards

The suggested standards were specific to the specifications the HMD screen would support. Other suggested requirements are that "VR HMD should have external hardware which offers an adequate VR area, fast and accurate motion tracking, spatial audio, and ergonomic interactions" [57, p. 6]. Also, the hardware in the computer "(i.e., the processor, the graphics card, and the sound card)" should meet the minimum requirements needed to run HMD applications [57, p. 6].

Chapter 3

Methodology

The chapter presents the methods and approaches used during the research. This includes data gathering methods, the human-centred design process, and thematic analysis.

3.1 Data gathering methods

Defining a research method is an essential step of performing structured usability research [95] Depending on the research motive, the data the researcher wants to collect, and how they prefer to conduct their research affects the type of research method that is chosen, which usually stands between performing qualitative or quantitative research.

The main differences between qualitative and quantitative research are the resulting data they produce [17]. Usually, qualitative data includes notes and transcribed information made from the direct processing of audio and video recordings or through direct observation and interviews with a participant. Quantitative data is the opposite. It usually includes considerable numerical data and statistics from closed, question-heavy surveys, or other indirect data gathering methods.

The advantage of using qualitative research is that it is flexible, which allows researchers to process new patterns if they emerge [17]. It also allows for data collection in real-world settings, focuses on people's experiences, which are important for improving a system or product, and allows for the generation of new ideas because of a focus on open-ended questions.

The strength of using quantitative research is that it allows for direct comparison of results, as it can be reproduced anywhere at any time, and the results can be compared statistically [18]. Standardised data collection also allows for easy replication and is an effective method for analysing a large amount of data.

Initially, the author chose a qualitative research method for two reasons [95]. First, as the research included nurses from the hospital during the pandemic, the number of participants who could or wanted to participate was expected to be low. Because of this, getting the most data from each participant was essential, as quantitative data needs a large sample to be valid. Secondly, there was a necessity in the early stages of the thesis to find possible usability issues relating to the product. As such, usability testing [71], which combines interview and usability tests with observation, was the preferred testing method. Usability tests allow direct observation and engagement with the participants, which is optimal for obtaining first-hand experience of their behaviour with the product. It also allows for direct interaction relating to their attitudinal dimensions about the product.

However, as the pressure on the hospitals from Covid-19 lightened at the beginning of April 2022, and as the product neared completion, which allowed for promotional videos to recruit participants, more nurses than expected expressed their desire to participate in the second data collection. Because of this, the interviews with observations were changed to a combination of interviews, group interviews, observations, and a survey. This turned the research into a mixed-methods approach [42], where qualitative and quantitative data gathering methods are used. Focus group interviews were used when a number of participants could participate on the same day and single interviews were used when participants could not participate in the group interviews. As the number of participants increased, so did the probability of receiving meaningful data through surveys. This allowed the research to be based upon a more complete picture and possibly make the results more credible.

Two data collection sessions were prepared for this thesis. The first collection relates mainly to the design and use of the product to discover usability and UX problems that need to be solved. This will be done using qualitative usability testing, which combines user testing during observation with an interview afterwards [71] in order to uncover problems, discover opportunities, and learn more about the target users, as seen in Figure 3.1. The data will be analysed using a thematic analysis explained in 3.3, data analysis. During observation, the user tasks will explore the entire application with as little input from the facilitator as possible.

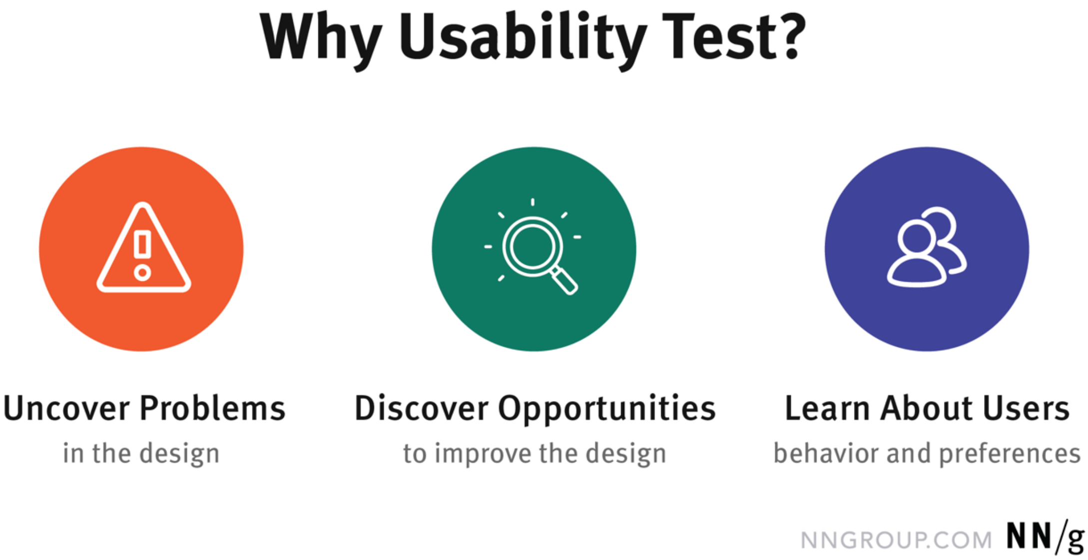

Figure 3.1: Three reasons to perform usability testing [71]

The second data collection session will focus on how the product fulfils the requirements of the users and stakeholders. It will also collect data concerning the research questions. The second collection will include two research methods: an interview and a survey. The interview questions will find answers to the research questions and explore the design of the application following the data collected during the HCD process. This is more thoroughly explained in chapter 3.2, Human-centred design approach. The setup for both the data collection interviews is explained in chapter 3.2.4, evaluating the design. The survey will mainly try to find answers to the two final research questions: What are the advantages and potential challenges of using VR scenarios for training nurses in psychiatric wards, and what are nurses' levels of satisfaction after using the VR simulation? The statements in the survey will be based on *The Computer System Usability Questionnaire* [60] and *The Usability Metric for User Experience questionnaires* [38]. The survey mainly explores the satisfaction levels of the participants. It will be provided to people who complete user testing of the product. The survey can be viewed in appendix B and the interview for the first data collection can be viewed in appendix C. Likewise, the interview guide for the second data collection can be viewed in appendix D.

3.2 Human-centred design approach

Human-centred design is the design approach used to develop the VR application. It is a practice where the focus of the design process is to create systems that fulfil human needs. Human-centred design focuses on the product users and where and how the users will use the product. HCD provides a framework for solving underlying fundamental issues in relation to the usability and user experience (UX) of the design. It considers the people, the environment, the contexts, and the technology to develop functional systems for human use and solve issues that prevent users from achieving their goals [50].

The user is involved throughout the design and process of human-centred development [33]. This is often performed by allowing users to engage in data gathering and active testing. This can be done through surveys, interviews, focus groups, or other data gathering methods where the user explains their needs or their experience testing the product. The user represents, to some degree, the characteristics of the user who will use the product. Ideally, the users involved in the test will themselves use the system [33, p. 6]. By including the users in different design process stages, new issues will likely arrive at all the different stages. This then exposes the need to use iterations while designing and developing the solution. The feedback provided by the user is invaluable to expose issues in the design, and the issues they find will be solved through iteration. Humans are complex. As such, the likelihood of developing a solution that fills all the needs and expectations of the users without iteration is improbable [33, p. 7]. This all expresses the need not to rush the development of the software. The human-centred design process stages require a time commitment in order to perform each stage optimally.

The activities presented in the human-centred design process are:

- Understanding and specifying the context of use.
- Specifying the user requirements.
- Producing design solutions to meet these requirements.
- Evaluating the design against the requirements [33, p. iii].

These activities are often illustrated as an interconnected spiral, as in Figure 3.2. Each activity is connected to the next, and all can be revisited if need be through iterations.

The following chapters will detail each of these activities and explain how they affected and structured the development of the VR application.

3.2.1 Specify the context of use

Understanding and specifying the context of use is the first step in the human-centred design process. The focus of this activity is to understand who the users and stakeholders are, what tasks they are to perform, and in what environment the design will be used. The goal is to gather sufficient data to support the design and development [33]. Each of these aspects is described below:

Users and stakeholders

The people who are going to use and interact with the system. Understanding their age, experience, goals, and constraints is important. This is also relevant when exploring the stakeholders. It is necessary to understand users' and stakeholders' criteria for the product's use, development, and accessibility before starting development [33].

User tasks

This concerns what tasks the user is expected to perform while interacting with the product [33, p13]. It is important to gather information that might affect the usability and accessibility of the application. This includes understanding the frequency and longevity of use and interdependencies.

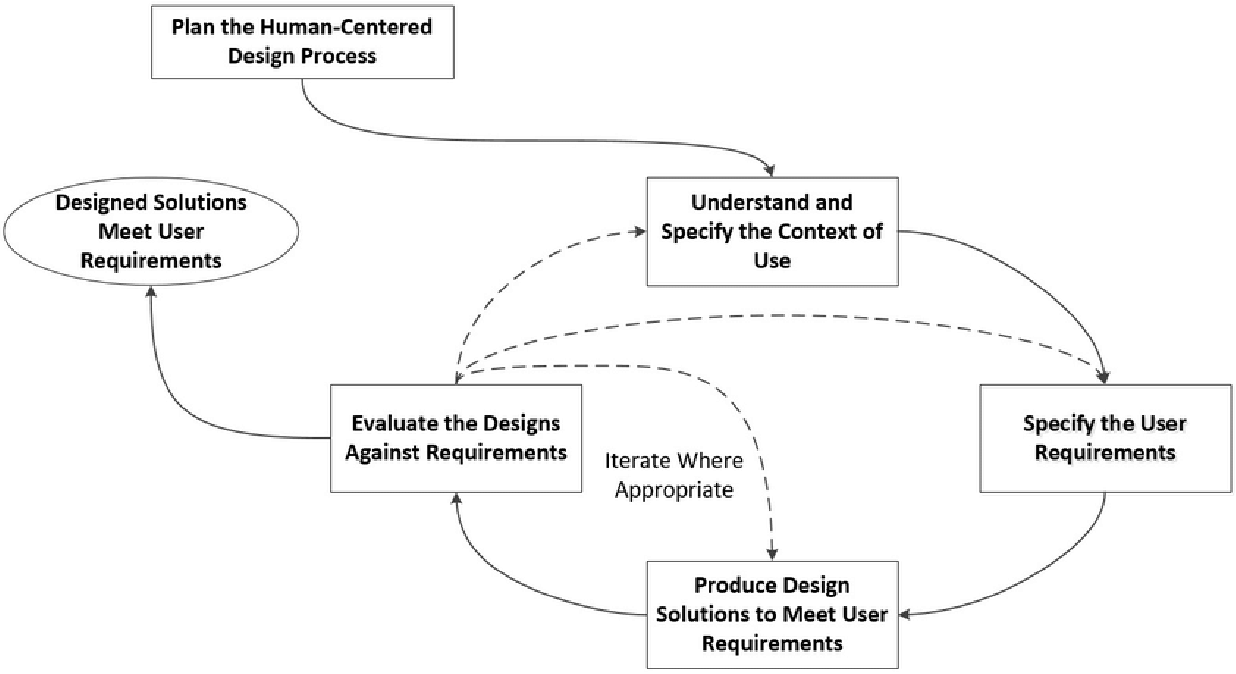

Figure 3.2: The four activities of human-centred design [47, p. 3]

One should also understand the health risks of the tasks, as they may affect the application's design. Understanding user tasks is important to comprehend what the users need to do while interacting with the product. This will assist in creating satisfactory design solutions.

Environments

The environments are the surroundings where the product will be used, both physically, socially, organisationally and technologically [33]. Environmental criteria for an indoor product can be vastly different from that of an outdoor product. For example, laptops are not meant to be used outside in the rain. Therefore, three specific environments should be explored during the context of use analysis: The technological environment, the physical environment, and the social and cultural environment.

The technological environment relates to the technology that will be used during development [33]. This includes hardware, software, and other materials. The physical environment includes thermal conditions, lighting, furniture, and other spatial layouts. Finally, the social and cultural environmental settings include work practises, organisational structures, and settings.

Understanding and exploring the users, tasks, and environment of the product will positively affect its quality. As such, ample time should be provided at this phase to ensure enough information is registered before moving on to user requirements.

PACT Analysis, user stories, and personas

A tool that can help develop a successful context of use analysis is performing the People, Activities, Context, and Technology (PACT) Analysis [75]. The information gathered by performing data gatherings can be put into the framework and organised into the letters PACT. PACT analysis expresses that people have different physical, physiological, and social differences, and have different mental models; that the users' activities can be simple or complex, regular or infrequent, and with or without time pressure; that the environment can be different socially, physically and organisationally; that the technology used in the solution has different input, output and communicational capabilities. These points show how the PACT is compatible and valuable during the first stage of the HCD process. The PACT analysis performed during this phase is shown in appendix E. It is constructed to include the necessary criteria for the context of use analysis.

Interviewing users and stakeholders

Organising meetings with representatives from different departments at the hospital was a necessary step of gathering information for the context analysis. The data recording was performed through unstructured interviews of health personnel, expert interviews, and observation of nurses performing simulations at the hospital. A total of five people were interviewed. Of these, two were experts at hospital e-learning, one was an innovation consultant, and two were healthcare personnel at the hospital. In addition, three nurses were observed as they performed simulation training. Unfortunately, this was done before Norsk Senter for Forskningsdata (NSD) approval could be established. Because of this, no personal data was collected.

The main focus of the data gathering was to understand how simulations are carried out at the hospital, as well as the overall goal of the e-learning plans currently in development. It was also necessary to understand how and when simulations were performed. As the product was likely to be a VR simulation closely related to a real-life simulation, it was important to understand how simulations were physically performed at the hospital.

The semi-structured expert interviews took place with an innovation consultant at the hospital and a university lecturer at UiA. The purpose of the consultant interview was to understand who the users and stakeholders are, what e-learning courses are currently in use at the hospital, what technology is used to engage with the courses, and what tasks users usually have to perform while interacting with the courses. The university lecture interview focused on the learning theories and methods used at the university and hospital to train nurses through simulation training. The hospital was, at this time, working to implement a new e-learning course relating to threats, violence and suicide prevention. The reason for the interviews was to understand where the thesis prototype fit in with the current e-learning systems and why there has been a shift to create new courses with the use of VR technology. The consultant interview guide is listed in appendix F, the interview answers listed appendix G, and the university lecturer interview is listed in appendix H.

User stories and personas

Capturing user needs and requirements can sometimes be challenging when designers only work based on data [46]. This can lead the designer to be disconnected from the users they are trying to satisfy. User stories [101] and personas [15] are two methods of creating descriptions of user requirements and providing a more personal connection between the designers and the users.

User stories represent the user's needs based on their perspective. They are usually short chunks of information that capture some user experience and usability goals. These are particularly useful when developing in a team. Information about the users can be easily shared between team members and helps start conversations that allow further clarification and extended requirements [101, p. 408]. The usual formula for creating user stories is as follows:

- "As a ‘Role’, I want ‘Behaviour’ so that ‘benefits’".

An example relating the project can be as follows:

- As a "nurse", I want "to perform simulations without having to meet up physically" so that "I will reap the benefits of simulation training where I am".

Personas are another tool that can be employed to achieve a good human-centred design [46]. It describes a fictional target user who defines their needs, concerns, goals, and relevant background information that brings the character to life. Even though the character is fictitious, it should still be a realistic description of a user. The persona's goal is to describe the characteristics that will impact the product's design. This allows the designers to read and remember who the audience is, which allows them to empathise with the user and develop solutions targeted at somehow improving their experience. Compared to working from statistics and broad descriptions, this might not connect the designers to the users to the same degree as using personas. The user stories and personas created for this master thesis can be found in appendix I.

3.2.2 Specifying the user requirements

Specifying the user requirements is a crucial part of human-centred design development [62]. A lack of understanding of user requirements might result in a confusing product that is not enjoyable to use. Because of this, the information gathered in the context of use analysis through stakeholder and user interviews should be used to construct specific requirements for the application [62]. In order to construct and organise the requirements, the Volere Requirements Specification Template by James and Suzanne Robertson was used [92]. This template organises the requirements into two different requirements: functional requirements and non-functional requirements. Functional requirements are the main conditions that must function in order for the application to perform as it should. This includes all the application's points to perform and process on a fundamental level. Non-functional requirements focus on the properties these functions must have. These are usually usability and performance-focused and are less evident for the product's users. Volere providers their own cards to be used for capturing requirements. These have been slightly modified to include the necessary information needed to capture the requirement for the VR project. The Volere template developed for this thesis can be found in appendix J.

Usability and User Experience Goals

According to Sharp et al. [101, p. 19-20], six usability goals evaluate a system's capability of allowing users to achieve their goals. These are effective to use(effectiveness), efficient to use (efficiency), safe to use (safety), having good utility (utility), easy-to-learn (learnability) and easy-to-remember how to use (memorability). These goals are often used to evaluate the usability of a system. They are used as criteria for such evaluations where they are operationalised as questions. Such evaluations can be valuable in HCD, as they question the system's ability to, for example, provide information rapidly and effectively (effectiveness and efficiency) or to teach the user how to operate the equipment to such a degree that they remember it when using the system again (easy to learn and easy to remember).

Figure 3.3 showcases the core usability goals in the circle's centre. These represent the core functions a system needs to have explored, or it might negatively affect the product's usability and user experience. The outer circle represents the user experience goals [101, p. 22]. These are different from the usability goals as they focus more on how the users experience the product. They are more subjective and aim to promote desirable aspects from the user. A product can, for example, be easy to remember and learn and be an effective tool while being unsatisfying and boring to the user.

3.2.3 Producing design solutions to meet user requirements

At this stage of the human-centred design process, the requirements can be used to create design solutions for the application. The method of designing the solutions can be varied. However, they should include the application's main functions and showcase the processes it needs to perform [33]. The solution selected for this master was a conceptual model.

A conceptual model is a high-level visual representation of how the system will work [101]. It showcases the different stages a user should be exposed to and how these stages interwork. The stages are based upon the requirements and are simple representations of how the product should function.

The conceptual model in 3.4 showcases the possible interactions the user can perform in the system. When conducting interaction design, the use of a conceptual model is essential to create the backbone for the tasks and interaction the system must provide [101]. The conceptual model is part of conceptual design, whose main focus is to understand and explore what the product will do and

Figure 3.3: Usability Goals from Adikari et al.[2, p. 2]. Based on the first edition of *Interaction design: Beyond human-computer interaction*[94, p. 19]

how it will behave to achieve its purpose. Conceptual design is also iterative and changes multiple times during development. Conceptual design is an abstract description of the interactive functions of the product. It also shows the relationships between all the tasks and is the bassline for further development for the application [101, p. 50].

Another part of interaction design is physical design [101]. In contrast to conceptual design, which focuses on the system's overall purpose, physical design takes the overarching descriptions of a product and uses it to create concrete design elements. As stated by Benyon [101, p. 51–52], physical design includes operational design, representational design, and design of interactions. These concern a product's function, structure and storage, style and aesthetics, and the structuring and sequencing of its interactions, respectively.

The visualisation of the design elements starts with exploring possible scenarios for the product. This was done at first with only one scenario in mind. However, it was later repurposed to include two scenarios. At this stage of the products development, performed low fidelity prototyping is typically performed to be able to quickly test and explore design solutions [101]. These are often called paper prototypes, as they are usually created using paper, which is easy to manipulate during testing. This allows design ideas to be produced and discarded quickly to generate different design solutions, making it ideal for early user testing. This stands in contrast to high-fidelity prototyping, where the product is in its later stages of development and is often used to get detailed feedback

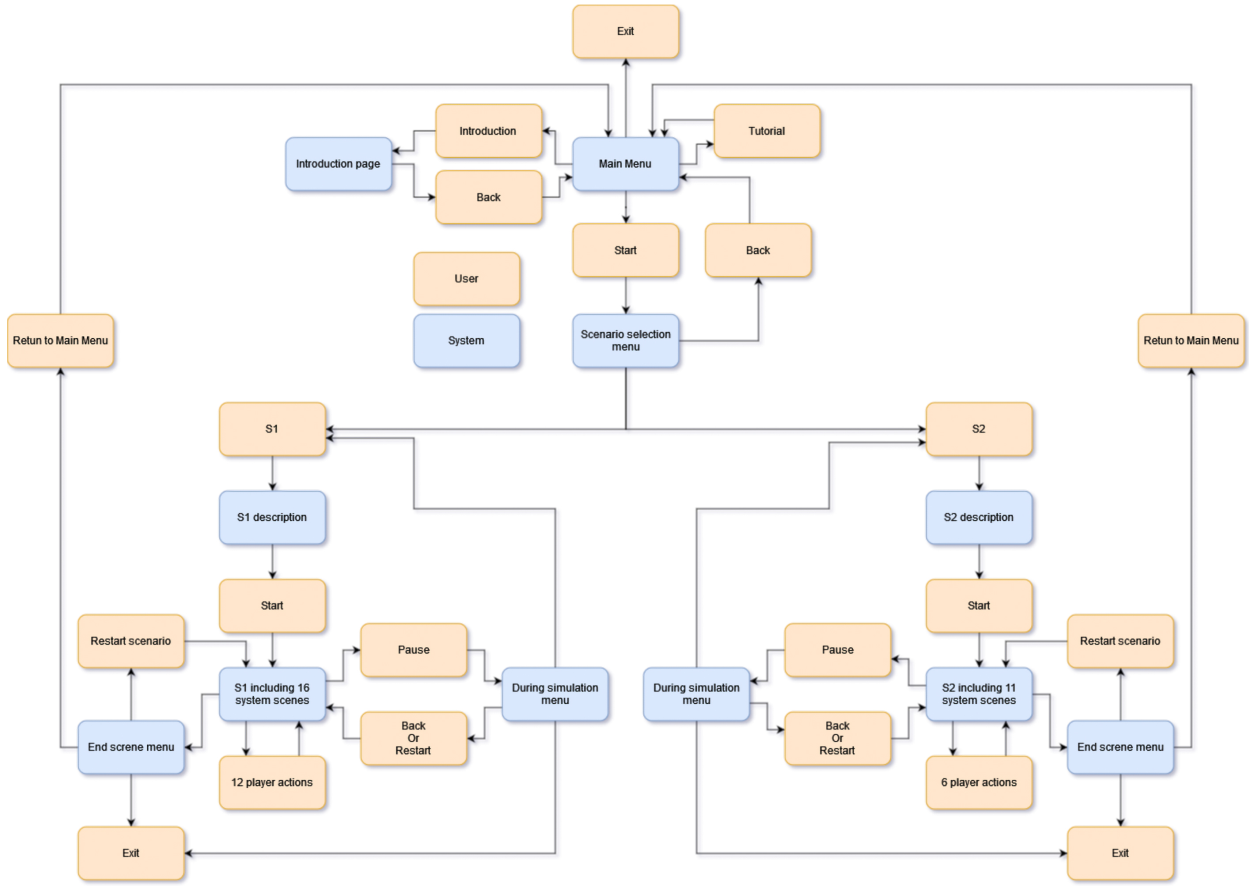

Figure 3.4: Conceptual model made for the SSHF simulation application

on the main design elements.

Prototyping

The low-fidelity prototype for this product was mainly created digitally. As the quality of the product was based upon the quality of the video scenarios, much focus was on the video production. This entailed finding products that could optimally record 360-degree videos, discovering how to properly record these videos, and the prework of video production by finding topics, location inspections, observations of simulation training, and creating storyboards. This made it difficult to focus on creating paper prototypes. Also, the videos are an essential part of the product and could not be tested with a paper prototype. Because of this, the focus became to create a working prototype to test the UI, simulations, tutorial and controller interaction simultaneously. Because of this, the low fidelity prototype was mainly a digital drawing of UI elements to explore where best to put them. These sketches were never tested on participants but became the framework for further UI development.

The high-fidelity prototype for the SSHF simulators was developed using multiple softwares and hardwares. The videos were recorded on an Insta 360 camera, and the sound was recorded using audio recorders. The video and audio files were edited on Adobe Premiere Pro and Audition, and the program was developed using Unity Universal Pipeline. This process is explained in detail in the 4 VR application design and development chapter. The application's high-fidelity prototype was developed to complete the next part of the human-centred design protocol.

The prototype displayed the main menu over footage of a hospital room, where spatial sound made noises from the equipment in the room. The player was presented with the menu where they could choose to start the simulation, view the tutorial, view the about page, or exit the application. This can be seen in Figure 3.5. There was also a large image to the left of the player presenting

Figure 3.5: The prototype's menu

the entire controller with button explanations. By pressing start, the player started the scenario without any scenario explanation. Inside the scenario, the player was presented with options and arrows pointing in the direction of the branching options if the user did not see them. The scenario changed instantly with each button click to the next scene. Finally, the user was presented with the end screen canvas at the end of the scenario, where the user could restart the scenario, return to the main menu, or exit the application.

3.2.4 Evaluating the design

The last stage of the human-centred process involves evaluating the application with stakeholders and users. Of course, evaluation happens to a lesser extent in multiple stages during the development of the product because of the nature of performing human-centred design. However, testing the entire design is nonetheless an important part of getting user feedback concerning the design solution as a whole. It is usually expensive to perform user testing, as the prework needed to perform these tests can be excessive [33].

For this thesis, the design evaluation part of HCD was performed early because of the pressure to test the product together with the video simulation. The chosen data gathering method is explained in detail in chapter 3.1. The user test performed in the evaluation included an interview and product testing in accordance with the usability testing method [71, 129]. This was used to identify usability problems and determine how satisfied the user was with the product. Any issues were organised into critical, serious and minor problems [128]. Critical problems are issues that are of high priority. Fixing these issues would result in a considerably more usable product. In essence, if the critical problems are not solved, then the participants cannot complete the scenarios. Serious problems include issues that seriously affect the user experience, while minor problems are issues that are annoying but that will not significantly affect the use of the product.

The usability testing method was performed in accordance with the eight-step process of conducting a test as described in part two in *The Process for Conducting a Test in the book Handbook of Usability Testing* [98, p. 63].

Developing the test plan

The planning phase included defining what was necessary to test and how to perform the testing. During both data collections, it was necessary to test the usability of the application by performing a usability test [71, 129] by performing an interview and observing the participant while they tested the product. The reason for this combination was to record both the attentional and behavioural data [95]. The test plan stage laid the groundwork the chapters presented below.

Setting up a testing environment

The user tests were located in Arendal, Grimstad and Kristiansand, as the healthcare personnel had departments in Arendal and Kristiansand, and for some, it was more convenient to participate at the university. Kvinesdal was added as a fourth location during the second data collection. It was deemed necessary to travel close to the nurse's workspaces and perform the usability testing outside of a lab to make testing as convenient as possible for the participants. However, this was not an ethnographic field study, as the locations for the user test were booked meeting rooms [113]. The environment where the usability testing took place included group rooms, offices, and meeting rooms at the hospital departments in Arendal, Kristiansand and Kvinesdal, and the University of Agder in both Kristiansand and Arendal.

Finding and selecting participants

Participants were recruited from the hospital and through email. An email was sent to relevant department managers, who forwarded the mail to their healthcare workers. Some healthcare personnel made contact and expressed a desire to participate, while others were directly contacted on the recommendation of department managers. The participants were representative healthcare personnel that worked in psychiatry. The goal was to include people of different ages, experiences and genders. This was to ensure that the people participating in the user tests represented healthcare staff in physiatry. However, as Covid-19 halted the first user tests less than two weeks before Christmas, the originally gathered and planned user tests were moved up to week three. Because of this, the number of participants was reduced, whereas those originally gathered participants participated if they still could. In the end, eight participants between the age of 20 and 50 participated in the first evaluation of the product, and 18 participants attended the second data collection. Details relating to the participants are displayed in chapter 5 results.

Preparing test materials

The high fidelity prototype was completed for the user test. It was a complete experience for the developer before the test day. An interview guide was created with a completed usability test dashboard [116]. During the usability tests, the main task was to explore every aspect of the product. Because of this, the usability test dashboard was constructed to include tasks that explored all aspects of the design. In the first user test, the participants had to explore the pages of the menu, go through the scenario twice, and use a different road than the first during their second round. Similar tasks were created for the second user test. However, instead of going through the same scenario twice, the participants had to go through the second scenario. The pre-questions were constructed to understand the participant's current understanding of VR and what they usually do at the hospital. The post-interview questions in the first data collection were constructed to evaluate all aspects of the application. The questions were added into sections relating to different parts of the application. These were the interface, button mapping, users' well-being, and scenario simulations. The interview guide created for the first evaluation of the product can be found in appendix C. During the second data collection, the questions were constructed to find usability problems, explore the nurses' satisfaction levels in using the application and discover the advantages and challenges of using the application as a learning tool. The interview guide created for the second data collection be found in appendix D.

Conducting the test session

The testing was performed as planned using the usability test method [129]. The interviewer asked the interview questions and allowed the participant to say what they had to say without interruption. Not before the user finished talking did the researchers ask probing questions or continue the interview. A group interview from the second data gathering is showcased in Figure 3.6. During the usability test, the participants were instructed to use the think-out-loud technique while they tested the application [98, p. 204]. During this time, the researchers silently observed the participant and only broke the silence if the participant experienced issues that were not supposed to happen. In addition, during this time, the researchers took notes on any issues that the user experienced during playtesting. The Figure 3.7 showcase two participants performing the user tests during observation.

Reporting findings and recommendations

The result from the findings can be viewed in the results chapter, and recommendations are discussed in the discussion chapter. However, further context of use data was collected during data collection. Firstly, when performing scenario training with the VR headsets, the participants should be placed in separate rooms or have headphones in order to reduce disturbance by each other's audio. Secondly, there is a lack of simulation training across all departments, and some participants' experience with simulation training was limited to their time as university students. This shows that the use of simulation training is lacking.

3.3 Data analysis

In order to properly organise the qualitative data gathered through observations and user interviews, the data were analysed using a thematic analysis. This is useful in qualitative research, as it makes otherwise conceptually challenging and complex research easier to handle and analyse [24]. Thematic analysis is performed to make sense of the often-significant data gathered at the discovery phase [96]. The reason for using thematic analysis is to collect and combine data into codes and themes that represent the participant's thoughts and feelings on a subject. A theme is revealed when findings appear multiple times across the data sources.

The challenges of analysing qualitative data revolve around the extensive quantity of rich data [96]. Without a systematic analysis of the data, the results might be superficial and without analytical thinking. The analysis might then lack details and not fully represent the data collected during the qualitative data gathering.

The thematic analysis performed during the thesis followed the steps listed in NNGroup [96].

Step one:

All the data collected through observation and interview has to be read, viewed, transcribed, and analysed. It is important to ensure that all the data is included and added to be reviewed later in the analysis. Focusing on memory only usually results in data being left behind, and the resulting analysis will only be of memorable events.

Step two:

This step is more relevant when a team of researchers performs the analysis. All the data must be read through in order to become familiar with the data before proceeding with the analysis. This includes reading all the transcribed data and all the field notes collected during the data gathering.

Figure 3.6: Group interview during data collection two

Figure 3.7: User testing during data collection two

Step three:

All the collected data need to be coded. This is done by reading through the transcribed interviews and field notes and adding relatable codes to what is being said or observed. All the interviews were read through in this thesis, and all the interviewee's comments were assigned code and clustered together. For example, suppose all participants commented, in various degrees, that the controllers were challenging to use. In that case, their comments would be sorted in the "controller bad" or "controller pain point" code collection. An image of the thematic analysis can be viewed in Figure 3.8.

Step four:

After all the data is coded, it is possible to explore the relationships, similarities, differences, or contradictions between the coded material to reveal themes. For example, if most of the participants felt the controller buttons were confusing, but the point and click features were easy to understand, then a theme might be that point and click is easy to understand and anything else is confusing. This theme suggests that changes need to be made concerning user interactions with the system hardware. During this phase, codes and themes might rise and fall depending on the collected data. Suppose only one user commented on an issue, it might not be warranted to create a theme because of this. However, this issue might still need to be considered if it was by chance that the other participants did not discover the issue.

Figure 3.8: The collection of codes created during the second Thematic Analysis

Step five:

Usually, the amount of work needed to perform the above points can be significant. As such, it could be a good idea to take a day's break from the analysis. This break might help the researcher to view the data with a fresh pair of eyes, allowing them to see new patterns in the data and achieve new insights.

Step six:

This is the last step of the analysis and involves scrutinising the themes. It is important that data supports the themes and that it is saturated with lots of instances. Themes that are not supported by data should be revisited. This might result in new insights, valuable codes, and new themes being created.

Chapter 4

VR application design and development

The development process uses different multimedia technologies and software applications to produce the VR application. It includes hardware, software and developmental techniques relating to video production, audio production, game development and VR development. This chapter will go through the tools and processes used to develop the application.

4.1 Tools and software

The video production technology included a 360-degree camera and post-production editing software. The camera used was the Insta-360 camera [49], which allows for a monoscopic 360-degree recording in 5760x2880 resolution. Each of its two lenses takes a 180-degree recording and combines them into a single video file. It also includes two microphones that record a stereoscopic recording of the environment. The recorded video file is called .insv, which needs a particular plugin or software editable.

Adobe Premiere Pro [3] were used to edit the videos. Premiere Pro [73] is Adobe's professional video editing software and is an industry-standard for video editing. It allows for direct 360-degree video editing and includes the tools and effects necessary to create the video files used in the application. These include 360-degree sphere rotation, masking using alpha adjust, and increasing and reducing noise. In addition, the audio recordings were synced in Premiere Pro by lining them up to claps at the start of the videos. Premiere Pro also supported high-quality video exports using H.265 (HEVC), which was used for the project. This allows for a higher quality video while reducing the need for high bitrate [70]. It also allows for a smaller video file while preserving the image quality.

4.1.1 VR hardware

The university provides multiple VR HMD that was available for use for the project. These include the Oculus Quest, Oculus Rift and the HTC Vive. In addition to these headsets, the hospital provided Oculus Quest 2, which could also be used for the same reasons. Unfortunately, of these headsets, none fully live up to the specifications provided by Kourtesis et al. [57], which is explored in chapter 2.5, in state-of-the-art. However, the Quest 2 is not far off on the requirements, as shown in Table 4.1.1.

Ultimately, the choice of selecting an HMD for the project was twofold. Firstly, the Oculus Quest 2 meets the screen, resolution and refresh rate requirements presented by Kourtesis et al. [57], but not the field of view, without needing any external sensors or computer to function. This makes the technology transferable and allows for easy distribution without substantially sacrificing the experience. Secondly, the hospital's investment into the Quest 2 made it the standard technology to be used by personnel at the hospital. As such, the objective would be to ensure that the application worked nominally on the Quest 2, as it would be the HMD the application would be distributed on at the project's closure.

Feature	Oculus Quest 1	Oculus Quest 2	Oculus Rift	HTC Vive
Display-resolution per eye	1440x1600 OLED	1832x1920 LCD	1280x1440 LCD	1080x1200 OLED
Refresh rate	72hz	90hz (120hz experimental)	80hz	90hz
Field of view	Hor: 93 Vert: 93	Hor: 97 Vert: 93	Hor: 88 Vert: 88	Hor: 108 Vert: 97
Requires external equipment	No	No	Yes	Yes

Table 4.1: Specifications and requirements for HMD technologies [133]

All the aforementioned HMD devices support playback in spatial audio, which is one of the specifications mentioned by Kourtesis et al. [57]. This is useful in 3D-developed environments, as sound sources placed in the 3D environment can generate a realistic spatial soundscape [119]. However, spatial audio is not automatically recorded when filming 360-degree videos. Cameras that support this technology include multiple microphones that point in all directions to store sound placements of the environment [43]. Because of this, if spatial audio is to be archived, dedicated spatial recording equipment is needed if the 360-degree camera does not support it [91].

There are also two different ways to view 360-degree videos, either stereoscopically or monoscopically [134]. Monoscopic 360-degree recordings usually utilise two camera lenses. They record from the front and the back of the camera with 180-degree lenses. When stitched together, the result is a fully 360-degree viewing environment that allows for fully immersive viewing of the environment; however, the depth of the recorded scenes is not as rich, compared to real life. This stands in comparison to stereoscopic recordings, which record the environment in 3D. Stereoscopic recordings have multiple lenses and result in a video file that includes two aspects of the environment, one for each eye. These create a 3D environment where the user more prevalently feels a sense of depth. For example, suppose an object is nearing the face of the user. In this case, a monoscopic result will show an object filling the screen. A stereoscopic result will be the same, only that the object will appear as close to the viewer's face.

However, the downside of using stereoscopic recordings is that they demand more resources to perform optimally [97]. This is because the video file contains a video for each eye, and as such, needs much higher bandwidth to display a clear and smooth video. This is compared to a monoscopic video, where the same video is shared among bough displays.

4.1.2 Audio tools and software

The audio production recordings included the microphones connected to the camera and the external audio recordings using mosquito microphones. In addition, the mosquito microphones were connected to a Zoom H4n Pro audio recorder, which wirelessly stored the audio onto an SD card. The camera microphone was used during scenario 1, while the mosquito microphones were used in the second scenario.

The software used to edit the audio was Adobe Audition [59]. Similar to Premiere Pro, Audition is a powerful tool for audio production. It provides tools for audio restoration, audio removal, and noise reduction. Both the microphone's audios were edited using Audition and exported in .mp3 file format with the same sample type as the source. The format settings were 320 Kbps Constant bitrate (CBR). Both audios were synchronised in Premiere Pro. However, only the first scenario was exported with the video, as the audio in the second scenario was placed externally in the unity scene, as explained in chapter 4.2.5.

4.1.3 Game development

Unity is a game engine from Unity Technologies that was used to develop the application [103]. As a game engine, it provides tools and methods for creating features that will make a game work. For example, it provides tools like UI elements, video and audio players and scene controls, which are used extensively during the simulation development. This is all provided through Unity's Integrated development environment (IDE). Unity's tools and functionality can be extended through C# coding. The editor used in this project is Microsoft Visual Studio, which merges seamlessly with Unity. Unity allows for creating gameobjects, scenes, UI elements, video playback, and audio playback, which can all be interacted with and utilised by a user.

4.2 Video production

Video production was performed through pre-production, video recording, and post-production. The pre-production phase included all the work that had to be done before the recording phase, namely, research and preparations. The recording was completed during filming. Finally, post-production included all the work needed to edit and utilise the videos and the audio before importing them into Unity.

4.2.1 Pre-production

The pre-production phase included exploring the capabilities of 360-degree video hardware and discovering the video production cycle of 360-degree videos. This was done by completing a course on LinkedIn called *The Basics of 360 Video* [45]. The course outlined 360-degree video production from start to finish and became the backbone for the video's development. The course also gave an introduction on how to reduce motion sickness and other general information about 360-degree video technology, tools and techniques.

It was also important to understand how 360-degree VR simulations were used at the hospital. To explore this, it was necessary to travel to the hospital to observe the simulation training. Healthcare personnel currently working in psychiatry were selected for the training due to their experience in simulation training. This is supported by an article written by Baksaas [11] that using healthcare personnel instead of dedicated actors creates a more authentic experience. As the goal of this study was to actively train nurses in handling violence, threats and suicidal ideations [87], a scenario relating to handling threats was initially created. The scenario was based on a previous physical scenario created at the hospital involving an aggressive patient who desires cigarettes. This can be viewed in appendix K.

As explained in the State-of-the-Art chapter, VR training is often a passive experience where the user observes the situations unfolding [84]. Because of this, in order to promote greater immersion and interaction, a player voice who could speak for the patient was included. This created a first-person experience in which the user's actions were experienced directly by the personal interaction between the patient and the player. Early in the context of use analysis, it was decided that the experience should be more active compared to observing a situation unfold. To create a more active learning environment, the user would directly choose how they wanted to behave while interacting with the patient. This was done by creating a branching narrative of 360-degree video clips that explored how the user's choices affected the situation.

A loose storyboard was created during pre-production that outlined the branching narrative that should be presented to the user, showcased in Figure 4.1. It was created to provide two choices three times per simulation playthrough. This was deemed the maximum number of choices because a large amount of video recording was needed for each possible choice. By allowing two choices three times during the simulation, the number of videos needed was potentially fifteen, and eight of these as endings. However, it was deemed necessary to have three branching narratives for the simulation to be meaningful.

The content of each video and the options to be presented to the player were not decided before the

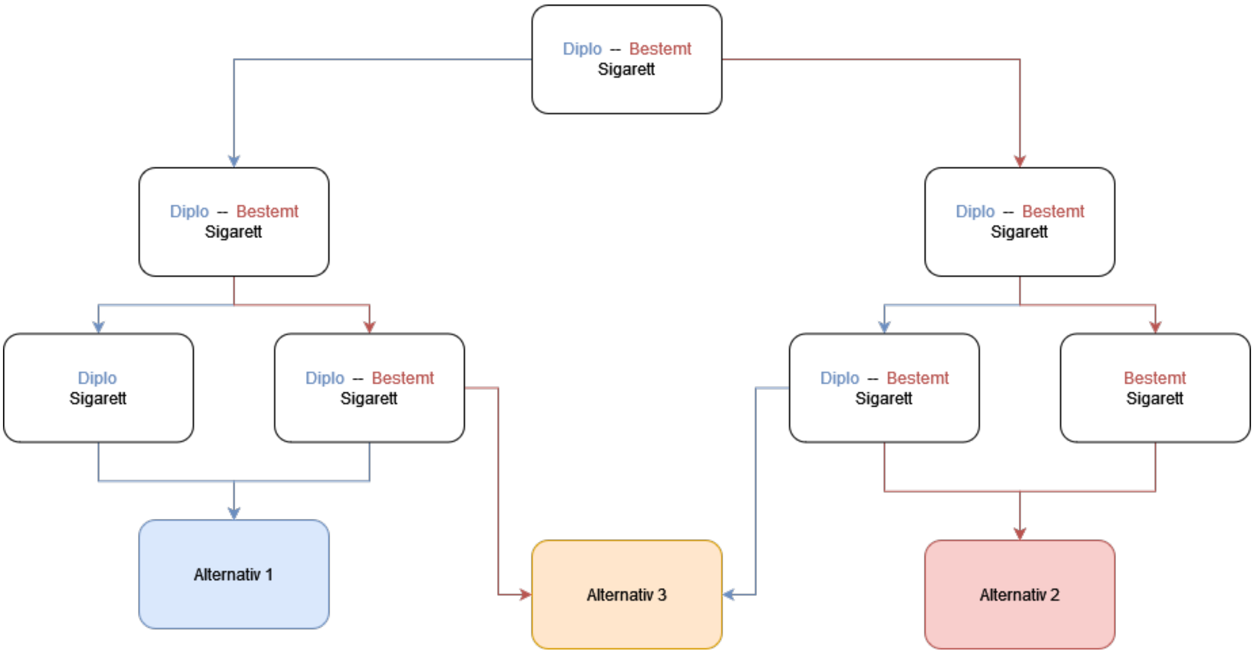

Figure 4.1: Storyboard from aggressive patient scenario

pre-recording briefing. This is because those with nursing experience were best suited to explore the content and options that the player should go through. During the briefing, it was concluded that an ending was to be re-used multiple times to reduce the number of recordings, creating the illusion of providing eight endings. This ending would be to give in and give the patient a cigarette. The briefing concluded that the user could have a diplomatic or determined attitude towards the patient. Also, during the briefing and recording, the actors were informed on how they should behave and interact with the camera to create less post-production work and maximise the user's immersion. This included not moving the camera, not moving around between scenes, not moving in the area where the lenses overlap, not moving to close the camera, interacting with the camera as if the camera was a person, and ensuring that the majority of the interaction took place between the patient and the camera.

The second scenario went through the same framework and preparation, except the theme was changed from threats to suicidal ideation, in order to provide a starkly contrasting scenario from the first, as threats and violence can be quite similar. The length of the scenario was shortened by reducing the branching options presented to the player because of constraints Covid-19 put on the actors and workplace.The storyboard created for the second scenario is showcased in Figure 4.2. The recording had to be done in half the time of the first scenario because the actors had to get back to work. This resulted in seven video clips, where four were endings.

4.2.2 The recording

The Insta-360 camera was placed at head height from the person who was to be the voice of the player. The actor then spoke straight into the camera without moving so that the audio would not be louder in one ear during playback. Additionally, the camera was positioned without objects being too close to the camera so that they did not tare between the lenses. During the first simulation, the user's colleague matched the attitude of the player's character. Next, the actor playing the patient mimicked a patient's attitude based on the player's choices during the simulation. Each shot lasted around a minute. Between each recording, the storyboard was reviewed to keep track of the timeline and process.

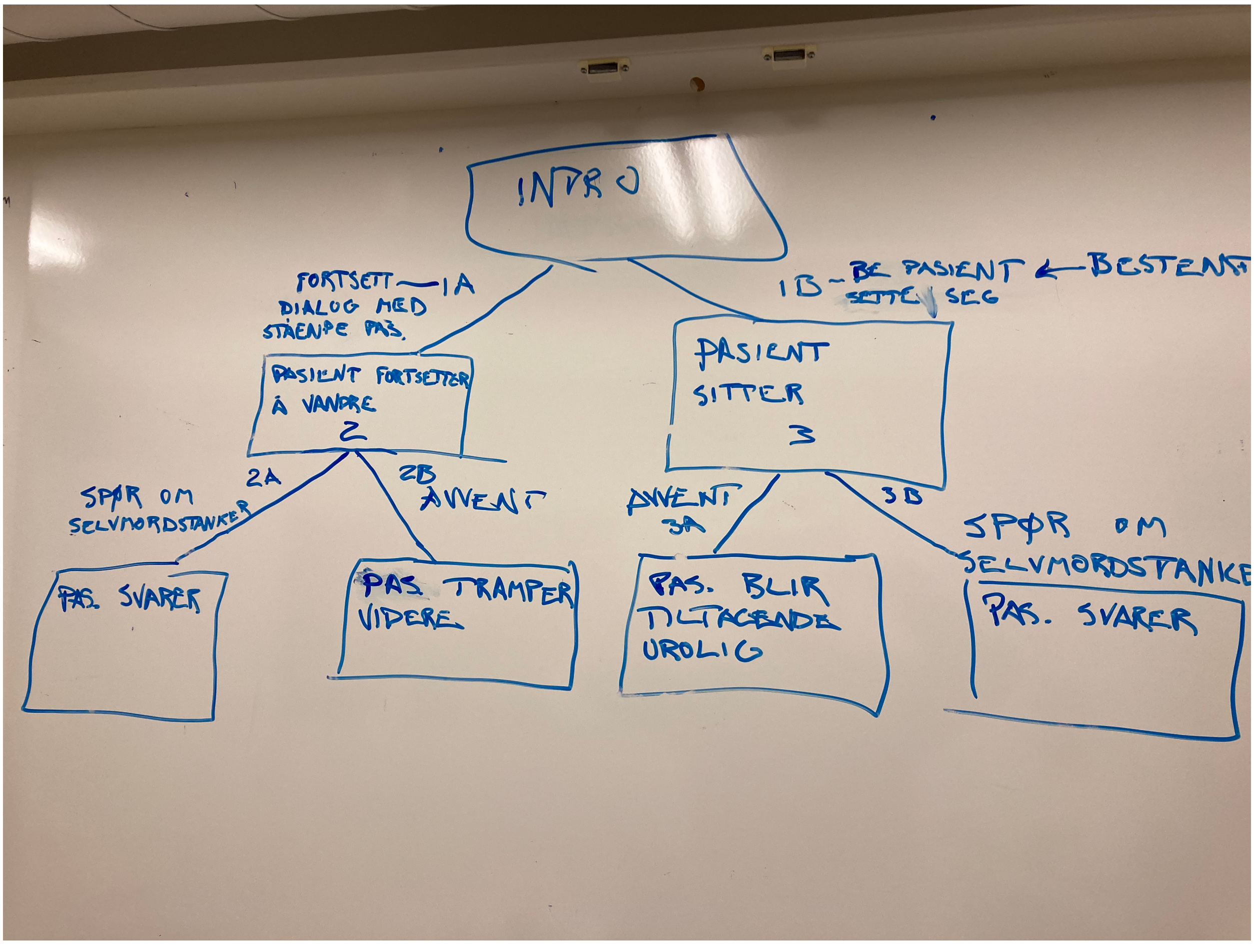

Figure 4.2: Storyboard from the second scenario about the suicidal patient

4.2.3 Post-production

Both scenarios underwent a similar editing process. Firstly, a video file was placed in Premiere Pro and clipped so that the video's start and end would fit as much as possible with the previous and preceding videos. Afterwards, the 360-degree video sphere was rotated 180 degrees so that the patient became the centre of the screen. The front lens had a scratch that caused the image to have a spot of blurriness, as such, the camera was flipped so that the blurry lens would face the wall behind the player. The next step was to mask any object that was not supposed to be there. Masking works by drawing an area of the image and changing it with something else. In this case, it was a recording of the environment without anyone present as seen in Figure 4.3. A video recording, rather than a still image, was used because a video has a slight movement of colours, contrasts and video noise. However, an out-of-place image would be noticeable. If the filler recording were done at the same place as the main video clip, then the mask would not be noticeable. However, if the camera has moved slightly, the result might be that the videos do not line up. This can be corrected by changing the video sphere of the filler video to line up as much as possible with the camera's new position. This might not create a perfect result, but the mishmash between the files will be reduced. Unfortunately, this had to be done extensively in the second scenario, as an actor touched and moved the camera, and this was not discovered before the edits of simulation two. The masking was used to remove anything unwanted. This included:

- The nurse behind the camera in both scenarios. Because the voice is the player, not a character.
- The room with the jacket and chairs in SIM 1. Because the chairs and jacket moved between shoots.
- The hallway in SIM 2 behind the player because a nurse's hands can be seen. This was solved

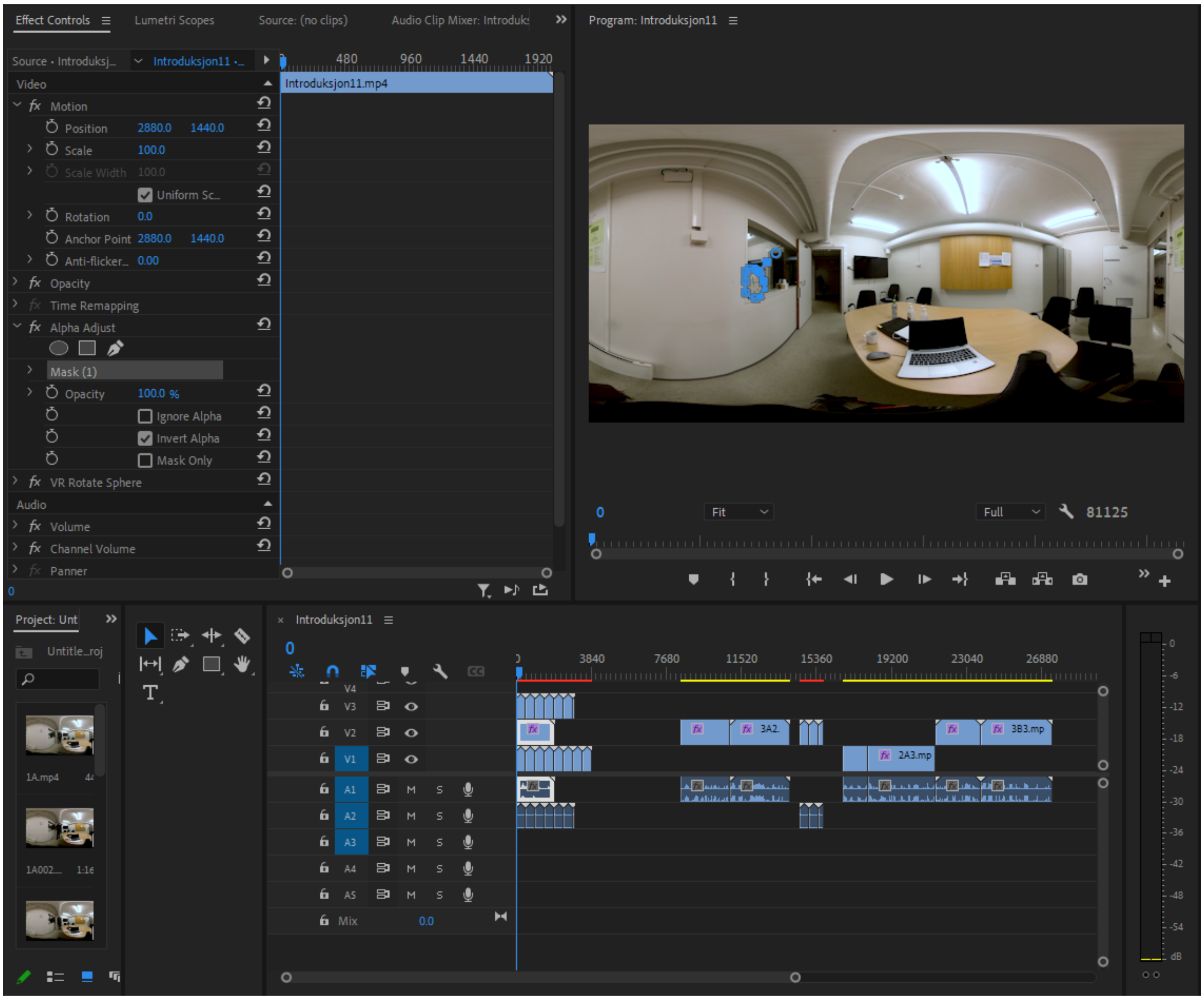

Figure 4.3: Video edit in Premiere Pro

by looping the frames where no one was in the hallway.

However, it was unfortunately necessary to freeze the clock in SIM 2 so that it would not randomly jump to different time stamps between clips. The clock error was not noticed until after the clips had been recorded, so it had to stay for the remainder of the recordings. It could not be masked out, as the patient would suddenly not be reflected in the window. Because of this, the image was frizzed to create the illusion of a broken clock. Noise grain was added to make it blend in with the environment. The last edit performed was to colour correct SIM 2 using Fast Color Corrector for White Balancing. This had to be done because the filler video had changed slightly in contrast and colour, resulting in a clear destination when the clip was used with the main video recording. To ensure the clips all had the same colour pallet, they were changed based on a sheet of paper on the wall using White Balancing. During the second scenario recording, the audio recording was performed using mosquito microphones instead of the camera's microphones, as the audio could be placed in a 3D space, which created the illusion of spatial audio. It was also used because of the increase in audio quality produced by the microphones, reducing the time spent editing the audio.

This process was performed on all 22 video files before being exported to the H265 mp4 format supported by Unity and Oculus Quest. The export settings were the same resolution as the source and at the maximum bit rate possible. Unity then downscaled the video through transcoding. The reason for doing this was because Unity had problems exporting functional builds to the Oculus due to Android and Oculus limitations.

4.2.4 Android and Oculus file size support

The rendering was a time-consuming process, with a full week dedicated to exporting video files. The motive was to discover the maximum amount of bitrate that could be used without crashing Unity. A higher bitrate would result in greater video quality at the cost of larger file size.

Unity would have ran the application on the computer used at the university. However, the program would not work on a laptop during user tests. This was fixed by reducing the bitrate from 100bits to 70 for each video in the current available first scenario. However, when it was time to export an Android build of the project, a message error appeared saying that the building process had failed. In order to fix this, the binary was split into both an .EXE and a .OBB file [126]. The reason for doing this was not known before the last user tests in April. The Oculus Quest 2 has a 4Gb [79] game size limit compared to the Android's 2Gb limit [6]. This resulted in only the first scene being able to play as the game .EXE could run on the quest [126]. As the 360-degree videos exported in the recommended 60-80Mbps bitrate [104] often resulted in a file larger than 1Gb, it is not too strange that the binary had to be split. As a result, the Oculus could only show the application's first scene. Unity complained that the OBB file was larger than the android's size limit. However, after the first reduction in video quality, the application worked as it should. Because of this, it was assumed that the limitation was not present on the Oculus. Only later, when the second scenario was implemented, did the issues resurface. When the source of the issue was found, the videos were further reduced through transcoding until the file size became under 4Gb. This allowed the program to run natively on the Oculus. Unfortunately, this also made it necessary to manually import the OBB file when installing the game.

4.2.5 Audio editing

The audio was edited in Audition to increase clarity and reduce noise and artefacts in the audio clips. The tools used for the audio editing were:

- Noise reduction tools for removing background noise, clicks and pops.
- DeReverb, which removes echo and reverb.
- A normalisation process to ensure that all audio was clear and easy to hear.

The normalisation process had to be used extensively during the first scenario, as it used the microphones on the camera. The actors' audio was sufficient as long as they faced the camera while speaking. However, when they faced away, the audio was reduced. To increase the clarity of their voices, the decibels during these periods had to be increased. This was done by increasing the decibels to a similar strength as the rest of the audio without making it noticeable during playback. This was performed on all audio clips in the first scenario to ensure that there would be no difficulties in understanding what the actors were saying. After the audio was at the same frequency height, the audio peaks were normalised to -1 decibels to ensure that the audio was high enough to be clearly heard using a VR HMD. As all the audio had the same height frequencies, the video's audio was close to having the same volume while keeping the audio dynamic. Figure 4.4 showcase an audio file from the first simulation under editing.

The normalisation process made noise more apparent because the lower audio levels were increased, as was the low-level noise. Because of this, noise reduction was used to decrease the unwanted audio on all the audio files. This was done by capturing the noise from a period in the audio clip where no one talked, which was then analysed and used to remove the captured noise across the audio file. Also, as the audio from the first simulation was recorded from the camera, room clang and reverb needed to be reduced using Auditoin's DeReverb function. Lastly, the audio was normalised to -1db, as all the processing resulted in somewhat lower audio.

In addition to the audio process mentioned, the audio from the second simulation needed to be synced and cut in Premiere Pro, so the audio and video would begin synchronised. This was done by importing the edited audio into premiere pro and lining it up with the video recordings. At the

Figure 4.4: A audio clip under editing

start of each video recording in the second scenario, the research clapped to create a high-pitched short audio that could be used to sync up the audio and video. By lining the audio with the clapping, both the player's voice and the patient's voice could be synchronised.

4.3 Unity development

The Unity development process commenced at the start of the master project. Firstly, the project explore whether Unity had the capabilities of using and developing around 360 spherical videos. This was done by reading through Unity's documentation and trying to learn how others have achieved it in the past. Afterwards, two test scenes containing downloaded 360-degree test videos were created to see how Unity handled changing between the two 360-degree videos. The short experiment supported the use of Unity as the development software for the project.

The main menu was developed to provide all the necessary information the user needs to understand and use the application. When the user enters the application, the user is greeted with buttons described with "start", "Introduksjon", "Om", and "Avslutt". To the user's left was another canvas with controller mappings, which can be seen in Figure 4.5, and to the to-be filled out created page. It was designed using a colour collection presented by FlatUI colours using the British Palette [109]. They provide colours that fit well with each other. These colours were used for the UI around the menu. The buttons were designed to look like buttons usually used on mobile devices. They change colour when the user points and selects the button. This is to make it easy for the user to see and test what elements on the UI are interactable. To further support this, audio was added that played when the user pointed and selected the buttons. Also, an animation was added when the user hovers a button, which further showcases usable UI elements. The audio is from Storyblocks [108] and Freesound [40]. The audio used in the final product is the Button Click 26 [107] when the user hovers on a button and the Button Click 15 [106] when the user selects a button. These were chosen because they fit well together, and they were used on all the buttons. Other external audio used is the people chatting from the hallway in the main menu [77]. The animation was developed using an asset from the Unity Asset Store [125]. The asset's name is called LeanTween [85], which provides the setup for creating animation using C#. LeanTween were used to showcase the extra information relating to each button when the user hovers, the transitions between UI canvases, and the fade in and out effect while changing scenes.

4.3.1 Unity Package Manager

The asset is downloaded through Unity's Package Manager [121], which provides different packages to the application that allow the developer to use external tools. Leantween was an asset package

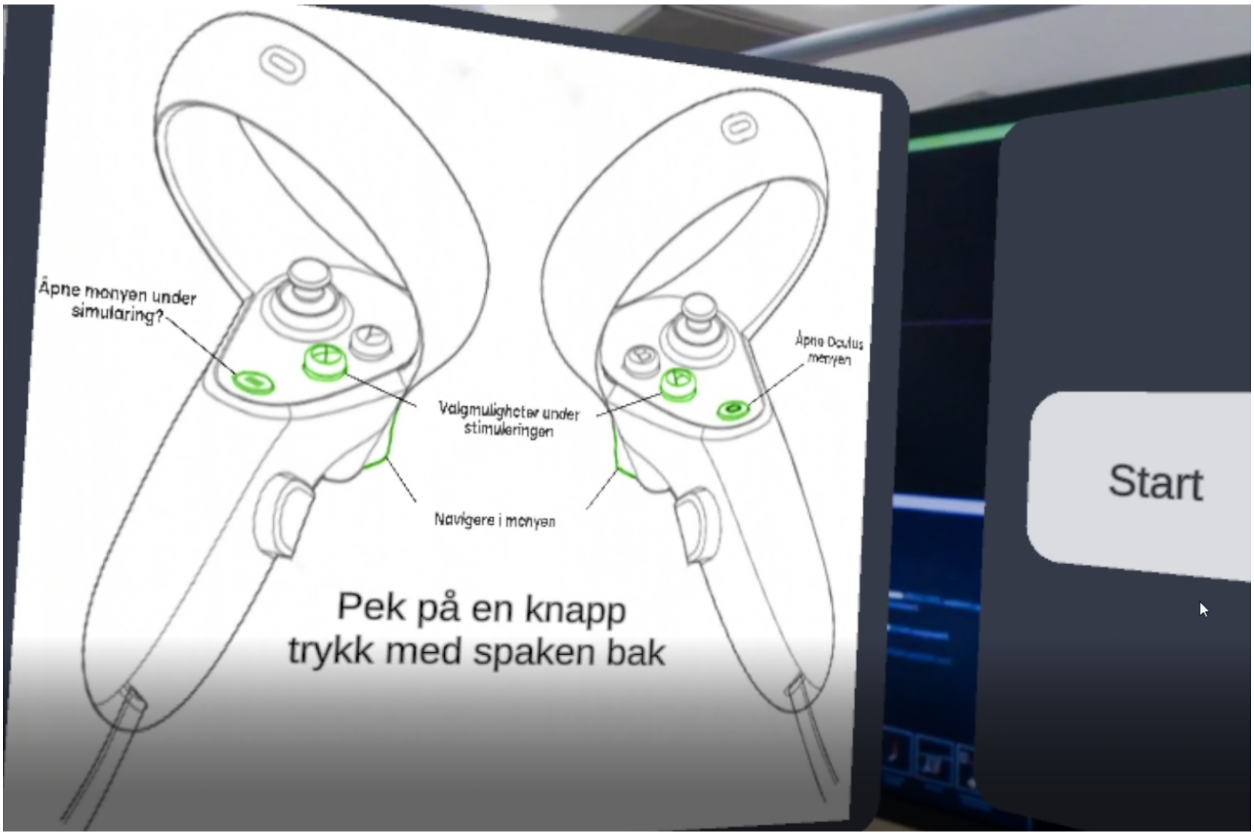

Figure 4.5: The first tutorial image

downloaded through the manager. However, most of the packages used to develop the application were from the Unity Registry of packages. Most packages come automatically with the Unity Engine. In addition to the standard packages provided by Unity, four other plugins were needed to develop the application. These are the Visual Studio Code Editor, the XR Interaction Toolkit, the Oculus XR Plugin and the OpenXR Plugin. The Visual Studio Code Editor was used to seamlessly connect Microsoft Visual Studio with Unity. The other plugins were used to develop the VR experience.

4.3.2 Scenes & Scripts

The application contains 29 scenes. This includes one menu scene, two introduction scenes, and nine ending scenes. The remaining 17 scenes are branching scenario scenes. Each scene collection contains a similar structure of gameobjects and scripts. Each script hare showcased in appendix P.

The Menu Scene

The Menu scene includes gameobjects related to each UI canvas, audio sources, the scene loader, and the XR gameobjects. The UI gameobjects are connected through button functions that activate and deactivate UI elements based on the button the user clicks.

The UI canvases include an introduction to the controller, information regarding who has participated in the project, an introduction to the scenarios, a scenario selection canvas, and a canvas that connects all of the aforementioned elements. The main menu in the final product is shown in Figure 4.6.

The menus contain three self-made scripts that provide function and animation to the menus.

MoveUnderButtons provides the necessary information for the button information UI (i.e., the information that arrives while the user hovers over a button). The script controls what button the user hovers on and moves the correct under-button UI to a hardcoded location. It also handles the

Figure 4.6: Two of the three menus on the main menu.

speed and visual appearance of the animation using LeanTween. It also ensures that the button information UI moves back to its original position when the user no longer hovers over a button.

ResetButtons reset the animation when the connected UI activates. Without this code, the originally selected button's information UI will stay down when the user returns to the UI. Because of this, the code ensures that all the under-button UI remains at its starting position when the user returns to a menu canvas.

MenuAnim uses LeanTween to create animations for the UI canvases. If a UI Canvas is activated, it will run animation for half a second. The animation will change the CanvasGroup component's alpha values from 0 to 1 on a button click. The fade-in and out effect style is also set in the code. When a canvas is closed and a new one is activated, the script will deactivate the old canvas without animation and start increasing the alpha values in the new canvas UI.

The audio sources contain the audio that plays when the user selects a button or loads into the menu. When the Main Menu scene is loaded, a chatter will be audible from the hallway to the right of the player. The audio comes from a gameobject placed in the world, which allows for positional audio from the hallway. The chatter will play and loop as long as the user is in the menu, creating the illusion of being in a populated place. The audio from the buttons is played when the user either hovers or selects a button.

The scene loader gameobject has the ChangeScene script connected to it, allowing the buttons to change scenes when pressed. When a button is pressed to load either of the scenarios, the script is run with information regarding which scene it is supposed to run, stated by an integer.

The **ChangeScene** script has several checks based on the current scene. If the scene is connected to a branching scene, the scene will not change until the video ends. When the video is over, the scene will fade to black using LeanTween and change scenes when the alpha value is 100%. If the scene is the last stage of a scenario, the change scene script will fade to black and automatically change the scene at the end of the video. This is done by counting up to a hard-coded number based on the video's playtime. When the script passes the hard-coded number, the screen will fade to black and will change with a scene-coded integer. Finally, if it is an ending scene, the script will instantly allow the user to change the scene. This is also possible in the main menu. Suppose the user selects one of the scenario buttons. In that case, the script will instantly load the scene with the corresponding integer connected to the button. Each scene has an accompanying integer that tells Unity what scene will load. It will also allow the user to exit the application.

The ChangeScene gameobject, the XR objects, audio sources and the EventSystem are used in every scene in the project and all have the same functions regardless of the scene.

Scenario introduction scenes

There are two scenario introduction scenes. These introduce the scenario and allow the player to start the scenario. Except for the ChangeScene gameobject and the XR objects, the scene contains a menu with scenario descriptions and a start button that loads the first scene of the selected scenario. One introduction scene is shown in Figure 4.7.

Figure 4.7: Introduction to the first simulation

Scenario scenes

The branching scenario scenes contain two menu canvasses and a video player. The video will start playing at the start of the scene. Then, when there are five seconds left of the video, two branching options will activate and fade in using LeanTween, allowing the user to select an option that will lock the user to a decision and load the scene connected to the button. This is shown in Figure 4.8 The selected button will stay visible while the other disappears, and the chosen scene will load after the video has ended and the screen has faded to black.

The video player showcases a panoramic video on the skybox material around the player. This was done by setting up the video player video source as a render texture [123]. Then, the texture was converted to a 2D dimension and edited to fit with the dimensions of the 360-degree videos using the 5.7k (5760 x 2880) resolution. The texture was connected to a material adjustment to receive 360-degree image types by converting the material to a Skybox/Panoramic shader. This material became the skybox for all the scenario scenes. In each scene, the SceneManager gameobject has a video player who plays a video at the start of the scene. The video is rendered to the 5k Render texture connected to the skybox material, which displays the video all around the user. The audio from the video plays directly to the audio listener on the XR-Rig. On the main menu scene, the skybox is edited to receive a cube map texture wrapped around the player.

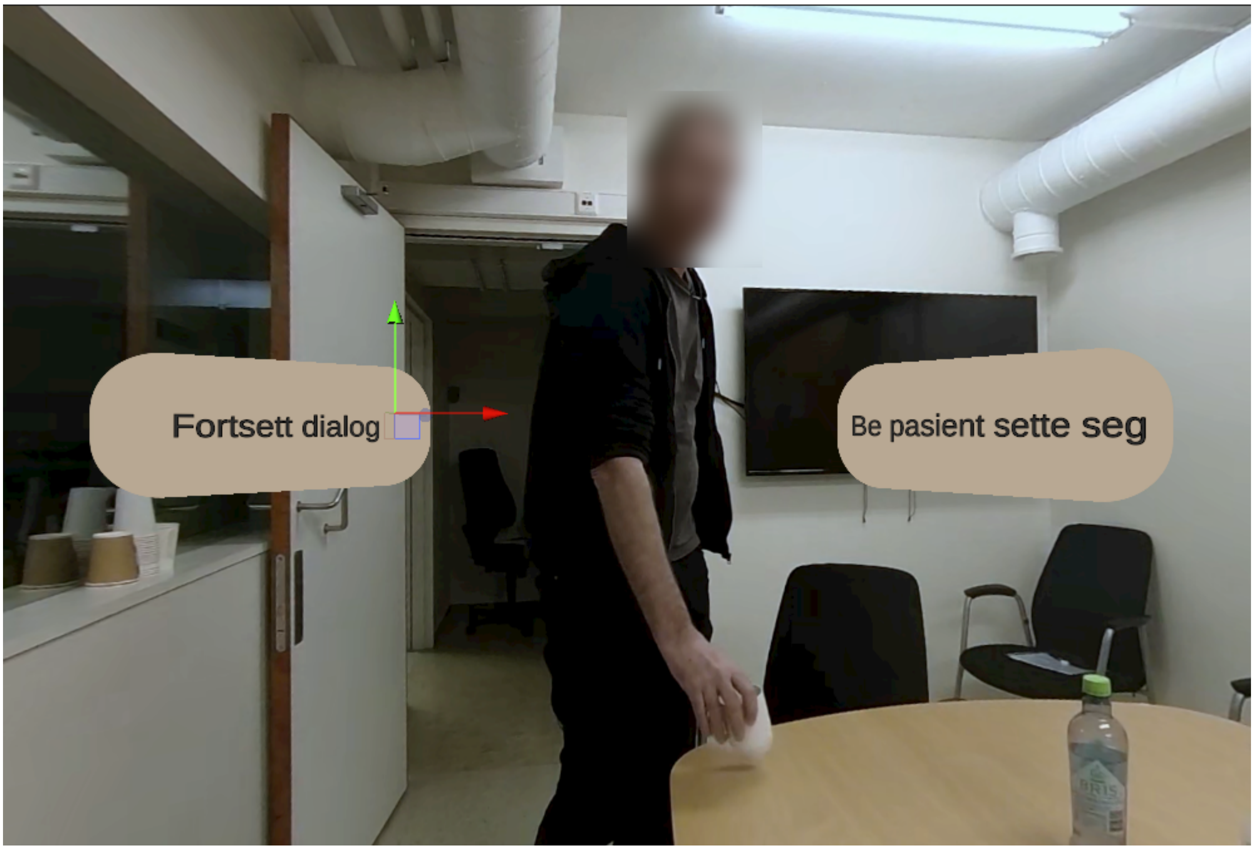

Figure 4.8: Option from the second simulation

During the second scenario, the audio from the patients and the user is detached from the video. This allows 3D positional audio to be played in the environment around the player. For example, when the player turns right, the audio from the patient will be heard in the left ear. In Unity, a hidden sphere is placed at an approximated distance from the user with 360-degree audio spread around to the user's location.

The scenes also include a menu that allows the users to return to the main menu, restart, or exit the application. This is activated by selecting "X" on the controller, which initiates a script that pauses the video and audio while the user is in the menu.

SimMenu is connected to the left controller and starts the video and all audio in the scene when the scene loads. It plays the audio with a 0.6-second delay because the audio becomes out of sync with the video during android builds. When "X" is pressed on the controller, the script will activate the menu, use LeanTween to fade the alpha value from 0 to 1 in half a second, and pause all video and audio in the scene. If the player clicks the X button again, the script will deactivate the menu and continue with the video and audio playback. The same will happen if the user selects the Return button on the branching menu.

The last group of scenes are the dark ending scenes. These contain a canvas UI that summarises the player's actions during the scenario. The user can return to the main menu, restart the scenario, and exit the application.

4.4 VR development

Unity is not suited for VR development in itself. To be used in VR development, experimental plugins must be added to create and configure extended reality rigs and interactive systems. As of this product's development, the XR Interaction Toolkit was still in a preview state in version 1.0.0-pre.8, which is the October 27. 2021 version of the toolkit. Preview packages [124] have to

Figure 4.9: Simulation ending screen

be forcefully downloaded by first being enabled in the Enable Preview Packages project settings. The reason for doing this is that the preview packages are supposed to be used for testing purposes [122]. Each update to a preview package can come with significant changes, to such a degree that the plugging does not support older versions. Because of this, the project did not use a newer version past the pre.8 version.

4.4.1 XR Setup

The XR setup was performed by, firstly, downloading OpenXR from the Unity Registry to make Unity VR capable. Then, the OpenXR settings were changed to support the Oculus Controller Profile. Afterwards, the XR Interaction Toolkit was downloaded, and the XR-Rig was added to the project. Default Input Actions were downloaded through the Interaction Toolkit and added to the XR-Rig's controllers. The Input Action Manager script was added to the XR- rig as a component, and the XRI Default Input Actions were then connected. This makes it possible for participants to engage in the application using Oculus HMD. The in-game hands are Oculus Quest 2 controllers from the Oculus website [78]. These were added as children of the "Hand" gameobjects provided by the XR interaction toolkit, and allow the player to view the controller's buttons while in-game. Additionally, a black canvas covers the player's view as a child of the player's camera on the XR rig. This is done to create a fade-in fade-out animation while changing scenes and was mainly done to smooth out the transitions between video clips, as the patient's movement between scenes became very apparent without a fade to black function.

In order to make the UI interactable with VR, the canvases were set up as World Space canvases and places in the scene. The UI was given a Tracked Device Graphic Raycaster, which allowed the controller's line renderer to interact with the UI. However, the EventSystem gameobject's Standalone Input Module must be replaced with the XRUI Input module. The EventSystem module handles events in the Unity scene [120] including input, raycasting, and sending events.

Chapter 5

Results

The results from the data gathering sessions are presented in two parts. The first part presents the usability test performed during the HCD process's first iteration. These results were used to develop the application further. The second data-gathering session collected data regarding the final design of the application and the strengths and weaknesses of using the interactive VR scenarios to answer the research question relating to the design of the product and the strength and weaknesses of using virtual scenarios in training. Finally, a survey collected participants' satisfaction levels after they had used the virtual scenarios.

The interview guides for the two data collections can be found in appendix C for the first data collection and appendix D for the second data collection. In addition, the transcriptions for these interviews are showcased in appendix Q.

5.1 Data collection one: evaluating the design

The first user test included nine participants who were randomly assigned a number between 1 and 100. Their characteristics are shown in Table 5.1.

Participant	Profession	Experienced using video game controllers
40	Health personnel in Psychiatry	Yes
54	Training officer	Yes
58	Health personnel in Psychiatry	No
66	Unit manager for research and development	No
76	Health personnel in Psychiatry	No
89	Health personnel in Psychiatry	No
93	Health personnel in Psychiatry	Yes
94	Innovation consultant	Yes

Table 5.1: Participants from data collection one (n=8, f=2, m=6)

Figure 5.1 showcases the participant's age (left), VR experience (middle) and work experience (right). Experience levels are structured from 1 to 3, where one is the lowest level of VR experience (i.e., the participant is not used to using VR). Three is the highest level, and represents experts in using VR. All participants voluntarily joined the user tests.

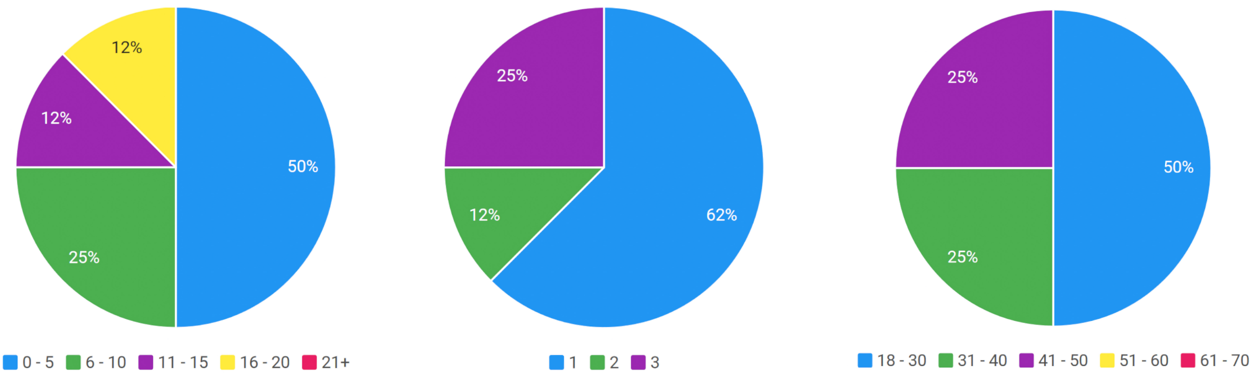

Figure 5.1: Data collection one: The participants age, VR experience and work experience in years.

The themes in this data collection explore the application's design concerning the research question: "How can effective VR scenarios of hospital simulations be designed for nurse training?". The resulting themes explore design elements to improve the final product.

Data collection one: Observation

The observation resulted in the participants spending, on average, 0.9 minutes exploring the introduction and the about page, 3.7 minutes on completing the first simulation, 3.1 minutes on completing it again while selecting other options, and 0.2 minutes on exiting the application. In addition, they experienced four critical errors that resulted in the researcher having to intervene.

Most participants forgot to think out loud the moment the scenarios started. However, two participants remembered to do so and made constructive comments. During the first scenario, one of the participants stated that the audio was low and commented that they felt it was difficult to hear everything the participants were saying. During the second playthrough of the scenario, he stated that it was difficult to feel like a participant because the nurse assistant did not look him in the eyes but instead looked behind the participant. He also stated that it was confusing that the buttons appeared before the video was over. When he exited the application, he stated that the simulation was a fun experience.

The other participant felt that the constant line renderer from the controllers was a distraction while performing user task 2. He also felt that the video should not immediately change when the user selects a button. He ended the application by stating that he enjoyed the experience. More information can be found on the first observation in appendix L.

Figure 5.2 showcases the thematic analysis performed after the observation and interview, which resulted in three relevant themes. A larger figure of the analysis can be viewed in appendix M. These themes concern the design and use of the product. One critical problem, five serious problems, and four minor problems were discovered and listed in Table 5.1.4.

Table 5.2 showcases the three themes from the first data collection, as well as relevant subthemes and the theme description.

5.1.1 The UI - Easy to use and understand

The UI - Easy to use and understand theme contains mostly positive statements regarding the usability of the application. This includes general statements regarding the simplicity of the UI and how the names of the buttons during the scenario were understandable and relevant.

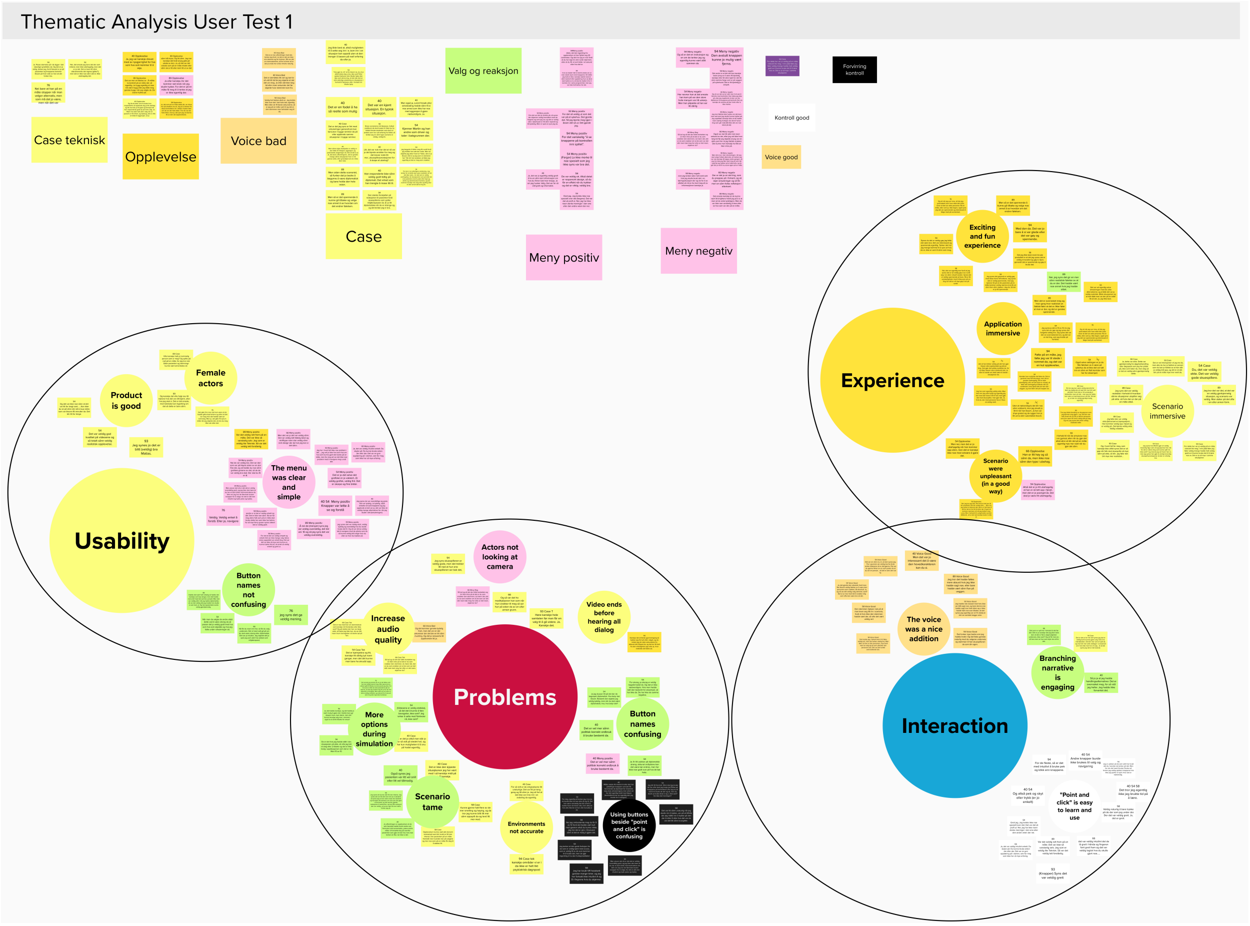

Figure 5.2: The thematic analysis for data collection one

Theme	Sub-theme	Description
The UI Easy to use and understand	- The menu was clear and simple - Button names are not confusing	Theme relating to the design both positve and negative statements. The results are mostly positive
The applicaiton Immersive and enjoyable	- Scenario immersive - Application immersive - Positive experience	Theme relating to the immersiveness of the application and the users' stated experience after testing the product
Interaction Engaging and easy to learn and use	- Branching narrative - VR controller	Theme relating to the experience while interacting with the product.

Table 5.2: The three themes of the first data collection

The menu was clear and simple

All of the eight participants responded positively to the design of the main menu. All participants stated that the menu was clear and understandable. In addition, six participants specifically stated that the menu was easy to use. One of the participants noted that the UI was clear and straightforward, that the colours were nice, and that there was not much that could go wrong while interacting with the UI: "For det at det var veldig simpelt og enkelt. Det var ikke mange valg. Selve meny oppsettet var enkelt farg. Det var det var ikke så mye som kunne en kunne trykke feil på, da tenkt så veldig enkelt og greit ut".

Button names are not confusing

Four participants stated that the branching options names during the scenario training were understandable and close to real life. One participant stated that the options they received during the scenario were intuitive, as he understood the essence of being diplomatic and determined even though he does not currently work as an environmental therapist. To quote the participant: "Nå får du noen inni her, så får du valg underveis. Det vil stort sett gå på om du skal være streng eller diplomatisk. Det var jo intuitivt. Jeg skjønte det jo sjelv jeg som aldri har jobbet som miljøterapeut".

Another participant stated that if this were an actual situation, the situation would have lasted much longer. However, he stated that the player and patient's reaction to being diplomatic was recognisable: "Hadde det vært helt virkelig så hadde det kanskje vart mye lenger, men det hadde nok endt med det samme uansett. Men det var veldig sånn når jeg trykka diplomatisk, så var det veldig det jeg trodde han skulle si som kom ut. Og han (pasienten) svarte veldig gjenkjennelig".

5.1.2 The application - Immersive and enjoyable

This theme contains statements about how the participants felt while using the application and the scenarios. This theme contains five subthemes that specify different aspects of the theme. These are the scenario, the voice, positive experiences, and environments.

Scenario immersive

Four participants expressed that the scenario was realistic and recognisable, both in physical simulation training and in the workplace. One of the participants stated that he felt it was realistic compared to how such situations play out in real life: "Jeg syns det var veldig realistisk i forhold til hvordan sånne situasjoner utspiller seg på ekte".

The same participant also mentioned that, in physical simulation training, the concepts of meeting up and roleplay are not something he enjoys. However, interacting with VR felt like a much more realistic experience. Another participant also commended the actor's performance, stating that even though the participant knew the actor, his acting performance as a patient was good: "Jeg synes han Martin gjør en veldig troverdig figur selv om jeg kjenner han. Så for det er sånne ting som kunne spilt inn, ikke sant? I og med at jeg vet hvem han er, men jeg synes han gjør et utrolig troverdig skuespill prestasjoner så den er virkelig bra".

Three participants stated that the experience was unpleasant in a good way. One of the participants commented on the unpleasantness of the patient's height, while the other two commented on the unpleasant experience when the patient came close to their face. These negative emotions were, however, not a negative for the experience. This is showcased through one of the participant's statement that it is unpleasant when the patient comes too close to the player but that this should be the point—it is supposed to be a little unpleasant: "Altså det er jo litt ubehagelig at han er så tett opp i fjeset, men det er jo poenget da. Det skal jo være litt ubehagelig".

Two participants did state that the environments did not match their workplace surroundings, noting that the environment was not similar to their departments' usual work environment. One stated that the surroundings were a little unnatural and that he quickly noticed that it was not inside a department: "For så vidt er de omgivelsene litt unaturlige. Det var litt ja trang gang og litt sånn ja. Jeg så fort at det ikke var inne inn i en avdeling da egentlig".

However, another participant stated that the environments were more realistic than those of physical SBLs, which usually involve gymnasiums:"i forhold til når de simulerer noe i en gymsal, eller når du gjør det altså sånn så blir det på en måte egentlig mye mer reelt når du gjør det sånn".

Application immersive

Six participants felt that the application provided an immersive experience. One participant stated that when the patient made direct eye contact, the participant felt a strong feeling of presence in that situation. The six participants supported the sense of being present. They individually stated that presence was achieved because of face-to-face interactions between the patient and the participant, and that the situation was unpleasant (in a good way) and that the setting was realistic. One participant stated that the VR scenario was more authentic than physical simulations because of the environment. He stated that they usually perform simulation trainings in gymnasiums. Being able to train in a hallway made the expereince more realitstic: " i forhold til når de simulerer noe i en gymsal, eller når du gjør det altså sånn så blir det på en måte egentlig mye mer reelt når du gjør det sånn". One of the other participants made a similar statement, expressing that the immersion was heightened because the corridor in the simulation was similar to a hospital corridor. When participant 94 was asked if anything surprised him with the experience, he stated that the realism was surprising: "Kanskje hvor realistisk det føles da. Det er generelt med VR teknologi, men det er ganske ubehagelig. Det er ekte ubehagelig, selv om det bare er virtuelt, så føles det ubehagelig at *Name* står 20 centimeter unna fjeset ditt når han slår i veggen, og man føler det på kroppen da".

Positive experiences

Four participants expressed that they thought the experience was exciting and fun. This related to both the technology and the scenario experience. One participant stated that it was fascinating to use the HMD, especially when the patient comes close to the user's face: "Jeg synes det generelt er veldig gøy med disse herre VR brillene. Jeg synes det er veldig spennende, men jeg kjenner litt på at når pasienten på en måte kommer veldig nærme at du får en sånn liten sånn stykker i deg da. Så det er jo litt spennende". Another participant stated that she was surprised by how real the experience felt because the actors were real people and not drawings. She also stated that going through the scenarios was exciting and interesting: "Og så når jeg var inne, så ble jeg overrasket over hvor ekte det virka. Over at det var ekte personer. På en måte, eller som ja, ikke tegna. også syns jeg det var spennende og interessant å følge med på scenarioet".

Five participants commented that the internal voice increased the experience positively. Moreover, four participants felt that the experience would have been reduced if there had been no voice interaction between themselves and the patient. Two of these participants said that the voice felt natural, and one participant said that he thought it would be strange before engaging with the product but was presently surprised by the experience: "Det trodde jeg i forkant kom til å føles veldig rart, men det funker veldig bra. Man føler at man er den personen, mye fordi man tar valg og da som påvirker den personen sier. Det var det funket overraskende bra".

5.1.3 Interaction - Engaging and easy to learn and use

The Interaction theme contains statements regarding users' experiences in interacting with the application. This contains general statements regarding using the branching narrative, the use of the controller, and the user's voice during the scenarios.

Branching narrative

Four participants stated that the interactivity during the simulation added to the experience. One participant stated that the branching narrative was the most enjoyable aspect of using the application: "Det som er nytt her i forhold til det før det. Det er jo kanskje det jeg liker best den at det er flere valgmuligheter underveis, ikke sant? Og så får man en, så kan man se hva som skjer da ut ifra det". The other participants supported this statement. Another of the four participants stated that he felt it was cool to have branching options during the simulation. The interaction made him an active participant in the scenario compared to only observing without interaction: "Det er det er for min del synes jeg det er veldig kult å kunne gjøre valg. Det å ha interaktivitet...Det blir mer som et spill da, og man blir mer aktiv deltager i scenarioet enn hvis ikke man har et valg.. Ja så det synes jeg det er det kuleste".

VR controller

Seven participants reacted positively to the point and click interaction. They all felt that point and click was an intuitive way to interact with the UI elements. One participant stated that it was a natural way to interact with the environment, even though they did not have much experience in VR: "Ja, det var veldig intuitivt enkelt. Du skyter på. Du kunne bruke enten der eller der. Det var en grei opplæring på i starten, selv for meg som ikke har så mye erfaring". Three other participants stated that they did not need any time to learn how to use the controller because of the point and click functionality. One of the participants stated that it was, in a way, self-explanatory. Even though the participant was not very technical, he had no problems understanding the application: "Var det veldig rett frem på en måte. Det var ikke så vanskelig selv. Jeg som er veldig lite Teknisk. Så var det veldig lett forståelig".

Concerning using the other buttons on the controller, four participants specifically stated that it was confusing or unnecessary. One participant stated that, even though he used VR headsets multiple times in the past, he did not know the location of the (A) and (B) buttons on the controller: "Jeg har brukt VR headsett ganske mange timer, og jeg har fortsatt ikke intuitivt A og B i fingrene hvis du skjønner".

This theme was reflected in other participant's statements, as they felt it was unnatural to use the other buttons on the controller. Participants only used these buttons when forced to do so during game testing, and stated that they would not have used them if the point and click options had not disappeared. Another participant stated that everything was fine until she had to look down at the controller; then she became confused: "Først så klarte jeg det helt naturlig, og så tror jeg det var. Når jeg begynte å se ned, så begynte jeg å surre. Da ble jeg litt usikker".

All the participants were asked to provide a number from one to 10 regarding how clear the menu was and how they thought the controller's buttons were used. In addition, the participants were asked to provide a number from one to 10 regarding how they felt during the user test and how realistic they felt the simulation was. The results are shown in Figure 5.3.

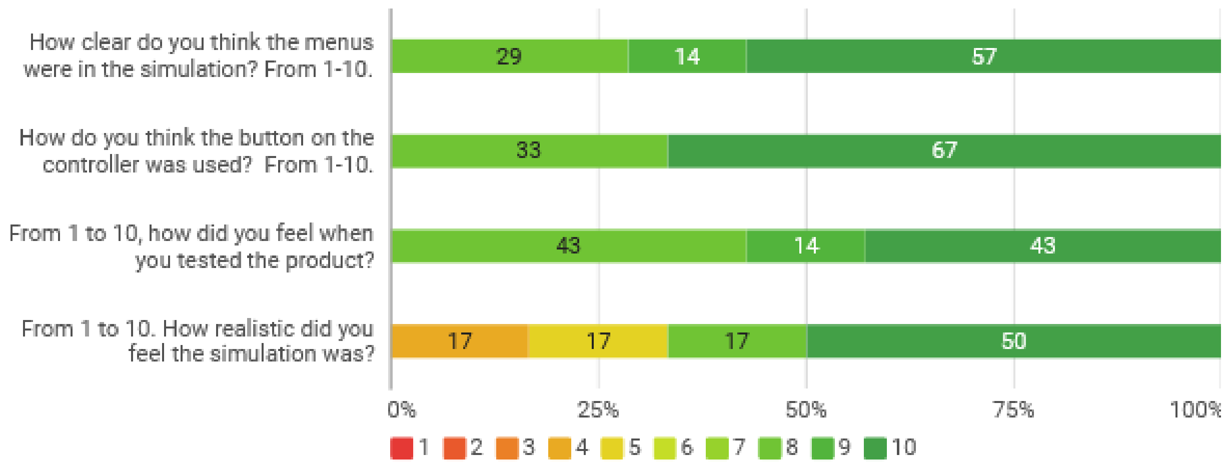

Figure 5.3: Data collection one respondents

Figure 5.3 shows a general high enjoyment, where most respondents gave a rating of 10, 9 or 8 to the different features. The lowest score was 5, concerning the realism of the simulation.

When asked if the users would have continued to use the product if they could, all responded yes. When asked whether the voice was a distraction, participants responded no, and responded yes when asked whether they were able to get used to it.

5.1.4 Problem severity levels

Eight critical, serious, and minor problems were recorded during observation and the interview. These relate to issues that should be fixed in the new iteration of the product. The problems that occurred during the first data collection are showcased in Table 5.1.4. It shows the severity of the problem, its name, and a description of the problem.

Severity	Problem	Description
Critical	Application crashed in one of the branching scenes	If the user selects a specific line of options during the scenario, the simulation will freeze, and the user will not be able to continue
Serious	Using buttons beside "point and click" is confusing	Using any button rather than pointing and clicking was confusing. One participant also spent considerable time reviewing the controller mappings. This reflects the need to streamline the tutorial to some degree.
Serious	Button names were confusing	Some participants felt that the "strict" branching option needed to be changed to "determined".
Serious	The video ends before hearing all dialogue	One participant felt they did something wrong when they selected an option too fast, resulting in them not experiencing the video's ending. He stated that he selected an option too quickly during the first playthrough, and because of this, he lost the last few seconds of the video. This reduced the realism somewhat.
Serious	No scenario description	During SBL, the participant is informed of the scenario before participating. This was done verbally during the testing, but it should be integrated into the application.
Serious	Line renderer annoying and in the way	One participant felt that the line renderer in the scenario got in the way of the experience. Seeing a constant line from the controller made it difficult for the participant to concentrate on the situation happening in front of him.
Minor	More options needed during simulation	Four participants expressed that the scenarios should have included more interactive options.
Minor	Subpar audio quality	Two participants felt that the audio quality was subpar at times.
Minor	Scenario was tame	Three participants felt that the scenario was tame
Minor	Actors not looking at the camera	Two participants noted that the actors did not always look at them. Instead of looking at the user, the actors looked behind them.

Table 5.3: Severity levels of problems in collection one

5.2 Data collection two: application as a tool for learning

The first user test included 17 participants that were interviewed both individually and in focus groups. The participant's profession and data collection method can be viewed in Table 5.4. Their experience in VR is structured from 1 - to 4, where one is the lowest provided VR experience, which states that they are not used to using VR. Four is the highest and represents experts in using VR.

Participant	Collection method	Profession
P1	Interview	Health personnel in Psychiatry
P2	Interview	Unit manager for research and development
P3	Interview	Health personnel in Psychiatry
P4	Interview	Training officer
P5	Interview	Health personnel in Psychiatry
GP1	Group interview	Health personnel in Psychiatry
GP2	Group interview	Health personnel in Psychiatry
GP3	Group interview	Health personnel in Psychiatry
GP4	Group interview	Health personnel in Psychiatry

Table 5.4: Participants in data collection 2 (n=17, f=10, m=7)

Nine participants participated in focus group interviews with three group participants (GP) each. Participants P1 - P4 participated voluntarily in the project. Participant P5 and the participants in GP1 - GP4 participated at the behest of their employers. Participant P2, P3 and P4 also participated in data collection one. The participant's age, VR experience and work experience can

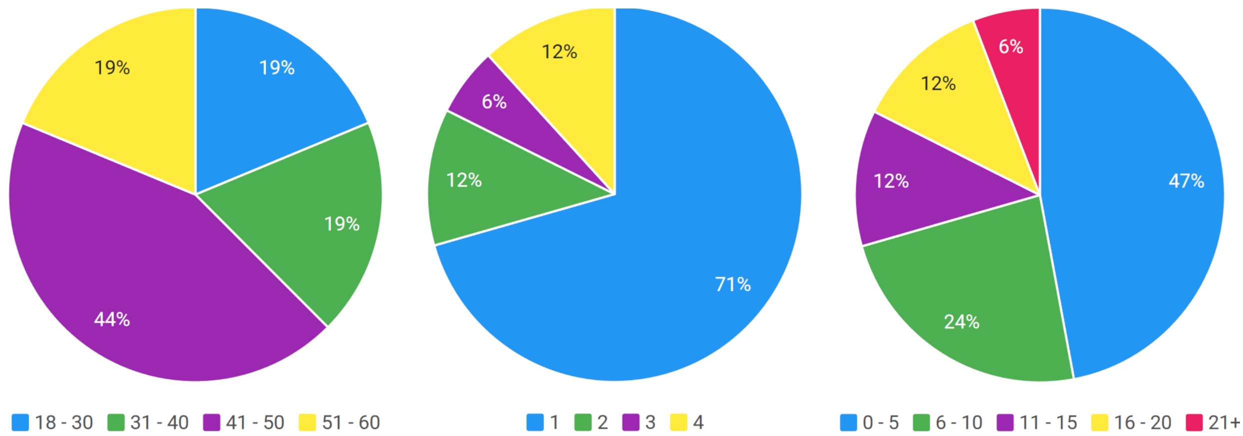

Figure 5.4: The participants age, VR experience and work experience in years.

be viewed in Figure 5.4. To the left showcase the age of the participants. The graph in the middle showcase the VR experience for the participants. This is structured from 1 to 4, with one being the lowest and represents no previous VR experience. Four is the highest and represents experts in using VR. Lastly, the graph to the right showcase the participants work experience in years.

Data collection two: observation

The observation resulted in the non-grouped participants spending, on average, 0.8 minutes exploring the introduction and the about page, 3 minutes completing the first simulation, 4 minutes completing the second scenario, and 0.1 minutes exiting the application. Unfortunately, the observation recording for P2 did not save after recording and could not be used in the observation analysis.

The group interview participants spent, on average, 2.5 minutes exploring the introduction and the about page, 5 minutes completing the first simulation, 5 minutes completing the second scenario, and 0.3 minutes exiting the application.

One individual and two group participants accidentally exited the application. One did so while trying out the buttons on the controller. The two others did so by selecting the "Exit" button instead of the "Return " button after ending a simulation. Because of this, the researcher needed to assist them in navigating back to the application.

Two other group participants did not understand how to use the controller. However, after the other group members assisted by explaining their correct understanding, they were able to use the controller. All participants made positive comments about the application after they finished testing. During the second scenario, the participants who selected "sit down" and "continue conversation" experienced an error where the audio was echoing. No other technical faults were discovered. Information regarding time, problems, and errors can be found in appendix N.

The themes relating to the design correlate with the first research question: “How can effective VR scenarios of hospital simulations be designed for nurse training?”. The learning potential, the flexibility of the tool, and general themes focus on exploring the other two research questions: “What are the advantages and potential challenges of using VR scenarios for training nurses in psychiatric wards?” and “What are nurses’ levels of satisfaction after using the VR simulation?”. Lastly, the questionnaire mainly focuses on nurses’ satisfaction. However, also provide further data concerning the advantages and challenges of using VR scenarios in training.

5.2.1 Data collection two: interview

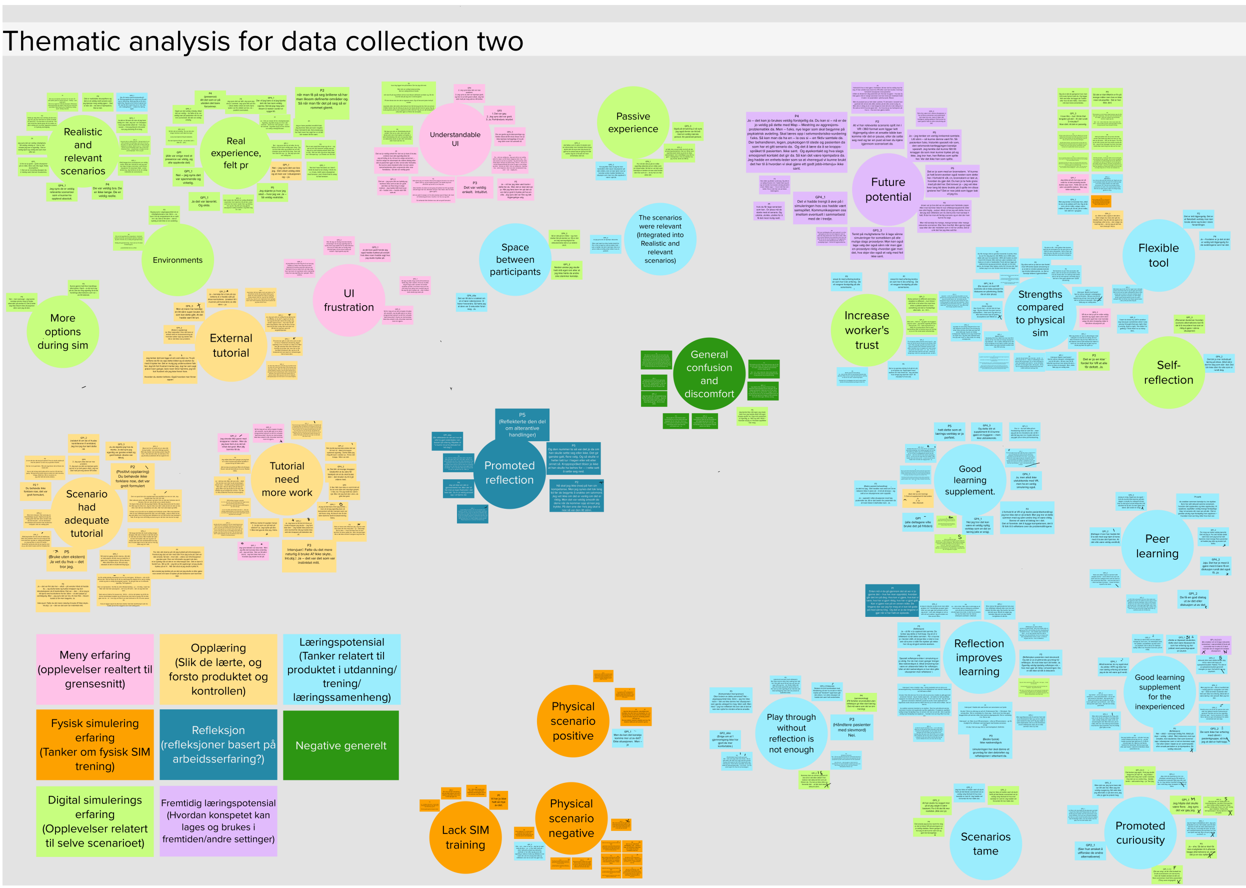

Figure 5.5: The thematic analysis for data collection two. A larger figure can be viewed in appendix M.

Theme	Sub-theme	Description
The Design Positive and negative	- UI - Tutorial - Scenarios	Theme relating to the design and use of the application
Learning potential of the application	- Supplement - Peer Learning - Reflection	Theme relating to the learning potential of the application
Flexibility of the tool	- Flexible - VR strengths	Theme relating to the flexibility of the tool
General subthemes	- Future potential - Worker's trust - Physical scenarios	General subthemes worth mentioning

Table 5.5: The themes from data collection two

The interview included seventeen participants, resulting in 4 relevant themes. They relate to the current strengths and limitations of the application's design, the use of the product in training, and the participants' thoughts and reflections on the use and future use of the application. A summary of the themes is showcased in Table 5.5, and the result from the thematic analysis is seen in Figure 5.5.

5.2.2 The Design - Positive and negative

The Design - Positive and negative theme includes subthemes related to the design of the UI, the tutorial and the scenarios.

UI

Fourteen out of seventeen participants made positive statements concerning the application's design. Seven participants stated that it was intuitively designed, making it easy to use and understand. One participant stated that combining different elements made the experience understandable and pleasant. He elaborated that the UI's audio, animation and structure were pleasant and easy to use: "Du – det var veldig bra. Jeg syns det er en veldig sånn fin, åpen, du får disse veggene sånn. Og – nei – det at det er lyd når du trykker. Og det kommer slike drop-down menyer og sånne ting. Det er – får du en visuell tilbakemelding på at det du gjør er det riktige og sånn. Så det var heilt. Det var veldig bra. Kjempe bra. Lett å skjønne, ikke noe sånn kompliserte ting som – nei – veldig bra".

Three participants stated that they experienced frustration concerning some parts of the UI. One of the participants felt that it was natural to press the "Avslutt" (Exit) button at the end, and because of this, he was thrown out of the game and back to the main menu. While there, he had problems figuring out how to return to the simulation: "Så for meg så var det jo logisk å trykke på «avslutt», og da gikk jeg ut av selve programmet og kom ut på min virtuelle hjemmeverden. Og da var det kanskje ikke like enkelt å vite «Hvordan kommer man inn igjen» ". Another stated that she could have pressed "Avslutt" (Exit) instead of the "Tilbake" (Back) button if the researcher had not told them to return to the menu and go through the other simulation.

Tutorial

Eleven participants made different positive statements about the product's tutorial. This includes that it was well formulated, well-structured, and easy to understand. One of the participants stated that he felt the application was functional and easy to use. Due to the inclusion of the instructions, it would be unlikely that anyone could misunderstand how the application works: "du får veldig tydelig instruksjon om hva du skal gjøre. Så liksom – når du får denne lille intro'en først da så når du skal begynne etterpå så er det jo veldig enkelt og det er veldig forutsigbart og det. Ja det går ikke an å misforstå egentlig. Terningkast 6". Two participants expressed that they had no problem using the application, even though they had minimal experience with VR. Another stated that it was usable without any external instructions, and another participant enjoyed that the tutorial was interactive. The other participants expressed that the tutorial's UI was easy to understand and use, and another said, when asked if they would remember how to use the application in the future, that the point and click mechanic would likely be remembered, but the button layout would have to be revisited.

However, some participants were confused about the interactions and functions of the application. Most of the confusion concerned the Oculus controller. Six participants made statements related to the button's placement on the controller. For example, one participant stated that it took time to find the usable buttons on the controller because she did not notice the buttons at the front of the controller: "Ja. Jeg bare to litt tid til å finne ut hvike knapper jeg skulle – Jeg fant ikke den – Jeg hadde ikke prøvd en sånn kontroll før. Så jeg hadde ikke sett den knappen på baksiden der så". Another participant made statements regarding the "A" button. She felt it was normal and natural to use the "A" button the first time the controller was used. When asked if the application could be used without external help, a participant stated that as long as the simulation was set up for them, they could easily proceed; if not, they may have trouble using the simulation.

Another participant agreed with this, saying that the difficulty would be in finding the application, not necessarily using it: "Ikke av hvem som helst tror jeg. Jeg tror man skal være litt vant med eller – ja – teknologi. Det er ikke – i hvert fall ikke frem til man kommer til selve spillet da. Eller simuleringen. Så er det ikke så lett å navigere seg frem da". Another participant did not notice the tutorial image, stating that she was too focused on the menu right in front of her to notice the tutorial canvas to her left.

Some participants stated that they desired an external source concerning the application's tutorial. For example, three participants wished for or suggested that there should be an external manual beside the headset that included information regarding the hardware and a guide for opening the software. One participant suggested that there should be a piece of paper beside the hardware with general instructions, as people get frustrated when they cannot understand where to find the information they need: "Jeg tenker det kan ligge et ark ved siden av. Ta på brillene da får du opp dette bildet og så starter du med å trykke her. Det er mulig jeg undervurderer folk her. Jeg blir fort frustrert merker jeg. Jeg har som sagt prøvd noen ganger, bare noen timer hjemme, jeg blir fort frustrert når jeg ikke finner fram".

Three participants stated that they would prefer if there were an external person who could help them if need be. One participant stated that it was nice that they could call on the researcher if any confusion or problem arose: "Ja. Jeg syns det var veldig fint at jeg kunne si, «Matias, er du der?», også var du der. For jeg ble litt sånn derre litt urolig. Jeg tenker også at noen – hvis man har litt sånn klausofobiv, eller har litt sånn så kan man bli litt sånn urolig. Når man ikke vet. Så det tror jeg kan være litt angstdempende".

Scenarios

The participants made both positive and negative comments relating to the scenarios. Firstly, two participants wished for more options during the scenarios. One of them stated that there should be a third alternative during the simulation because he felt that the options did not reflect the situation as he viewed it: "Nei – men somsagt – jeg kunne kanskje ønska meg et tredje alternativ på øvelse to. Det å sette seg tilsa liksom ikke situasjonen sånn som jeg så den.".

Six participants mentioned that the scenarios were realistic to situations that might occur at work. This relates to the familiarity of the situation, as stated by one of the participants: "Det var jo også en relevant situasjon. Referanse med paranoide og redde. Folk som tror at de blir overvåket. Noen skal ta de. Forgiftning. Veldig kjent. Veldig relevant.", as well as to the performance of the actors, as stated by another: "Det er realistiske skuespillere og det er et veldig reelt senario som jeg kjenner meg veldig igjen i. Det er det. Så – nei det er kjempebra. Det er det".

Two participants felt that the environment did not represent the environments used at their workplace. One participant stated that the experience was realistic enough with the exception of the environment, as it is clear that the scene is not in a hospital department. Another stated that the environments are reminiscent of standard hospital corridors and meeting rooms. He did not state that the environments were unrealistic. However, he felt they were recognisable as hospital interiors.

Ten participants gave statements that the experience felt real. They felt, to a varying degree, that they were part of the scenario, that the patient was standing close to them, and that they were transported somewhere else. One participant stated that they felt that everything from the outside disappeared: "Alt det som er på utsiden det bare forsvinner".

This statement is matched to a varying degree by the other participants, who felt present while engaged in the scenario. One participant stated that he was in a completely different setting and that he was immersed in a situation that was almost too real: "Ja – Det var nesten litt for virkelighetsnært. Egentlig. Jeg følte at jeg var inne i det rommet – stod inne i den gangen – inne i det rommet. Jeg følte at jeg var der. Så det var veldig virkelighetsnært".

This was also reflected in the emotional experience of some of the users. Two participants stated that they felt fear when the patient became aggressive and close. Others felt unease when the suicidal patient searched the room while visibly distressed. One participant felt the need to move backwards when the patient came too close.

One participant also stated that she felt that the scenarios were relevant concerning the work they do perform in their department. She mentioned the first scenario and stated that they also have emergency rations of cigarettes available if the patient gets too unruly.

5.2.3 Learning potential of the application

Learning potential of the application theme contains subthemes relating to the application in a learning context. This includes use of the application as a learning supplement, as a peer learning promoting mediator, and how it can be used in SBL.

Supplement

Everyone, to some degree, made positive statements regarding using the application as a learning supplement. Four participants made statements promoting the use of the application as a tool for learning. One participant said that she thought the tool could be handy for learning, to which all GP4 participants agreed. However, she stated that it should not be used as a replacement for physical training but rather as a learning supplement.

One participant stated that the product could be a good tool for learning. Adding many different scenarios could be beneficial in learning and a good way to experience the situations. He had no doubt that it would be beneficial, and he looked forward to being able to perform VR simulation in their department: "det var veldig bra laget. Eg mener – fint på at dette er et godt, et godt middel for å kunne lære i sånne situasjoner. Med masse forskjellige senarioer. Veldig god måte å trene på. Spør du meg. Uten tvil. Jeg er ikke i tvil ett sekund. Vi er jo – lurer litt på tid vi får muligheten til å bruke det. Det har vi jo tenkt mye på. Så det venter vi egentlig bare på. Få muligheten til å gjøre".

Some participants made statements relating to the application's ability to allow users to complete a scenario multiple times. One stated that if the participant feels a great deal of anxiety in using the application, they can go through the scenario multiple times, which might decrease the stress of such a situation. Subsequently, when such situations occur in real life, they might be more comfortable because they are more used to them: "Og du kan gjøre det om igjen også (de andre er enig). Fordi la oss si det jeg følte da, at det var litt sånn spenning i situasjonen. Jeg tenker generelt at det er lurt å få den spenningen litt ned. Altså det er lurt å være – jeg tror det er ganske lurt å være trygg og rolig selv i situasjonen. Så det å øve flere ganger kan jo gjøre folk mer kjent med slike situasjon sånn at hvis den oppstår i virkeligheten så kan man kanskje mere skjenne at «ok, nå er det det som skjer» så er man mer vant til å liksom – være i noe tilnærmet lik en slik situasjon". One participant stated that the application could be used as part of simulation training because of its ease of use. Another stated that the three minutes he spent in the VR scenario provided a far more valuable learning experience than sitting in lectures on the same topics.

However, nine participants specifically stated that they felt that the learning experience would be best for new or inexperienced healthcare workers. For example, one participant stated that a new employee could go through similar virtual courses four to five times during their first six months. He states that this will likely make them better at handling related situations. A new employee supported this, stating that he felt the application was personally valuable. However, she only wished there had been more scenarios that she could use and explore.

Another participant mentioned that the scenarios could be useful for students during the bachelor's program in nursing. He stated that nurses generally lack SBL concerning intoxication and psychiatry: "Akkurat sånn som dette tenker jeg må jo være helt topp på sykepleierstudiet. Faktisk. For det er jo sykepleierstudiet generelt mangler jo mye i forhold til rus og psykiatri".

One participant made a statement regarding how she felt the application could be structured. She stated that different scenario levels could be based on the user's experience. In that case, the application could be used by both students and newly hired, inexperienced, or experienced employees.

Participants stated that the scenarios were too tame for experienced healthcare personnel. They wished the patient had reacted more aggressively when the user was strict with him. This would have increased the realism of the scenario: "At han skulle ha reagert mer på at jeg valgte å være bestemt. For å få det litt mer realistisk. (Alle sier ja)". The same participant as quoted above later stated that the scenarios were too calm compared to their work in real life. The participants also expected a higher degree of interaction during the scenario. Two participants stated that they felt they merely observed a situation instead of actively engaging in it.

Peer learning

Six participants made statements about using the application as a possible mediator for peer learning. For example, one participant stated, in English, that if employees could engage with the scenario at work, they could discuss it afterwards and learn from each other: "there are other ways to connect with people and to – and I think if we use it at work and my colleague here, and we look at the scenarios like that – and we discuss it – then we learn to know - I learn to learn myself a lot more". A participant also stated that it would have been nice to be able to take the application home with them.

Reflection

Seven participants made statements that reflection positively affects the learning process. For example, one participant stated that through SBL, the participants often observe different things and have different opinions on relating matters: "du snakker sammen kanskje to, tre stykker. Som har sett akkurat samme senarioet, hvordan det opplevdes og ikke opplevdes. Vi opplever, oppfatter veldig mange forskjellige ting i et senario når man ser på det. Det er ganske utrolig mye forskjellig man opplever – hvordan man ser ting. Eller hva man ser".

Another participant stated that it would be exciting to try out new options during the next playthrough, as he would like to know how things escalate during the other options. However, he stated that this could also be explored during the reflection period: "Men det er vel kanskje noe for neste steg det å kanskje gå til en evaluering. Hva gjorde en bra. Hva gjorde en ikke bra. Hvorfor tok jeg de valgene jeg tok. Hva gjorde pasienten. Hva påvirka det pasienten. Da ta side-valg". When asked if the VR scenarios could be used to improve patient treatment, he stated that they likely could, but that this depended on the use of reflection.

Five participants made similar statements to the presented results. These include that reflection after viewing the VR scenarios is excellent for learning. It allows all participants of the SBL to learn from each other, learn the "why's" and "how's" of their actions, and listen to the stories that affected their choice in the scenario. When asked if the VR scenarios provide the same reflection opportunity as physical scenarios, one participant stated: "Det ser jeg. Det er sammenlignbart. Definitivt".

In some way or another, all of the participants did reflect on their experience after completing the user testing. They discussed the objects in the scenario, their environment, and their actions. The participants in GP1 spent some time discussing what they would have done differently based on their experience. One participant stated that they could have discussed this all day: "vi kunne mi jo ha diskutert en hel dag".

Three participants made statements regarding the application's ability to promote self- reflection. One participant described how a person who uses the application might start to reconsider the right thing to do in such situations. She later stated: "I learn to know myself in another way, because sometimes when I was young I thought 'that was right', 'that is wrong', 'that is right'. The older I'm getting, I think that it is so many (ler)..".

However, six participants stated that playing through both scenarios did not make them more comfortable handling such situations in real life. Concerning the suicidal patient, one participant stated that different questions needed to be asked and that the scenario did not showcase an entire picture of the situation. Another explained that suicide cases are incredibly complex. He stated that the video must be longer and must fulfil specific criteria: "Nei – Det tror jeg ikke fordi det der selvmords kasuset er så utrolig komplekst. Fordi at den ene pasienten har det symptomet og den andre pasienten har det symptomet". He continues: "Da må du ha – skal du gjøre en sånn form for kompetanse om selvmordsrisiko-vurdering så må du ha mye lengre video da. Da er det visse kriterier. Beskyttelses-faktorer da".

Two participants also emphasised that the learning effect diminished when using the scenarios without reflection and briefing. One stated that the scenario in and of itself did not affect him. However, he says that if it were a reflection period afterwards, the effect would likely be heightened, especially for new employees. Another participant stated that patients are different, so the playthrough will not prepare users for all future interactions.

5.2.4 Flexibility of the tool

The flexibility of the tool theme contains subthemes relating to the application as a tool for learning. This includes subthemes relating to the flexibility of the HMD and the general strengths of VR simulation compared to physical simulation.

Flexible

Three participants made statements relating to the flexibility of the application. Two the participants stated that the application is an accessible tool for the department due to it having its own HMD. One participant also stated that it could be used independently or in larger groups of people: "Det er lett tilgjengelig. Det er et fleksibelt verktøy man kan bruke alene og bruke i store forsamlinger ".

One participant also stated that when a scenario is created, it can be more accessible to people when included as a VR experience: "Så tenker jeg at når man har laget noen rollespill så kan man bruke det om og om igjen på mange. Eller så må man jo spille rollespillene liksom med alt det derre «hvem er det som melder seg til rollespill» også bare hvordan var det? Også bruke masse tid på debrif at man har vært i rollespill. Men nå så kan man liksom gå på saken – eller ja litt på andre ting da".

VR strengths

Thirteen participants made positive statements about using VR and using VR instead of physical scenarios. To summarise, there are nine topics related to this subtheme:

- VR scenarios do not need a large space and are less time-consuming than physical scenarios.
- VR scenarios increase organisers' ability to train many healthcare workers because the hardware is mobile.
- VR scenarios do not demand external actors, nor do they require participants to act as patients. This reduces planning time and removes the stress of possibly being selected to participate in the scenario.
- People who cannot participate in the training because they are busy with something else can participate at a later date.
- VR scenarios might reduce the time between tests.
- Everyone can participate in VR scenarios, compared to physical scenarios where some are observers and others are participants.
- Physical scenarios can be affected by participants not taking the simulation seriously. This is avoided in a virtual scenario.
- Physical scenarios can be affected by bad actors. This is avoided in a virtual scenario.
- Because of the reflection used in SBL, the learning potential of a VR scenario can be on par with that of a physical scenario.

Concerning the hardware's mobility, a participant mentioned that it could be challenging to gather all health personnel who need to perform simulation training, as there are 300+ patient-facing personnel at the department, and it would be difficult to perform physical simulation training with everyone. However, with the VR headset, this has become more realistic due to the mobility of the hardware: "Du får mange. Det er ganske krevende å samle. Hvis du ser for deg jeg tror alle 400la oss si 300 siden dette alle som har pasienter i ARA det hadde du aldri klart å få til fysisk. Men det kan være realistisk ved hjelp av et ved er headsettet. Fordi det kan ligge på vaktrommet og pauserommet, det går an å ta det alene, du trenger ikke hjelpe andre for å bruke det. Det tenker jeg er en stor fordel med det du har laget".

Another participant stated that performing simulation training with VR headsets might reduce the possible two-year interval between trainings because: "det kan jo gå to år mellom hver gang du får en slik hendelse. Du sliter med å håndtere deg selv. Da vil dette kunne – hvis du kan trene jevnlig på det så vil du kunne klare å vedlikeholde din egen – din egen selvkontroll på det. Selvregulering på det. Så dette tror jeg er veldig fint å kunne bruke på denne måten".

Concerning whether the product would have been better if it were physical. A participant stated that he did not think so: "Det kommer an på. Hvis du bruker det alene, sånn at du bare tar på brillene, men hvis du bruker det i en setning med andre det er de ser det samme, så tenkte jeg ja det kan vi like godt utbytte som i fysisk simulering".

5.2.5 General subthemes

This theme is a collection of general positive subthemes related to the product's future potential, how it can promote workers' trust, and general subthemes relating to physical scenarios.

Future potential

All participants made statements regarding the future potential of the application. This includes using different scenarios that train in new fields and that happen more securely. In addition, some participants saw its use in fields outside of psychiatry, such as the somatic field.

Worker's trust

Three participants made statements regarding how the product can be used to increase trust between workers. For example, one participant stated that she knows the people who have worked in the hospital over the past 20 years so well that she knows exactly how they will behave in different situations. However, she does not know how new employees will behave: "For di jeg har jobba sammen med i tjue år – jeg bare ser på de og så vet jeg hva de tenker. Ikke sant? Men det gjør jeg ikke med folk som jeg bare har jobba noen måneder sammen med alltid. Hvordan man vil reagere om noen knuser noe på et rom eller noen – ja – der… Vi har jo hatt noen ting rundt her som det – prøvd og hengt seg i noen tre, sprunge på elva. Ja sånn".

Another participant later stated that everyone is different, and the application provides an opportunity to learn how people react in different situations. Furthermore, by allowing them to test and discuss VR scenarios, participants might develop greater relationships with each other: "Ikke sant – med at – og gjøre oss tryggere. Jeg tror sånn – jeg tenker egentlig litt sånn stort på det. For – først og fremst er jo dette for at pasientene skal ha god behandling. Men så tenker jeg at en bi-ting er jo at vi får enda bedre arbeidsmiljø".

Physical scenarios

One participant expressed how a physical SBL scenario might be a more fulfilling than SBL training using VR scenarios. To quote the participant: "Men da kan det kanskje komme mer ut av det? Ekte situasjonen. Men – ja".

Another stated that physical scenarios provide a more "near" experience compared to virtual scenarios. Because of this, the persons participating in the scenario are more dependent on the people around them, meaning that the interactional element is heightened. The participant stated: "Ja ja ja. For sånn vanligvis når man kjører fysiske simuleringer så er det jo noen ganger at det kan være – at et kan oppleves enda nærere enn – og da blir man mye mer avhengig av de rundt det når den – samspillet. Så jeg tenker att det – begge deler ja takk".

However, some participants made statements that showed physical scenarios in a negative light. When asked if the scenarios would have been better in a physical simulation, one participant stated that he was tempted to say yes. However, he felt that the positive elements of virtual scenarios outweighed the positive traits of physical scenarios. This included gathering actors, preparation, organising participants, etc: "Jeg fristet til å svare ja. Det hadde kanskje blitt sterkere. Men om det oppveier ulempene med å ha det fysisk, sånn som rigget, og det å skaffe seg skuespillere, preppe, få folk til å møte på post. Det tror jeg kanskje ikke".

Concerning the environments of physical scenarios, another participant stated that it can be a challenge to create realistic environments.

One participant also stated that, in their department, they usually have not engaged in as much SBL as the other departments due to the lack of workforce in their department. Because they do not have enough people, the staff have to collaborate with other departments during SBL sessions: "Men i Ara så har det vært gjort mere simulering på de andre postene å, og vi har hatt ett sammarbeid med andre poster med å kjøre simuleringer. For vi har ikke vært nok folk". Besides this, when asked if they had had any previous experience with simulation training, the consensus from the interviews was that they had not been engaged in much simulation training outside of their education. Some participants stated that there had been 1-3 years since the last simulation training, and others stated that there had been a general lack of simulation training. One participant stated that she had participated in one simulation training outside of her education, which was when she started working in psychiatry: "Det har vært veldig lite av, em vi har vel hatt en sånn bitte lit – en sånn enkel kort en da jeg startet. Ingen større simulering eller sammensatt. Det har bare vært en sånn kort enkel oppgave på sånn lett utskreven samtale. Så det har ikke vært noe mer enn det. Sånn simuleringer som jeg har vært med på".

5.2.6 Severity levels of problems

Table 5.6 shows three serious problems were recorded during the observations and interviews for both the individual and focus groups. These relate to issues that should be fixed in the future.

Severity	Problem	Description
Serious	Accidentally exiting the application	Some participants accidentally exited the application
Serious	Failure to recover from errors and issues understanding the use of the controller	The participants who exited the application could not recover from the error. Some participants also had problems understanding how the controller is used
Serious	Voice echo during one of the scenarios	During the ending of one of the branching scenarios, the audio is played twice

Table 5.6: Severity levels of problems in collection two

5.2.7 Data collection two: questionnaire

Sixteen participants answered the seven-point Likert-scaled survey that explored health personnel's levels of satisfaction with using the product. This was given to all participants who tried the product. All the participants played through both scenarios in the application. Of the 16 who filled out the survey, 69% stated that they currently worked in psychiatry and 31% stated that they have experience working in psychiatry, as seen to the left in Figure 5.6. The majority of the participants were between 41 and 50 years old at 59%, 19% were 51-60 years old, and the rest were equally distributed as 18-30 years old and 31 – 40 years old, as seen to the right in Figure 5.6.

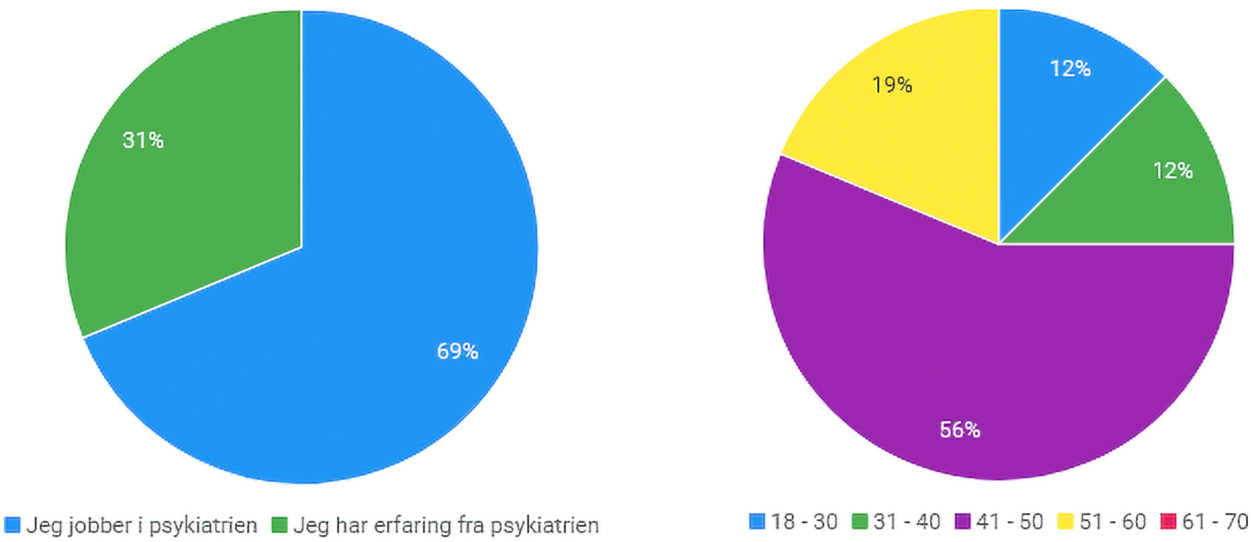

Figure 5.6: Working vs having experience and participant's ages

The survey was structured into six themes relating to different aspects of the application. These include statements relating to the menus, UI, the scenario, the interaction, and the applications used as an SBL tool.

Agreement with the menus and interface of the application

The participants were first asked how they felt about the menu and UI of the application. 94% of the participants strongly agreed or agreed that they enjoyed the application's visual appearance, as shown in Figure 5.7. 56% either strongly disagreed or disagreed that they became confused by interacting with the menu. 19% were in minor disagreement about the statement, but 25%

were in minor agreement that they felt confused during the interaction. The next statement had a similar result, where 56% of participants agreed, and 19% were in minor agreement with the statement that "*I had no trouble finding the information I needed*", while 19% slightly disagreed, and 9% disagreed with that statement. The remaining statements in this theme received positive feedback from the participants. In response to "*I think the information offered was meaningful and relevant*", 94% either strongly agreed or agreed. In response to "*I think the interface (menus, buttons, and everything else graphically) to the application was satisfactory*", 82% of participants agreed. Moerover, 87% of the participants agreed with the statement, "*I think the application had all the features and characteristics as expected*".

The participants were asked to elaborate on whether something confused them, whether there were problems, whether any features or characteristics were missing, or whether anything else should be mentioned regarding the menu or UI. After finishing a scenario, a participant stated that the back button should be called the main menu button because the exit was believed to exit the scenario, not the application. One participant felt that reducing the need to move the head around to view all the information had potential for improvement. Another participant felt that the branching buttons appearing while the simulation was still playing was something that needed improvement. The last two participants who left comments said that there are too many buttons to select on the controller and that the buttons should receive an explanation about their use before starting the application.

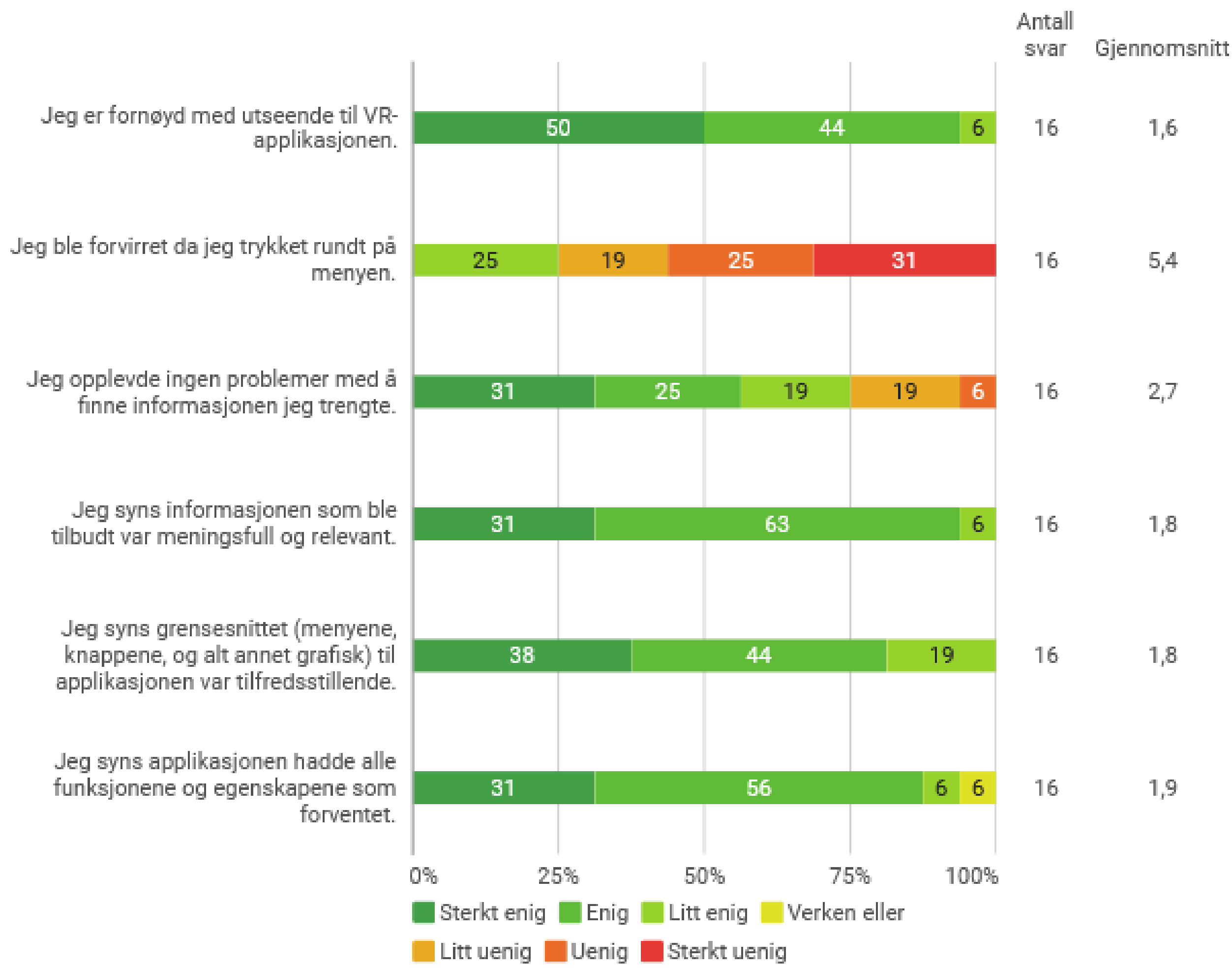

Figure 5.7: Statements from participants relating to interface one

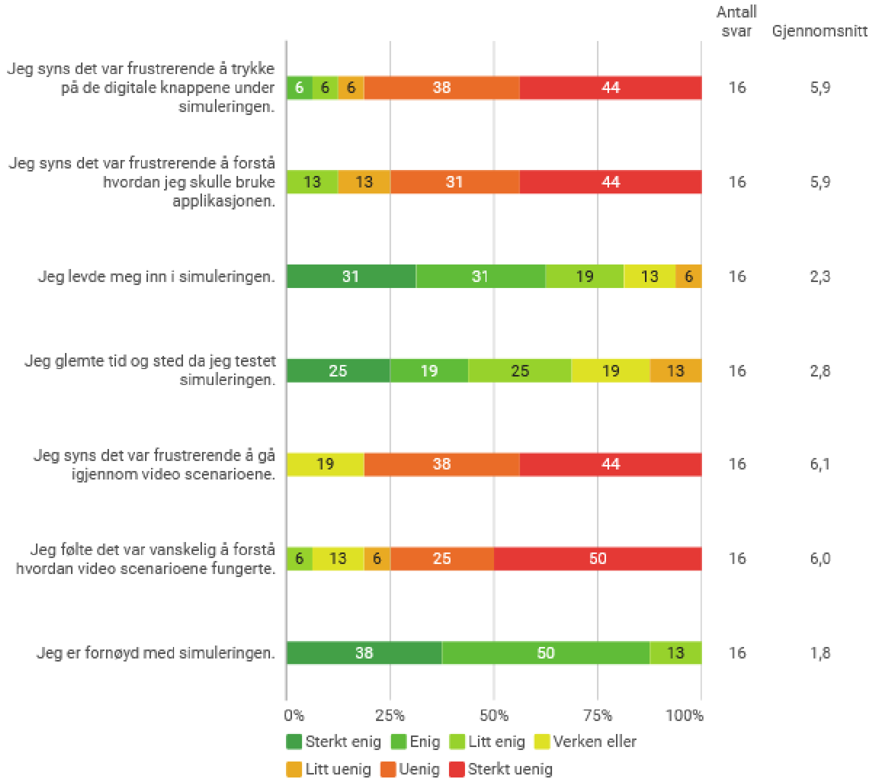

Figure 5.8: Statements from participants relating to interface two

Agreement with the interface (digital buttons and menus) during the simulation

As shown in Figure 5.8, 82% of the participants disagreed with the statement that it was frustrating to select the digital buttons during the simulation. Six per cent slightly disagreed with the statement, and 12% either slightly agreed or agreed with the statement. 75% of the participants disagreed with the statement, in that they felt frustration in understanding how to use the application. Thirteen per cent both felt a slight disagreement and slight agreement with the statement.

Relating to whether the participants became immersed in the scenario, 62% agreed with the statement. Nineteen per cent slightly agreed, and 13% did not agree or disagree with the statement. The remaining 6% were in slight disagreement. The next statement was similar to the immersion, and asked whether participants forgot time and space while testing the simulation. Fourty-four per cent either strongly agreed or agreed with the statement, 25% were in slight agreement, 19% neither agreed nor disagreed, and 13% were in slight disagreement.

In the next statement, "*I find it frustrating to go through the video scenarios*", 82% either strongly or slightly disagreed with the statement, while 19% neither disagreed nor agreed with the statement. In response to a similar statement that it was difficult to understand how the scenarios worked, 75% disagreed, where 50% of those strongly disagreed with the statement. Six per cent slightly disagreed, 13% neither disagreed nor agreed, and 6% slightly agreed with the statement.

Lastly, when the participants were asked about the statement, "*I am happy with the simulation*", all participants agreed in various degrees. Thirty-eight per cent strongly agreed, 50% agreed, and 13% agreed slightly.

The participants were also asked to elaborate on whether something confused them, whether there were problems with the simulation, whether any features or characteristics were missing, or if anything else should be mentioned regarding the menu or UI during the simulation. One participant stated that the reason for neither agreeing nor disagreeing on a non-specified statement is that they would like to have had more branching options during the scenario. Another user felt it was slightly frustrating that the participants' choices led to actions they would not have performed themselves were they placed in a related situation. One participant also stated that a silhouette of the controller got stuck at the centre of the screen in the scenario.

Agreement with the application

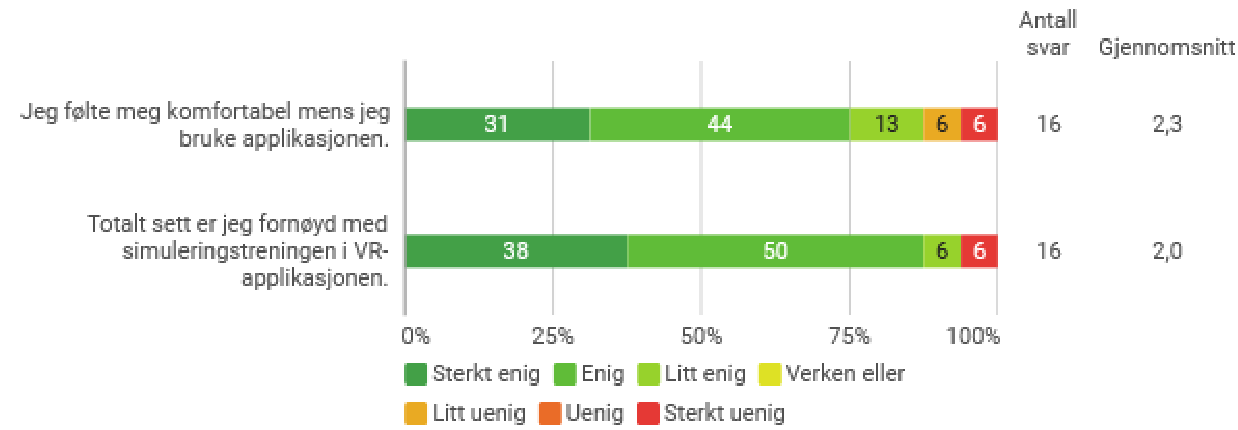

Figure 5.9: Statements from participants relating to the application

Figure 5.9 show's participants responses to statements relating to how they felt during their use of the application. In response to the statement, "*I felt comfortable while I used the application*", 75% of participants agreed, 13% slightly agreed, and 6% both disagreed and strongly disagreed with the statement, respectively. In response to the last statement related to their overall happiness with the simulation training in the VR application, 88% of participants stated that they were happy overall with the training, and 6% slightly agreed. The last 6% strongly disagreed with the statement.

Degree of agreement relating to the scenarios

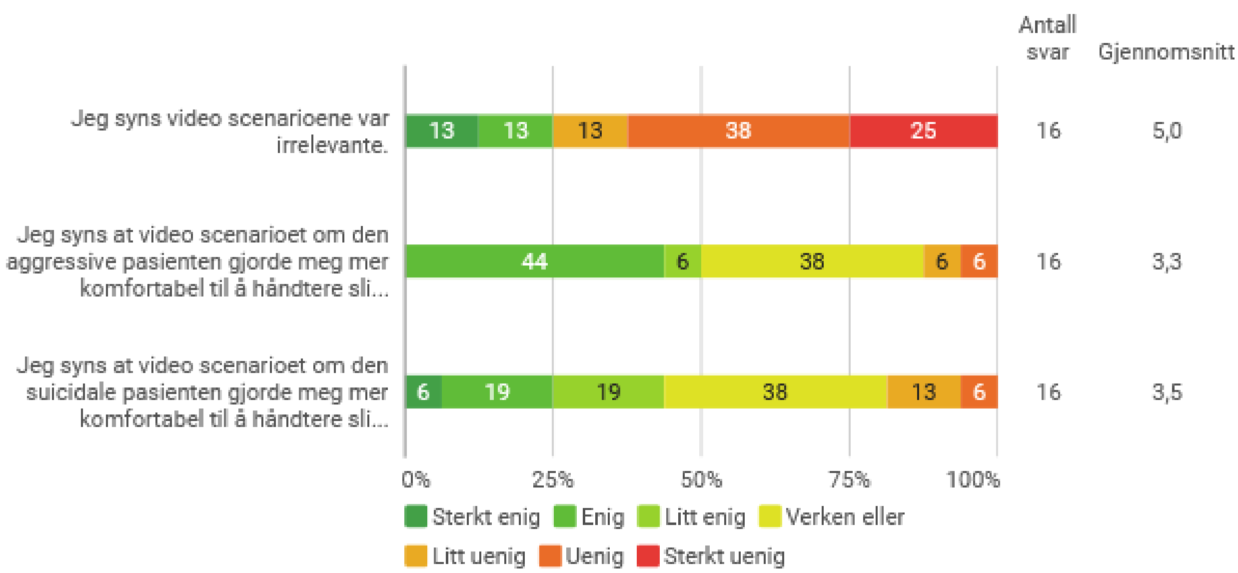

Figure 5.10: Statements from participants relating to the scenarios

In Figure 5.10, the statement, "*I think the video scenarios were irrelevant*", was met with 63% disagreement, while 13% slightly disagreed, and 26% agreed with the statement. The next statement, "*I think the video scenario about the aggressive patient made me more comfortable dealing with such situations at work*", received mixed feedback. Zero per cent strongly agreed with the statement, while 44% agreed, 6% slightly agreed, 38% neither agreed nor disagreed, 6% slightly disagreed, and 6% disagreed with the statement. The last statement, "*I think the video scenario about the suicidal patient made me more comfortable dealing with such situations at work*", was met with similar results. Twenty-eight per cent agreed with the statement, 6% strongly agreed, 19% slightly agreed, 38% neither agreed nor disagreed, 13% slightly disagreed, and 6% disagreed with the statement.

Degree of agreement with the interactivity

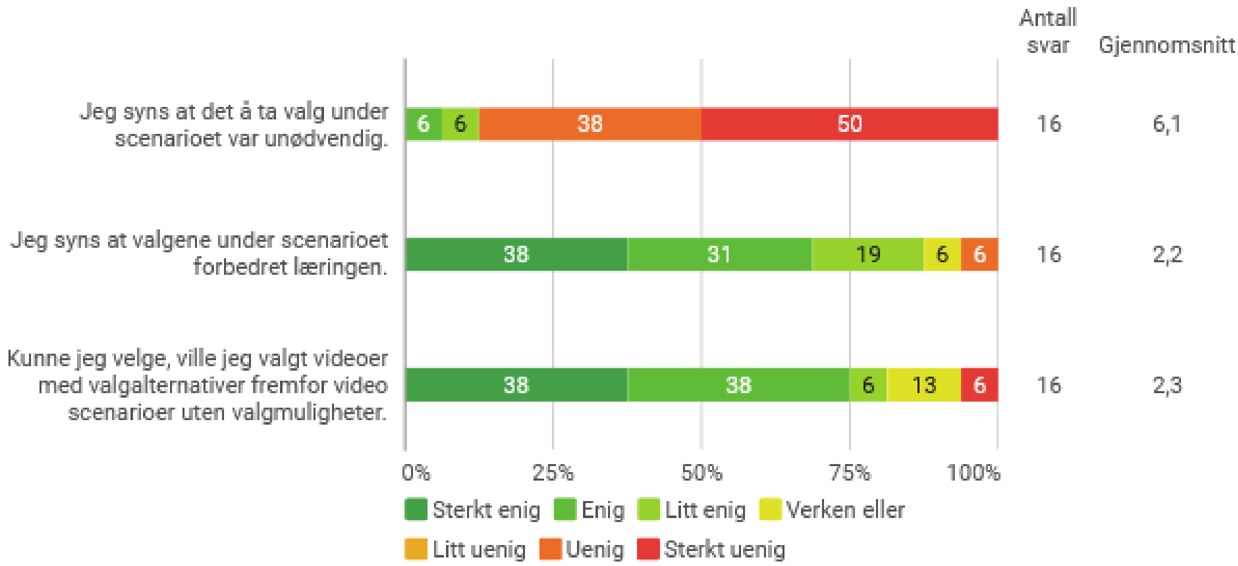

Figure 5.11: Statements from participants relating to simulation interactivity

Figure 5.11 showcases the three statements relating to the interactivity of the application. The first statement asked participants whether they agreed that the choices they made during the scenario were unnecessary. Fifty per cent strongly disagreed, 38% disagreed, 6% slightly agreed, and 6% agreed with the statement. The next statement focused on whether the choices during the scenario enhanced learning, where 38% strongly agreed, 31% agreed, 19% slightly agreed, 6% neither agreed nor disagreed, and 6% disagreed. The last statement, "*If I could choose, I would choose videos with choice options over video scenarios without options*", was met with 38% strong agreement, 38% agreement, and 6% slight agreement. Thirteen per cent of participants neither agreed nor disagreed, and 6% strongly disagreed.

Degree of agreement related to the simulation training

As shown in Figure 5.12, in response to the statement regarding whether the videos provided worse training compared to regular simulation training, 31% of participants strongly disagreed and 19% disagreed. Thirteen per cent were in slight disagreement with the statement, while 25% neither disagreed nor agreed with the statement. Thirteen per cent agreed with the statement that the videos provided a worse training experience compared to physical simulation training. In a similar statement, "*I prefer standard scenario training over virtual scenarios*", 19% strongly disagreed with the statement, 13% disagreed, 31% slightly disagreed, 25% neither disagreed nor agreed, 6% slightly agreed, and 6% strongly agreed.

When asked about the statement, "*I think the VR product can be a good tool in simulation training*", 92% agreed with the statement while 8% slightly agreed. However, this statement was answered by 13 people compared to the 16 participant's answers on the other statements because the statement was added while the survey was live, and three participants had already completed it before it was finished. In the last statement of the survey, "*Overall, I'm happy with the virtual simulation training*", 44% of participants stated that they strongly agreed, 38% stated that they agreed, and 19% stated that they slightly agreed.

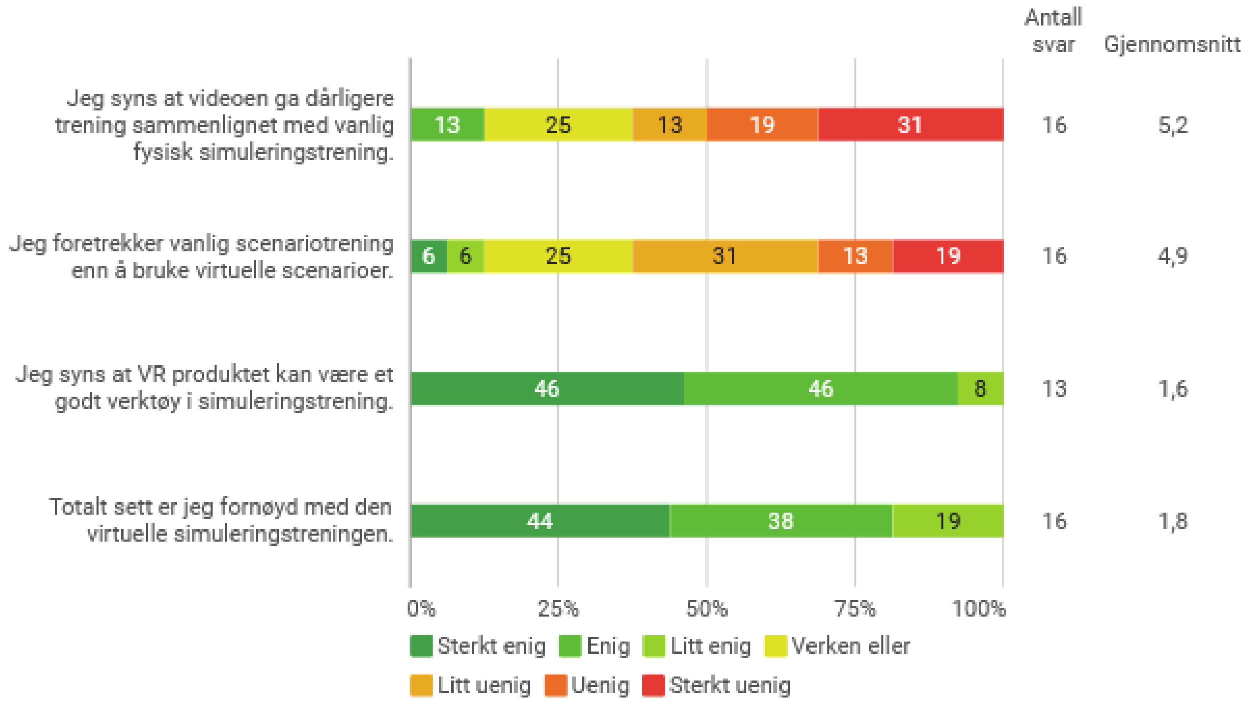

Figure 5.12: Statements from participants relating to the simulation training

Chapter 6

Discussions

Based on the results from the data gathering, the structure of the discussion is divided into three sections, each of which discusses the relevance of the results concerning the research questions. Chapter 6.1 explores how the results relate to the research question: “How can effective VR scenarios of hospital simulations be designed for nurse training?”, chapter 6.2 explores how the results relate to the research question: “What are the advantages and potential challenges of using VR scenarios for training nurses in psychiatric wards?” and chapter 6.3 explores how the results relate to the research question: “What are nurses’ levels of satisfaction after using the VR simulation?”.

6.1 How to design effective VR scenarios

The human-centred design process presented in chapter 3.2 was the approach used to tackle the development and design of the application [33]. The result of this design process presents a product that can be used in simulation training as an interactive virtual scenario. The main focus of the HCD process is to create a product that fulfils the needs of the users and stakeholders, taking into account the environment and the technology. In this case, the product was an application created on an Oculus Quest 2, with a focus on providing better training and learning [11, 80, 110].

The research question is answered through the HCD process, where the prototype is presented in chapter 3.2.3 and the final products are presented in chapter 4.3. The changes between the prototype and the final solution were based on the result from the first data collection. The arrows shown during the scenarios and in the about page on the menu were removed as they were deemed unnecessary. The participants viewed the buttons without issue, and the closing credits was moved as a UI on the main menu. The buttons on the controller were reduced from using multiple buttons on the controller to only using two. The large image of the controller was removed and replaced with an image showcasing the use of the UI interaction button at the back of the controller. The new menu and tutorial are shown in Figures 6.1 and 6.2. Additional scenes with scenario introductions and endings were created. Moreover, the severity levels of problems were fixed with the exception of those relating to the scenario, as any changes to the scenario would require re-shoots. This was not deemed possible due to Covid-19-related complications [51](appendix A) and because of the timeframe of the thesis. The focus was instead put on improving the use and design of the application, as well as increasing the content through new scenarios. The new scenarios were created to reduce the issues presented in the first scenario.

In relation to the evaluation of the design, in the second data collection, the application performed adequately on most of the requirements created during specifying the user requirements, as explained in chapter 3.2.2. The application provided all the functional requirements as stated, where the participants reacted positively concerning the design and use of the product in trainings [92]. This is reflected in the discussion presented below in relation to the possible use of the application and the participant’s levels of satisfaction relating to the use of the product. The video and audio recording, editing process, and the product’s development are more thoroughly explained in chapter 4, VR

Figure 6.1: Final design of the menu

application design and development.

However, concerning the non-functional requirements of the application, there were some areas where the product did not fully deliver [92]. This relates to the fact that the product should be usable by anyone with or without technical experience. It should be understandable without instructions, and usable without any issues or frustration. As observed during user testing and further explored during the interview, some participants had problems understanding how the tutorial works. This suggests that the tutorial needs to be reevaluated to make it easier to understand how to use the application. This initial issue caused frustration and confusion, which clashes the product usability goal of being easy-to-learn [101]. This also hinders users' ability to use the application without external help. However, as discovered during the context of use analysis, the application's main purpose is its use in simulation training. With simulation training, the organisers will be able to assist the participants [102]. However, as stated in the results, the application might need either an expert to assist in use the application, an external introduction on the controller's use and interaction with the application, or for participants to explore the controllers and hardware before using them. For example, the controllers could clearly display which buttons are usable.

Another issue discovered during the second data collection session was that the participants might exit the application unwillingly when finishing a scenario. This is a usability problem relating to the safe-to-use goal [101]. Users were not sufficiently informed of the consequences of pressing the buttons, so when hovering over a button, participants often pressed it before the 0.2 seconds long animation relating to the button's function was visualised.

These usability issues should be fixed in future iterations of the product. However, generally, the result of the HCD development process resulted in a usable product that fulfils the main stakeholder requirements and is usable as long as users are informed of the user of the controller buttons and that that the "Avslutt" (Exit) button would exit the application, rather than the scenario.

Figure 6.2: Final design of the tutorial

6.2 Advantages and potential challenges

This section will explore the positive and negative benefits of using VR scenarios as educational tools.

6.2.1 The advantages of VR scenarios in simulation training

The results present positive and negative uses of VR scenarios in simulation training. The primary advantages of VR are related to it being a good supplement to promote learning through simulation training [110]. This is mainly concerning SBL training [65]. However, the results suggest other uses concerning VARK [28] and peer learning [32]. As a tool, VR allows for scenario training without the constraints usually affecting SBL [63, 37]. It requires less space and less preparation [37], allows for more direct participation in the scenario, and participants do not need to worry about peer pressure. In addition, it may be used as a test for new or inexperienced employees so that experienced employees may know how they react to different situations.

As a tool

The main motivation for using VR scenarios in simulation training was to explore the advantages and challenges associated with the digitalisation of physical scenarios [87]. In line with the research question, "*What are the advantages and potential challenges of using VR scenarios for training nurses in psychiatric wards?*", the results present varying positive and negative points concerning VR scenarios in training.

As mentioned in the State-of-the-Art chapter, one of the main negative traits of SBL is the expensiveness of planning, training people, and gathering materials [37]. As stated by Farbu et al. [36], the time and investment needed perform simulation training may be excessive. However, as stated in 2.3, Virtual reality in healthcare education, HMD has been shown to be a cost-effective educational tool. The hardware is affordable [37, 82, 84], does not demand much equipment [37, 81], reduces the need to prepare actors [37, 63], and reduces the possibility of expensive hardware being damaged during scenario training [74].

In line with the State-of-the-Art, the results support VR hardware as an economical method of performing traditional simulation training [37, 82]. As stated in 5.2.4, Flexibility of the tool and 5.2.5, general subthemes themes in the results chapter, the VR application removed the need to hire and train actors and demands less preparation and participant organisation. As the VR scenarios are pre-made, the only equipment that stands in danger of being damaged is the VR hardware and the surrounding environment. Furthermore, the flexibility of the hardware allows it to be re-used in simulation training without extensive preparation. As stated in State-of-the-Art, nurses often have limited access to simulation training [68]. This is supported in the results chapter, as participants often had little experience in SBL outside of their university education. As stated in the VR strengths subtheme in 5.2.4, Flexibility of the tool, participants suggest that the tool might increase scenario training capabilities due the hardware's mobility and lack of human resources requirements. Furthermore, if healthcare personnel are not available at a particular time, they can participate in the scenario later, as long as the hardware is available. This is partially supported in State-of-the-Art, as students can participate anywhere [8, 81], providing meaningful contexts in different educational establishments [44]. This suggests that, considering the usually excessive planning related to SBL, VR may be a mobile tool that makes simulation training more accessible and may promote more frequent use, as the scenario is already prepared [37, 58].

As mentioned in the expert interview of the university lecturer, seen in appendix H, while performing the data gathering related to exploring the context of use, it became apparent that not everyone participates in SBL. Not everyone can participate in physical trainings as trainers usually perform simulations with numerous participants. Therefore, some become observers of the roleplay instead of participants. As displayed in subtheme 5.2.4 VR strengths, one possible strength of VR scenarios is that they can potentially include everyone in the scenario as long as there is enough HMD.

The scenarios

One of the reasons for simulation training is that healthcare professionals can experience realistic simulations in safe environments [19, 29, 36, 102], which allows them to improve their competencies when supporting patients [83]. This makes it appealing to use VR technology, as it separates and immerses users into a different world [58, 53]. It also has been shown to provide a positive emotional experience for partaking participants [7, 8, 44, 81, 117, 130].

The results from the data collection support the positive experience of the VR scenarios. As stated in the subtheme 5.2.5 physical scenarios some participants felt that the experience was more "near" compared to physical scenarios. The subtheme Application immersive in 5.1.2 suggest that the experience was immersive for multiple reasons. Some participants do not enjoy the roleplaying element of scenario training [36]. Not participating in roleplay during the VR scenario increased their immersion because they did not need to focus on the acting. Other elements that increased immersion were the actors' performances and how realistic and recognisable the scenario was, both compared to physical simulation training and in the workplace. The survey supports this further, as shown in Figure 5.8 in chapter 5.2.7, the majority of the participants agreed with the statements regarding being immersed in the experience and forgetting time and space during the simulation.

Concerning the emotional aspect of the VR experience, the participants either felt that the experience was fun and exciting, as observed after user tests, or that the experience was positively unpleasant. Notable comments relate to the patient's height, as shown in the subtheme 5.1.2 Scenario immersive in chapter 5.1.2 and uncomfortable behaviour, shown in the Scenarios subtheme in chapter 5.2.2, which created a sense of fear and unease.

The learning

Simulation training is one of the main methods of educating healthcare professionals in Norway [93]. It allows healthcare professionals to test their knowledge in a close-to-real-life but safe experience [19, 29, 36, 102]. This is follows the experiential learning theory, wherein participants engage in learning by actively performing a task [61]. It may also relate to affective learning, as the user's values might change by engaging in emotional situations [11, 41].

Both data collection and the survey provided positive results relating to the use of the application as a tool for learning. It allows the participant to participate in a situation that normally would have been dangerous in real life [29, 102]. In line with experiential learning, reflection was stated to be a major element in the learning process [35, 66]. Both in 5.2.3, Learning potential of the application and the result from the survey, as seen in Figure 5.10 and Figure 5.12, suggest that the use of VR scenarios without reflection might create a sub-par learning experience. In the group interviews, the participants often reflected on the situations they experienced based on their knowledge and previous experiences. This might support the use of the scenarios in experiential learning to promote reflections in a similar way to physical scenarios [35, 66].

It is also stated in experiential learning that the insights from the learning should be repeated to apply new ideas and test the experience [35, 66]. However, in the scenario training currently used at the hospital and in 360-video recordings in general, most videos provide a passive learning experience [84]. This makes testing and exploring new insights difficult based on their conceptualisation[35]. However, active interaction with the branching narrative provided in the application's scenarios might make this more possible. Experimental learning incorporates active learning through roleplay and SBL, making it possible for participants to repeat activities and achieve new outcomes [35, 66, 112]. As the application allows the users to tackle the situation differently during replay, as stated in the Supplement subtheme in 5.2.3, participants felt that the ability to replay might improve their learning [110].

The ability to test and repeat new insights may also be facilitated through the affective learning domain, as the participants may have values related to handling emotional experiences [41]. As stated in 5.2.3 Reflection subtheme, the participant felt that going through the scenarios might promote self-reflection and a questioning of their previous beliefs in handling such situations. By doing so, the participants might add new values and use these values to try and resolve relatable situations [41]. Through active replay and later at work, the participant may be able to test out these new values. Based on the experience, the user is provided with the ability to explore these new values further [41].

Another possible method of exploring the experience could occur through peer learning [32]. The resulting discussion relating to users' experiences could be explored with co-workers, allowing for the provision and acquisition of peer feedback and to assess their understandings [89]. It was suggested from the Peer learning subtheme in chapter 5.2.3 that the application could be used as a mediator for peer learning. This could possibly reduce the need to engage in organised simulations as desired through experiential and affective learning [41, 35, 66]. This might also increase workers' trust, as presented in the workers' trust subtheme in chapter 5.2.5, if the scenario is provided to someone new or inexperienced, their actions during the scenarios can be discussed with peers afterwards.

However, the use of virtual scenarios and participating in scenario training at large might be learning methods best suited for visual, audial and kinesthetic learners [28]. Learning through physical interaction is the style most associated with scenario training, as the scenarios demand active interaction. As stated in chapter 2.4.6, VR and Education, the HMD supports learning through all the VARK learning styles by using the hardware's display, speakers and controllers [133]. The VR application is mainly focused on showcasing visual and audial information through a simulation and allowing the participants to affect the scenario using branching buttons directly. This might make it less suitable for the write/read prefered learners, and more preferable to the visual, audial and kinesthetic learners [28].

6.2.2 The challenges of VR scenarios in simulation training

One challenge of the technology's ability to immerse healthcare professionals is that more experienced workers might not be as immersed in the scenario as inexperienced workers. Challenges also occurred in developing the scenarios, as some healthcare professionals might feel discomfort in being immersed in unpleasant scenarios [36].

Immersion

As stated, one of the advantages of using VR technology is the possible immersion it provides [53, 58]. This immersion in the VR environment provides might be the reason for the educational use of the hardware [81]. Issues might then occur when the participants are not immersed in the scenario for various reasons. Based on the results, these reasons may include inaccurate environments (chapter 5.1.2), the irrelevance of the scenarios (Figure 5.10 in chapter 5.2.7), and the tameness of the experience (chapter 5.2.3 and in Table 5.1.4). As stated in the results 5.2.3, Learning potential of the application, the scenarios created for this study might be more useful for new or inexperienced participants, as the interaction with patients at work might be too intense.

The immersion experience, as when performing physical scenarios, might also be negative for some. For example, in relation to the VARK, a healthcare professional might not enjoy the experiential learning method provided through scenario training [28, 19]. Aside from the organisational [36] and economic [37] elements that provide a challenge to the use of VR scenarios in education, healthcare professionals might not enjoy participating in situations that might cause discomfort [36]. The immersion from the VR hardware might promote anxiety if the situation is related to a previous unpleasant situation [36].

Planning and development

As stated, performing scenario training can be an expensive endeavour because of both the time and money involved in organisational expenses [36, 63]. However, there are still expenses involved in the use of VR scenarios. The expenses related to training people, writing scripts, and gathering materials and actors are still present; however, they are a one- time payment compared to continuously going through the same expenses at each scenario training [37, 52]. Also, as showcased through the HCD process, many expenses relate to the time investment of creating proper virtual branching scenarios. Previous research showcases how previous application developments lack frameworks or research-backed design models [30], which might result in poor experiences [8]. This suggests that delegating time to develop the scenarios is necessary to create sufficient applications.

Physical scenarios

Even though VR hardware is an interactive and immersive technology that might pro- mote the feeling of being in another place, it may not be immersive enough to replace physical scenarios in some areas altogether [53]. For example, as stated in Ulrich et al. [117] the 360 videos were not on par with physical lectures. They may also not be as beneficial in teamwork training as in physical scenarios, as the participants do not interact with each other directly through 360 video recordings [36]. This is shown in chapter 5.2.5, as some participants felt that they might have had a more fulfilling and "near" experience when performing physical scenarios compared to virtual scenarios.

6.3 Health professional's levels of satisfaction

As stated in the State-of-the-Art chapter, providing a positive emotional response is a common conclusion for researchers exploring the use of VR in learning [7, 8, 44, 81, 117, 130]. It was then of interest to explore healthcare professionals' experiences using VR scenarios after participating in physical scenarios.

From the data collected during the survey and supported by the observation during the user test and the interview, the consensus is that the application provides a satisfactory experience where the unsatisfying elements of the application are confusion relating to the tutorial and the lack of warning before quitting the application.

The general response to the application and scenarios was positive during the observation and interview. The experience relating to the application's visual design was positive, and the participants enjoyed interacting with the experience. However, confusion concerning the use of the controller to interact with the application lowered user satisfaction. As stated in the tutorial subthemes in chapter 5.2.2, The Design - Positive and negative, reducing confusion about the use of the application could have increased user satisfaction with the product. The environment also affected the satisfaction of some participants, as they felt that increasing the environmental quality would have increased the perceived realism of the application.

The survey supported most of the user testing and observation data. In relation to the visual appeal of the UI, the information presented, if the UI was satisfying and if all functions and characteristics were as expected (Figure 5.7 in chapter 5.2.7). The average score stood between strongly agreeing and agreeing to the statements. Likewise, the highest level of disagreement related to user frustration in interacting with the branching buttons and that it was frustrating to understand how the application functioned. This showcases a low satisfaction level relating to the menus and the interface of the application. This is supported by the data collected during observations and interviews, as experiences relating to the application's visual design were positive, and the participants enjoyed interacting with the application, as presented in chapters 5.1.1 and 5.2.2. However, user satisfaction relating to interaction with the menu was reduced. Participant's suggestions on how to increase satisfaction and reduce confusion were related to the learnability and safety usability goals [101]. This included ensuring that the user did not do anything they did not want to do and improving on the tutorial.

Other high satisfaction levels related to statements surrounding frustration in completing the scenarios and difficulty understanding how the application worked. The average user indicated that it was a satisfying experience to complete the scenarios and that they were pleased with the simulation used in the VR training, as none of the participants stated anything less than slight agreement. The same result was related to being comfortable while using the application. This is seen in Figure 5.8 and 5.9 in chapter 5.2.7.

In relation to learning, the general consensus was that the participants were between slight agreement and neither agreeing nor disagreeing to the statement that the scenario playthrough during user testing made them more comfortable in handling such situations, suggesting that learning satisfaction in the absence of reflection or peer learning, as mentioned in the second research question discussion in chapter 6.2, did not provide ample learning effect. The participants were satisfied with the interactivity of the application and preferred to use videos with branching options compared to videos lacking such branching options, as seen in Figure 5.11 in chapter 5.2.7. However, most participants were split on whether they preferred physical or virtual scenario training. Lastly, when asked whether they felt the product would be a good learning tool and were pleased with the virtual simulation training, the response was positive, with the average participant strongly agreeing or agreeing, as seen in Figure 5.12.

Chapter 7

Conclusions and future work

A VR scenario application has been developed to train and educate psychiatry healthcare professionals in handling threatful and suicidal patients. It provides an active and engaging experience where the user's interaction will affect the virtual scenario. Based on the learning goal of the simulation training, the participants can choose which scenario they desire. The first scenario showcases a patient who desires cigarettes but is not allowed to have one. The participant must choose between being diplomatic or determined in handling the situation and, in the end, decide whether the patient should receive a cigarette or continue on the path the healthcare professional has chosen. During the second scenario, the participant is greeted by a visibly distressed patient who hears invisible voices. The user can decide how to interact with the patient by letting him roam freely in the room or asking him to sit down. Afterwards, the user receives the option to confront the patient about his suicidal thoughts. The user is presented with a summary of their choices at the end of the scenario, which can be used during debriefing and reflection.

In order to answer the research question: "How can effective VR scenarios of hospital simulations be designed for nurse training?", the application was created using human-centred design, which focuses on creating a product that fulfils the need of the users and stakeholders. It provides a framework for solving underlying fundamental issues concerning the usability and UX of the design. This resulted in a usable learning product for the hospital's different psychiatry departments. The design was developed and explored using mixed-method data collection, which includes usability testing, observation with an interview, and a survey. This was done to explore how to design effective VR scenarios of hospital simulations for healthcare professional training. However, the data gathering also focused on exploring the advantages and potential challenges of using VR scenarios for training nurses in psychiatric wards and nurses' levels of satisfaction after using the VR simulation.

Concerning the second research question: "What are the advantages and potential challenges of using VR scenarios for training nurses in psychiatric wards?", benefits relates to the mobility of the tool rather than organising full scenarios. This allows for simulation training without the need for extensive planning and organisation. Moreover, compared to SBL training, all participants can engage in the simulation simultaneously, as long as there are enough available HMDs.

The scenarios in the application were realistic and relevant to situations that might occur at work. Moreover, participants became immersed in the experience. This resulted in a fun and exciting experience and positively unpleasant feelings of fear and unease among participants.

Concerning learning potential, the advantages of using the application related to using it as a mediator for peer learning, as part of simulation training using experiential learning and affective learning through the emotional experience of using the application. Furthermore, it provides a virtual active learning environment that is likely more attractive to visual, aural and kinesthetic learners.

Challenges relate to achieving immersion with the scenarios presented in the application, suggesting that experienced personnel may need more intense scenarios to become fully immersed. This likely diminishes the learning potential. In addition, some participants may dislike participating in the simulation because of the fear of re-living unpleasant situations. This is relevant in VR scenarios as well as physical scenarios [36].

There are also challenges relating to the production of the VR scenarios, as it can be an expensive endeavour. In addition, a time investment is necessary to create proper virtual branching scenarios as a lack of attention to the application's design might result in poor experiences. Lastly, virtual scenarios might not have the same educational effect as their physical counterparts.

Lastly, concerning the research question:" What are nurses' levels of satisfaction after using the VR simulation?", data collected during the survey and supported by the observation during the user test and the interview supports a satisfactory experience, where the unsatisfying elements of the application are confusion relating to the tutorial and the lack of warning before quitting the application.

7.1 Future Research

The research has explored the benefits and challenges of using interactive VR scenarios as a learning tool. However, the research did not go in-depth to test whether the different benefits and challenges hold up extensively. The research was conducted by asking healthcare professionals about their options relating to the benefits and challenges that might surround the use of VR scenarios. Future research should re-evaluate these benefits and challenges to test whether they are relevant or not. This could involve, for example, exploring the use of interactive VR scenarios in the context of SBL, testing whether they promote peer learning, and testing whether they require the participant to be engaged in the scenario.

The research could also be moved outside of healthcare to other professions. As stated in The Potential of 360° Virtual Reality Videos and Real VR for Education—A Literature Review[84], healthcare is the largest field of research concerning VR, and 360-degree videos. The technology could be tested in other fields with similar training to explore if it would return similar results.

In other fields, the design of the application through HCD might be vastly different as well. Possible future research could explore the design differences that materialise in other professions. Satisfaction levels may also be very different between different professions and cultures. Exploring the desire to use interactive VR scenarios as educational tools for different cultures and professions could further visualise the challenges and limitations of using interactive VR scenarios.

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Appendix A

OKL regulations

OKL viderefører bestemmelser

Overordnet kriseledelse (OKL) vedtok i går at eksisterende bestemmelser vedrørende kurs, møter, sammenkomster, hjemmekontor samt bruk av munnbind, alle videreføres ut januar. Dette er begrunnet i den forventede økningen av omikronvarianten i regionen.

- Jeg er klar over SSHF kjører et noe strengere regime enn enkelte signaler ute i samfunnet skulle tilsi. Mens enkelte etterlyser en normalisering, må vi ta utgangspunkt i at utbrudd i sykehuset er langt mer alvorlig enn i andre deler av samfunnet, sier fagdirektør Susanne Hernes. Hun minner om at vi må vise ekstra aktsomhet også fordi mange av SSHFs medarbeidere kan ha omikronsmitte hjemme uten å vite det.
- Vi ser at smitten øker nå som barn er tilbake på skole og barnehage, og jeg mener vi gjør klokt i å avvente før vi velger å endre på våre bestemmelser, sier hun.

Dette betyr at bestemmelsen om at alle kurs, møter og sammenkomster som ikke er strengt nødvendige for driften skal avlyses **ut januar**.
Det åpnes heller ikke for trening i treningssenteret, og eksisterende retningslinjen for bruk av munnbind fortsetter også ut januar.

Av Signy Svendsen

Artikkeldato: 06.01.2022 08:00 | **Publisert av:** Signy Svendsen | **Sist endret:** 06.01.2022 13:06

Figure A.1: OKL canceling everything that is not strictly necessary

Appendix B

Survey

The following pages showcase the survey used during data collection one. The survey explores the advantages and potential challenges of using VR scenarios for training nurses in psychiatric wards as well as nurses' levels of satisfaction after using the VR simulation research questions. The survey was provided to people who completed user testing of the product.

Velkommen til undersøkelsen knyttet til SSHF simuleringen!

Hei! Jeg heter Matias Sjøvold Kortsen og er student ved Universitetet i Agder. Jeg jobber for tiden med masteroppgaven
min som handler om å lage og forske på et e-læringskurs i VR som skal brukes ved Sørlandet Sykehus, og jeg håper du kan bli med i forskningen ved å delta i en studie! Hensikten med forskningen er å lage en VR applikasjon som skal støtte simuleringstrening.

Denne undersøkelsen tar utgangspunkt i at du har prøvd SSHF Simuleringen. Undersøkelsen skal samle informasjon relatert til hvor tilfredsstilt du er til designet av en VR-applikasjon og dens potensiale til å bli brukt til simuleringstrening.

Før du kan delta så må du godkjenne samtykkeskjemaet på neste side. Den beskriver alle dine rettigheter som deltager til undersøkelsen. Jeg setter utrolig pris på alle som kan delta. Det vil hjelpe meg å lage et bedre produkt og gjøre mye for kvaliteten på masteroppgaven.

Deltaker Samtykkeskjema

E-læringskurs ved SSHF

Navn på forsker:
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Formål med forskningen

Kjære deltaker, jeg er student ved Universitetet i Agder og jobber for tiden med masteroppgaven min. Oppgaven er å lage og forske på et e-læringskurs i VR som skal brukes ved Sørlandet Sykehus, og jeg håper du kan bli med i forskningen ved å delta i en studie. Hensikten med forskningen er å lage en brukervennlig applikasjon for å støtte læring.

Viktig informasjon til deltakerne

For å lage et godt produkt er det viktig å inkludere deg under utviklingen. Dette gjøres ved at du svarer så oppriktig du kan på spørsmålene som kommer. Spørsmålene er satt opp som påstander, hvor du derreter bestemme hvor enig du er i påstanden. Informasjonen som samles inn fra studien vil anonymiseres, krypteres, oppbevares trygt og kun brukes som en del av dette masterprosjektet og relaterte publikasjoner. Personopplysningene som samles inn vil ikke bli brukt i den tekniske løsningen, men brukes til å dokumentere at du som deltager er representativ og relevant til forskningen. Du har også rett til å sende inn en klage til

Datatilsynet om behandlingen av dine personopplysninger.

Samtykke til å delta i forskning
Vennligst les gjennom punktene:
• Jeg forstår at datainnsamlingen vil bli sett av forskeren og muligens veilederne for prosjektet.
• Jeg forstår at datainnsamlingen vil være anonymiserte og kan brukes i masteroppgaven samt relaterte vitenskapelige publikasjoner. Når den er ferdig, vil all informasjon som ikke er en del av sluttrapporten bli slettet.

Ved å gå videre med å trykke på **"Jeg godtar samtykkeskjemaet"** knappen så godtar jeg å delta i forskningen og bekrefter at jeg har lest og forstått
informasjonen ovenfor. Jeg gir også samtykke til at mine personopplysninger kan behandles frem til sluttdatoen for prosjektet, ca. Desember 2022.
Din deltakelse er verdifull og settes stor pris på

- ☐ Jeg godtar samtykkeskjemaet
- ☐ Nei takk. Jeg ønsker ikke å delta.

Velg det som passer deg best

Har du testet SSHF simuleringen og testet begge scenarioene?

- ☐ Ja
- ☐ Nei

Hvilken passer deg best?

- ☐ Jeg jobber i psykiatrien
- ☐ Jeg har erfaring fra psykiatrien

Hvor gammel er du?

- ☐ 18 - 30
- ☐ 31 - 40
- ☐ 41 - 50
- ☐ 51 - 60
- ☐ 61 - 70

Velg hvor enig du er relatert til menyene og grensesnittet til applikasjonen.

	Sterkt enig	Enig	Litt enig	Verken eller	Litt uenig	Uenig	Sterkt uenig
Jeg er fornøyd med utseende til VR-applikasjonen.	☐	☐	☐	☐	☐	☐	☐

Jeg ble forvirret da jeg trykket rundt på menyen.	❑	❑	❑	❑	❑	❑	❑
Jeg opplevde ingen problemer med å finne informasjonen jeg trengte.	❑	❑	❑	❑	❑	❑	❑
Jeg syns informasjonen som ble tilbudt var meningsfull og relevant.	❑	❑	❑	❑	❑	❑	❑
Jeg syns grensesnittet (menyene, knappene, og alt annet grafisk) til applikasjonen var tilfredsstillende.	❑	❑	❑	❑	❑	❑	❑
Jeg syns applikasjonen hadde alle funksjonene og egenskapene som forventet.	❑	❑	❑	❑	❑	❑	❑

Kan du utdype om noe forvirret deg, om det oppsto problemer, om noen funksjoner eller egenskaper manglet, eller om noe annet bør nevnes?

Velg hvor enig du er relatert til grensesnittet (digitale knapper og menyer) under simulerigen?

	Sterkt enig	Enig	Litt enig	Verken eller	Litt uenig	Uenig	Sterkt uenig
Jeg syns det var frustrerende å trykke på de digitale knappene under simuleringen.	❑	❑	❑	❑	❑	❑	❑
Jeg syns det var frustrerende å forstå hvordan jeg skulle bruke applikasjonen.	❑	❑	❑	❑	❑	❑	❑
Jeg levde meg inn i simuleringen.	❑	❑	❑	❑	❑	❑	❑
Jeg glemte tid og sted da jeg testet simuleringen.	❑	❑	❑	❑	❑	❑	❑
Jeg syns det var frustrerende å gå igjennom video scenarioene.	❑	❑	❑	❑	❑	❑	❑
Jeg følte det var vanskelig å forstå hvordan video scenarioene fungerte.	❑	❑	❑	❑	❑	❑	❑
Jeg er fornøyd med simuleringen.	❑	❑	❑	❑	❑	❑	❑

Kan du utdype om noe forvirret deg, om det oppsto problemer, om noen funksjoner eller egenskaper manglet, eller om noe annet bør nevnes?

Velg hvor enig du er relatert til grensesnittet til applikasjonen.

	Sterkt enig	Enig	Litt enig	Verken eller	Litt uenig	Uenig	Sterkt uenig
Jeg følte meg komfortabel mens jeg bruke applikasjonen.	❑	❑	❑	❑	❑	❑	❑
Totalt sett er jeg fornøyd med simuleringstreningen i VR-applikasjonen.	❑	❑	❑	❑	❑	❑	❑

Neste del av undersøkelsen vil om

handle hvordan VR applikasjonen fungere i din trening.

Velg hvor enig du er relatert til scenarioene

	Sterkt enig	Enig	Litt enig	Verken eller	Litt uenig	Uenig	Sterkt uenig
Jeg syns video scenarioene var irrelevante.	❑	❑	❑	❑	❑	❑	❑
Jeg syns at video scenarioet om den aggressive pasienten gjorde meg mer komfortabel til å håndtere slike situasjoner på jobb	❑	❑	❑	❑	❑	❑	❑
Jeg syns at video scenarioet om den suicidale pasienten gjorde meg mer komfortabel til å håndtere slike situasjoner på jobb.	❑	❑	❑	❑	❑	❑	❑

Velg hvor enig du er relatert til samhandlingen/interaktiviteten med applikasjonen.

	Sterkt enig	Enig	Litt enig	Verken eller	Litt uenig	Uenig	Sterkt uenig
Jeg syns at det å ta valg under scenarioet var unødvendig.	❑	❑	❑	❑	❑	❑	❑
Jeg syns at valgene under scenarioet forbedret læringen.	❑	❑	❑	❑	❑	❑	❑
Kunne jeg velge, ville jeg valgt videoer med valgalternativer fremfor video scenarioer uten valgmuligheter.	❑	❑	❑	❑	❑	❑	❑

Velg hvor enig du er relatert til simulerignstreningen.

	Sterkt enig	Enig	Litt enig	Verken eller	Litt uenig	Uenig	Sterkt uenig
Jeg syns at videoen ga dårligere trening sammenlignet med vanlig fysisk simuleringstrening.	❑	❑	❑	❑	❑	❑	❑
Jeg foretrekker vanlig scenariotrening enn å bruke virtuelle scenarioer.	❑	❑	❑	❑	❑	❑	❑
Jeg syns at VR produktet kan være et godt verktøy i simuleringstrening.	❑	❑	❑	❑	❑	❑	❑
Totalt sett er jeg fornøyd med den virtuelle simuleringstreningen.	❑	❑	❑	❑	❑	❑	❑

Takk for at du tok deg tid til å fullføre undersøkelsen! Det vil hjelpe meg å lage et bedre produkt og gjøre mye for kvaliteten på oppgaven!

Tusen takk! :)**Samtykkeskjemaet må godkjennes før du kan delta i undersøkelsen.**

Undersøkelsen vil være her om du ombestemmer deg en gang i fremtiden :).

Appendix C

Intervjuplan: Test av applikasjon

The next pages showcase the interview guide that was used during the first data collection interview.

Intervjuplan:
Test av applikasjon

Undersøkelsen samler inn data relatert til funksjonaliteten og opplevelsen av VR simuleringen. Hensikten er å finne feil eller mangler ved produktet som må rettes opp.

Introduksjon

Samtykke skjema signeres av brukeren før intervjuet starter.

Oppvarming

Oppvarmingsspørsmålene knytter seg til deltakerne og de kunnskapene de har om teknologien.

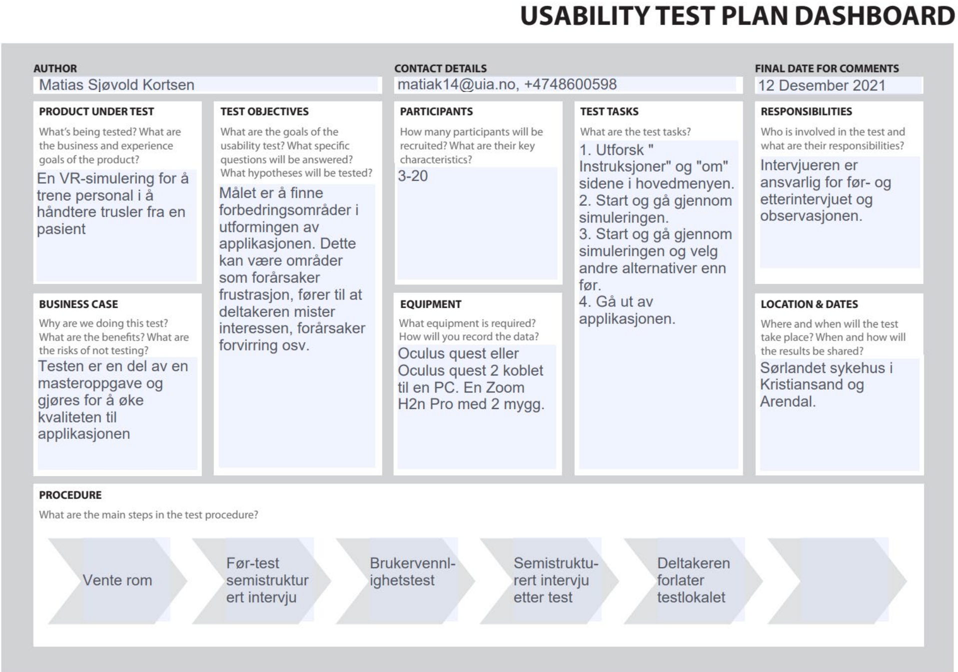
- Kan du fortelle meg kort om jobben din på sykehuset?
  - Hvor gammel er du?
  - Hvor lenge har du jobbet på sykehuset?
- Deltar du ofte i fysiske simuleringer på sykehuset?
- Har du noen gang brukt et virtual reality hodesett før?
  - Har du brukt det i forhold til simuleringer?
  - Har du brukt det i forhold til simuleringer på sykehuset?
- Hvilke av følgende vil du si passer din kunnskap om bruk av VR:
  - Alternativ 1: Jeg er ikke vant til å bruke VR.
  - Alternativ 2: Jeg er ganske vant til VR
  - Alternativ 3: Jeg er ekspert på VR.
- Hvilken teknologi bruker du daglig?
- Er du erfaren med å bruke spill kontrollere eller kontrollere som bruker til VR?

Informere om betydninger:

Simuleringer i denne konteksten blir da samhandlingen mellom deg og pasienten inni head settet.

Observasjon

Deltakeren tester applikasjonen mens det oppmuntres til å tenke høyt.



USABILITY TEST PLAN DASHBOARD

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FINAL DATE FOR COMMENTS: 12 Desember 2021

PRODUCT UNDER TEST
What's being tested? What are the business and experience goals of the product?
En VR-simulering for å trene personal i å håndtere trusler fra en pasient

TEST OBJECTIVES
What are the goals of the usability test? What specific questions will be answered? What hypotheses will be tested?
Målet er å finne forbedringsområder i utformingen av applikasjonen. Dette kan være områder som forårsaker frustrasjon, fører til at deltakeren mister interessen, forårsaker forvirring osv.

PARTICIPANTS
How many participants will be recruited? What are their key characteristics?
3-20

TEST TASKS
What are the test tasks?
1. Utforsk " Instruksjoner" og "om" sidene i hovedmenyen.
2. Start og gå gjennom simuleringen.
3. Start og gå gjennom simuleringen og velg andre alternativer enn før.
4. Gå ut av applikasjonen.

RESPONSIBILITIES
Who is involved in the test and what are their responsibilities?
Intervjueren er ansvarlig for før- og etterintervjuet og observasjonen.

BUSINESS CASE
Why are we doing this test? What are the benefits? What are the risks of not testing?
Testen er en del av en masteroppgave og gjøres for å øke kvaliteten til applikasjonen

EQUIPMENT
What equipment is required? How will you record the data?
Oculus quest eller Oculus quest 2 koblet til en PC. En Zoom H2n Pro med 2 mygg.

LOCATION & DATES
Where and when will the test take place? When and how will the results be shared?
Sørlandet sykehus i Kristiansand og Arendal.

PROCEDURE
What are the main steps in the test procedure?
Vente rom → Før-test semistruktur ert intervju → Brukervennl-ighetstest → Semistruktu-rert intervju etter test → Deltakeren forlater testlokalet

Spørsmål basert på observasjon

Spørsmålene vil være basert på observasjonen av deltakerne og være rettet mot om brukeren gjorde noe merkbart under engasjementet. Spørsmålene vil være relatert til hva deltakeren tenkte mens han utførte en handling, hvorfor deltakeren navigerte dit de gjorde, osv. Dette gjøres bare om noe må utdypes.

Spørsmål etter testing

Spørsmål knyttet til opplevelsen av applikasjonen etter at brukeren har fullført test tasks fra usability test plan.

Grensesnitt

Her stiller jeg spørsmål relatert til designet og utseenet til menyene og knappene i applikasjonen. Dette gelder både den i start menyen, knappene og menyene under simuleringen. Altså der man kommer etter man trykker start.

- Fra en til 10, hvor oversiktlig syns du menyene var i simuleringen?
  - Hvorfor ga du det en X?
- Opplevde du noen problemer relatert til forståelsen eller hensikten med noen knapper?
  - Var knappene lette å se?
  - Var knappene lette å forstå?
- Kan du fortelle meg hva du syns om fargene som ble brukt til menyene?
  - Syns du de var en fin kombinasjon?
  - Er det noe du syns passer bedre til programmets funksjon?
- Kan du fortelle hva du syns om animasjonene på menyene?
  - Påvirket animasjonene opplevelsen din av produktet?
  - Syns du animasjonene nyttige?

Knapper

Her stiller jeg spørsmål relatert til kontrollene som ble brukt til simuleringen. Dette da om knapper og interaksjon med produktet.

- Fra en til 10, hvordan syns du knappene på kontrollen ble brukt?
    - Kan du fortelle litt mer om hvorfor du ga det en X?
- Hvordan var det å lære seg hva de forskjellige knappene gjorde?
- Falt det deg naturlig å bruke knappene slik det var satt opp i programmet?
    - Var det noe som forårsaket frustrasjon relatert til knappene?
- Var din oppfatning av hvordan kontrollerne ville fungere annerledes enn slik det var i programmet?
- Burde andre knapper brukes til navigering og valg?

Velvære

Her stiller jeg spørsmål relatert til behageligheten og opplevelsen av produktet. Dette da om hvordan du følte deg mens produktet ble testet.

- Fra en til 10, hvordan følte du deg mens du testet produktet?
    - Var er tanket bak det valget?
- Kan du fortelle om de følelsene du fikk mens du brukte produktet?
- Fra en til 10, der 1 en er kjedelig og 10 er gøy, hva vil du gi produktet?
- Ville du fortsatt brukt produktet om du kunne?
- Følte du noen gang noe ubehag mens produktet ble brukt?
    - Følte du deg kvalm?
    - Følte du det svimmel?

Selve simuleringen

Her stiller jeg spørsmål relatert til opplevelsen av simuleringen. Etter man trykker start.

- Fra en til 10, hvor ekte følte du simuleringen var?
    - Kan du begrunne det valget?
- Hva, om noe, føler du kunne ha økt opplevelsen?
- Var det noe som to deg ut av opplevelsen?
- Hvordan opplevde du å ha en stemme i simuleringen?
    - Var det en distraksjon?
    - Økte den opplevelsen av simuleringen?
    - Ble du vant til stemmen?
- Syns du at valgene du fikk passet med reaksjonene til deg og pasienten?

Generelle avsluttende spørsmål

- Hva likte du best med å bruke produktet?
- Hva likte du minst?
- Hva, om noe, overrasket deg med opplevelsen?
- Hva, om noe, forårsaket frustrasjon?
- Hvis du kunne endre en ting, hva ville det vært?
- Har du noen spørsmål?
- Noe annet du ønsker å diskutere om?

Appendix D

Intervjuplan: VR simulering som kompetansehevende tiltak

The next pages showcase the interview guide that was used during the second data collection interview. It was used for both the interviews and focus group interviews.

Intervjuplan:

VR simulering som kompetansehevende tiltak

Undersøkelsen samler inn data relatert til nytten av å bruke en VR simulering som et kompetansehevende tiltak. Hensikten er å finne ut fordelene og de potensielle utfordringene ved å bruke VR-scenarioer for opplæring av klinisk helsepersonell i Klinikk for Psykisk Helse.

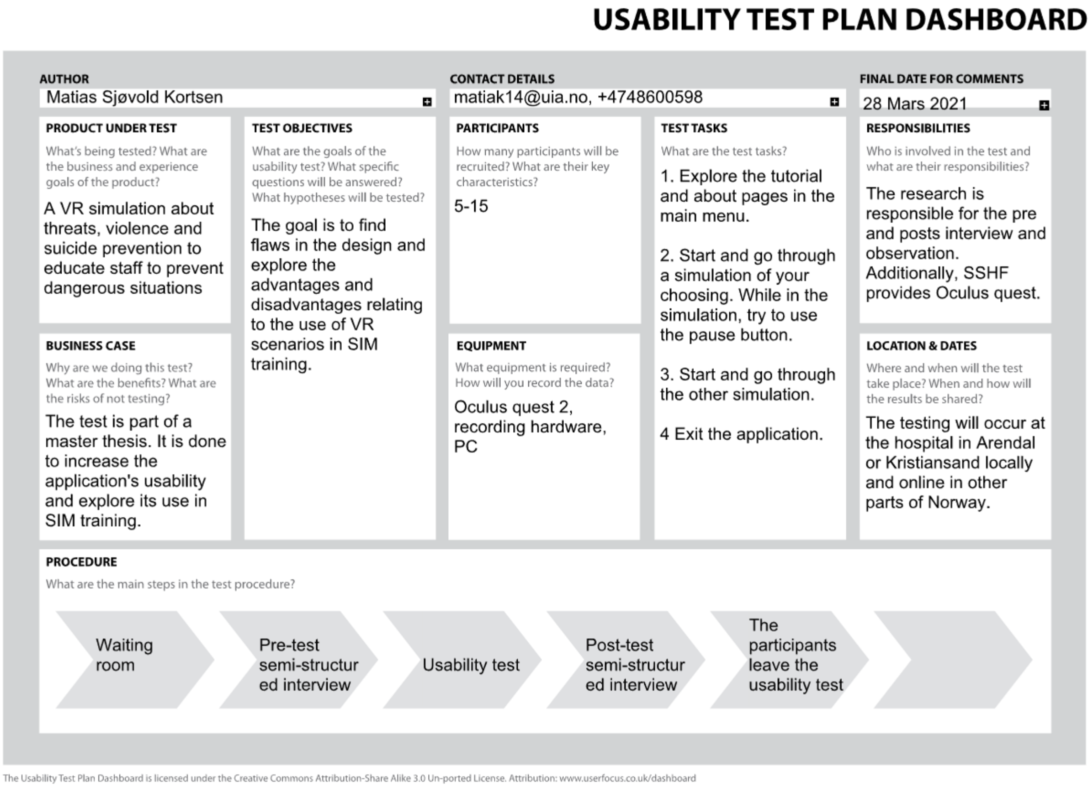
Introduksjon

Samtykke skjema signeres av brukeren før intervjuet starter.
Introduserer produktet og forteller hvordan det skal integreres og brukes i simuleringstrening ved institusjoner. Introdusere også usability forskningen og hvordan noe problemer som oppstår under testing ikke er brukerens feil, men en feil i produktet.

Oppvarming

- Kan du/dere fortelle meg kort om jobben din?
    - Hvor gammel er du/dere?
    - Hvor lenge har du/dere jobbet i Klinikk for Psykisk Helse
- Deltar du/dere ofte i fysiske simuleringstreninger?
- Hva syns du/dere om å delta på slike fysiske simuleringstreninger?
- Har du/dere noen gang brukt et virtual reality hodesett før?
    - Har du/dere brukt det i forhold til simuleringer på sykehuset?
- Har du/dere deltatt tidligere på intervju til dette prosjektet?
- Hvilke av følgende vil du/dere si passer din/deres kunnskap om bruk av VR:
    - Alternativ 1: Jeg er helt ukjent med VR.
    - Alternativ 2: Jeg er ikke vant til å bruke VR.
    - Alternativ 3: Jeg er ganske vant til VR
    - Alternativ 4: Jeg er ekspert på VR.
- Føler du/dere deg flink eller erfaren i å bruke datamaskiner og andre teknologier?
- Er du/dere erfaren med å bruke spill kontrollere eller kontrollere som blir brukt til VR?

Observasjon



USABILITY TEST PLAN DASHBOARD

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FINAL DATE FOR COMMENTS
28 Mars 2021

PRODUCT UNDER TEST
What's being tested? What are the business and experience goals of the product?
A VR simulation about threats, violence and suicide prevention to educate staff to prevent dangerous situations

BUSINESS CASE
Why are we doing this test? What are the benefits? What are the risks of not testing?
The test is part of a master thesis. It is done to increase the application's usability and explore its use in SIM training.

TEST OBJECTIVES
What are the goals of the usability test? What specific questions will be answered? What hypotheses will be tested?
The goal is to find flaws in the design and explore the advantages and disadvantages relating to the use of VR scenarios in SIM training.

PARTICIPANTS
How many participants will be recruited? What are their key characteristics?
5-15

EQUIPMENT
What equipment is required? How will you record the data?
Oculus quest 2, recording hardware, PC

TEST TASKS
What are the test tasks?
1. Explore the tutorial and about pages in the main menu.

2. Start and go through a simulation of your choosing. While in the simulation, try to use the pause button.

3. Start and go through the other simulation.

4 Exit the application.

RESPONSIBILITIES
Who is involved in the test and what are their responsibilities?
The research is responsible for the pre and posts interview and observation. Additionally, SSHF provides Oculus quest.

LOCATION & DATES
Where and when will the test take place? When and how will the results be shared?
The testing will occur at the hospital in Arendal or Kristiansand locally and online in other parts of Norway.

PROCEDURE
What are the main steps in the test procedure?
Waiting room → Pre-test semi-structured interview → Usability test → Post-test semi-structured interview → The participants leave the usability test

Spørsmål basert på observasjon

Spørsmålene vil være basert på observasjonen av deltakerne og være rettet mot om brukeren gjorde noe merkbart under simuleringen. Spørsmålene vil være relatert til hva deltakeren tenkte mens han utførte en handling, hvorfor deltakeren navigerte dit de gjorde, og lignende. Dette gjøres bare om noe må utdypes.

Spørsmål etter testing

Hvordan designe effektive VR-scenarioer
Starter med å fortelle produktets hensikt i KPH. Dette da hvordan det skal brukes som en del av simuleringstrening. Første delen av intervjuet angår designet av produktet.

Spørsmål:

- Kan du/dere fortelle meg litt om hvordan det var å navigere rundt og bruke menyen og, de digitale knappene i produktet?
- Kan du/dere fortelle meg hva du/dere syns om opplæringen til produktet?

    - Altså informasjonen den tilbudte relatert til hvordan simuleringen fungerte og hvilken knapper man kunne bruke?
- Føler du/dere at produktet kan brukes uten ekstern opplæringen?
- Føler du/dere at produktet gjorde deg oppmerksom på dine fysiske omgivelser?
- Kan du/dere fortelle meg hva du syns om de to scenarioene du gikk igjennom?
- Var det noe frustrerende som skjedde eller noe som ødela innlevelsen?
- Er det noe annet du/dere ønsker å fortelle meg relatert til hvordan det var å bruke produktet? For eksempel en god og en dårlig ting som ikke er nevnt enda.

Utforske fordelene og utfordringene ved å designe og bruke VR-scenarioer
Denne delen av intervjuet skal utforske de potensielle fordelene og utfordringene relatert til bruk av VR scenarioer i KPH.

Spørsmål:

- Tror du/dere at å inkludere VR scenarioene i trening vil gi en bedre pasientbehandling?
- Har du/dere blitt mer komfortabel med å sette grenser for aggressive pasienter?
    - Kan du/dere utdype?
    - Hvis produktet var en del av simuleringstreningen, med brifing og refleksjon, hadde det da hatt større effekt?
- Har du/dere blitt mer komfortabel med å håndtere pasienter med selvmordstanker?
    - Kan du/dere utdype?
- Hadde det vært bedre om scenarioet var fysisk?
    - Kan du/dere utdype?
- Hvilke tanker har du/dere om hvordan VR scenarioet kan brukes i psykiatrien?
- Føler du/dere at VR scenarioet gir lik mulighet for refleksjon sammenlignet med fysiske simuleringer?
    - Kan du/dere utdype?

Avsluttende spørsmål:

- Hvilke fordeler ser du/dere for deg produktet kan gi psykiatrien?
- Hvilke utfordringer føler du/dere må løses for at produktet kan bli bedre?
- Var det noe som overrasket deg/dere med produktet?
- Var det noe du/dere forventet at produktet skulle gjøre som det ikke gjorde?
- Er det noe du/dere ville ha gjort annerledes relatert til scenarioene eller produktet i sin helhet?
- Har du/dere noen spørsmål?
- Noe annet du/dere ønsker å diskutere om?

Takker for deltagelsen

Appendix E

PACT Analysis

People: The target users that will engage with the product are healthcare personell in psychiatry. The product might also be used by somatics and PTSSs. All of these would be employees at Sørlandet sykehus. The users are both young and old, newly educated and veterans in their field. All nurses must participate in simulations a few times a year. As such, the product is likely to be used at these simulation gatherings. It is to be expected that most users have never interacted with an HMD before.

The goal of the nurses is to be able to use the application without much effort. Staff will be provided with time to engage in simulations. However, it should also be possible to use them during nightshifts if desired.

The constraints are that staff need to use the technology at work. Headsets are supposed to be used at planned sessions and during quiet shifts, and staff cannot take the headsets back home with them after work.

Stakeholders are people who will distribute HMDs and the applications to employees. These will be part of the VR division of the ongoing e-learning development at the hospital. In addition, innovation advisors and department managers will be part of the VR operations performed at the hospital. For example, when simulations are to be staged at the hospital, department managers should be able to take the VR HMDs with them to the simulation.

The goal of the stakeholders is to have a functional prototype that can be used as a proof of concept. They also want to find out if the product is in any way functioning as an educational tool.

Their constraint is that the software will be built using VR and 360-degree video.

Activities: The product is a simulation. The users will likely go from start to finish in a 360-degree video by progressing through a branching narrative. The users will need to learn the application intuitively at the start of the experience and complete the experience all the way through.

The user will be presented with the main menu to start the application. Afterwards, they will be presented with three directional buttons at different intervals. The buttons will arrive at different points at meaningful locations during the simulation.

The simulation will consist of the users interacting with a patient, and it will be based on real-life situations. Throughout the day, nurses will be presented with several situations. As the focus of the thesis is VR trainings on violence, threats, and suicide prevention, the simulation will reflect some of the real-life situations that nurses are presented with related to these topics.

The simulation will be used both alone and with others through simulation sessions. Because of this, the application needs to provide the necessary information relating to the product's function and scenario to reduce confusion. The application will also likely not be used more than two times a year. This creates the need for comprehensive tutorials and introductions. However, the program's primary function is to present a simulation. Because of this, the user should be only need a few clicks to begin the simulation.

Adverse health effects might occur when using the simulation. For example, the participants might be affected by cybersickness or fall over if the patient suddenly gets too close to the camera. Because of this, the application should include warnings and health instructions. Users should also be able to pause the simulation if they need to take a break or get their bearings. However, it is expected that most users will finish the simulation in one go, as this is supposed to be of similar realism as physical simulations.

As the simulation uses 360-degree video, the users are not expected to move around much. This is beneficial in relation to cybersickness, as less movement reduces sickness and makes it possible to use the application synchronously with others. For example, the users could all be in the same room, standing a view meters away from each other while completing their individual simulations.

Context: The physical location where the application will be used can vary. For example, regular simulations are sometimes performed at gymnasiums. Because of this, the HMD will presumably be transported to similar locations and be used in gymnasiums. Also, as the application should be usable during quiet night shifts, the physical environment might be in break rooms or offices. As such, the physical environment will vary; however, it will likely always be indoors. The physical environment can be expected to be furnished with chairs, tables, sofas, desks, computers, shelves, and other hospital furniture. This is only relevant if the user uses the HDM by themselves at night or if the simulation sessions are stages inside a larger office or break room. If the simulation is performed at a gymnasium, then there will likely be nothing close by the users.

The social and organisational aspects of the training will include simulation sessions with multiple users performing simulations synchronously. However, the users should be able to use the application at their leisure as long as they have the time and the equipment is available. Moreover, the application will be part of a larger e-learning project. However, the VR part of that project will be distinct.

Technology: The application will be installed on an Oculus Quest 2. Because of this, the HMD is the only perceivable technology the users will use. This technology consists of two displays (one for each eye), two speakers, head tracking, hand tracking, and finger sensors. The application will consist of a 360-degree video, graphical 3D UI, sound, and button interactivity using the controller. For this application to function, users must be able to interact with the product with ease. It is likely that the users have never interacted with an Oculus Quest 2 before. As such, much focus should be on ensuring ease of learning and ease of remembering.

Appendix F

Interview Plan: Context Analysis SSHF

Introduction

This interview is designed to provide information about who the users are, what tasks they should or perform, and in what context and with what technology they should perform them.

Warm-up

The warm-up questions relate to the users of the e-learning course.

- What is your role at the hospital?
- What is your typical day like at the hospital?
- What technology do you use daily?
- Have you ever taken the hospital's e-learning courses about violence, threats and suicide prevention?
- Do you know who uses the e-learning course?

    Could you specify what staff use the learning material?

    Do patients use the e-learning course?

Main body

The central part of the interview concerns technology and an e-learning course. Several questions also concern user tasks.

- Is the violence, threats, and suicide prevention course separate or a single e-learning course?
- Who oversees the e-learning courses?
- Do you know if the development of the course was outsourced or created in-house?
- Who has an interest in the development of the course?
- What does the course teach about violence?
- What does the course teach about threats?
- What does the course teach about suicide prevention?
- Do know how long the course usually takes to complete?
- Is the course used in a high or low-stress environment?
- How do the users get access to the learning material?
- On what devices is the e-learning course available?

- Is it possible to take the course remotely?
- Is the learning material always accessible?

User tasks:

- What tasks must the users perform to complete the e-learning course?
- How often is it expected that users should complete the e-learning course?

Cool-off

The cool-off questions relate to user input on how they would enhance the courses.

- If you could improve the course, how would you do so?
- What do you like about the current solution?
- What don't you like about the course?
- Who has an interest in the development of the course?
- Do you have any questions for me?
- Is there anything else you would like to mention that we did not discuss?

Appendix G

Expert interview - Context Analysis SSHF

Interview innovation consultant

- What is your role at the hospital?

Int.obj: Redacted.

- What is your typical day like at the hospital?

Int.obj: Redacted.

- What technology do you use daily?

Int.obj paraphrased: Lots of technology. Technologically minded.

- Have you ever taken the hospital's e-learning courses about violence, threats, and suicide prevention?

Int.obj paraphrased: No. In essence, it does not exist yet.

This is where most of the questions were changed because the course was under development rather than being a previously developed course that needed improvements. When this interview was conducted, there were no courses on preventing violence, threats, and suicide.

- Do you know who will use the e-learning course?

Int.obj paraphrased: It is supposed to be used by psychiatry, somatics, and ptss (Prehospitale tjenester) staff. It is not designed to be used by patients. It reviews how employees can respond to violence, threats, and suicide.

- Is the violence, threats, and suicide prevention course a separate course (from the VR simulation) or a single e-learning course?

Int.obj paraphrased: It is one big course. The violence, threats, and suicide prevention course is an overall project containing many elements. The VR simulation is a part of the project but should be used as a standalone experience. The co-worker "**No name recorded**" seems to be in control of the project and knows more about the e-learning elements. The VR project is exclusively related to simulations.

- Who oversees the e-learning courses?

"No name recorded."

- Do you know if the development of the course was outsourced or created in-house?

Int.obj paraphrased: Internal development took place at the hospital in collaboration with Kompetanseenheten, who is responsible for training at the hospital. Clinics are also likely involved, as well as other professional staff.

- What does the course teach about violence? - Skip
- What does the course teach about threats? - Skip
- What does the course teach about suicide prevention?

Int.obj paraphrased: In all departments, staff may experience situations of threats and violence directed toward them. The course's main focus is to increase competence in how situations are handled. The interview subject does not know the content of the learning material. They have received a lot of simulations from other hospitals.

- *Question regarding how the implementation of branching narratives could work.*

Int.obj paraphrased: Performing simulations is not black and white. The participant does things that are either smart or not so smart. It is usually the case that some decision is better than another. Usually, this is all about communication, but some cases might focus on something else. The usual workflow when performing physical simulations is as follows:

First, try to define what the participant shall learn from the experience (i.e., the learning objectives of the simulation). Then, prepare the scenario itself (What will happen? How will it happen? Etc.). Then perform the scenario. Afterward, the participants can discuss how the simulation went.

There have also been video recordings of simulation with accompanying discussions after- wards. This is what is done at the moment in relation to VR simulations.

- Is the course used in a high or low-stress environment?

Int.obj paraphrased: The goal at the moment is to provide time to perform the virtual simulations. It might also be possible to view simulations during night shifts or during periods of low activity. Staff are not expected to take headsets home to perform a simulation in their spare time. Currently, the video files are stored on a shared server where they need to be downloaded. It is not possible to stream the video files because of low or unstable bandwidth.

- If you could improve the courses, how would you do so?

Int.obj paraphrased: Add interactivity and branching narratives. During development, there will likely be other elements that can be implemented. Issues with VR include the loss of immediate feedback. However, VR technology allows participants to look around and notice more details than they would have in real life. Some people get nervous from simulations. However, some people get sick from VR.

- *Have there been other user tests before?*

Int.obj paraphrased: No. There has been no previous user testing.

Appendix H

Expert interview - university lecturer

The questions below were structured prior to the interview. They were answered through a conversation while taking lots of notes. These notes were compiled and reformulated to answer the questions in a more structured way. The interview was in Norwegian but has been translated to English.

How is simulation training usually performed in the hospital?

Usually, this is done based on experience gained at the hospital. These are topics on which the nurses have a potential for improvement. In psychiatry, trainers can gather a group of staff and perform simulations based on said experiences. In other words, simulation training can be a larger scheme where simulations go from when a person is found until they is transported to the emergency room, where the person must be taken care of and possibly rescued. Every minute counts in such a simulation.

As described in SBL, the simulation participant is introduced to the simulation via a briefing. They also participate in a debriefing period with reflection after participating in the actual simulation training.

How often do students or staff perform simulation training?

Simulation training is performed once per semester for students. Students who specialize in psychiatry only complete simulation training related to their profession.

Are themes related to threats, violence, and declining prevention often used?

This is very common in the emergency room, where there is often a great focus on how the participants manage to protect themselves while protecting the patient. This is often related to how one manages to gain control of the situation. Specialists often participate in suicide assessment training. Suicide mapping is currently not something that is often simulated; however, in the future, this will become more popular in nursing education.

Does everyone participate during trainings, or are there many spectators? How long is the simulation training?

Simulation training takes about an hour and a half from briefing to completion. Usually, not everyone participates in the simulation. For example, in psychiatry, 20-30 people usually meet up, while only some are selected to participate in the simulation training. The rest are observers.

What learning theories are co-trainings based on?

David Kolb's experiential learning theory is the basis for simulation training.

Appendix I

User stories and personas

The user stories and personas are based upon the data collection performed during the context of use analysis. The names used in the discussion were randomly generated using a name generator.

I.1 Personas

Tobias Thorvald

Age: 26

Gender: Male.

Tobias has worked as a nurse in the physiatry unit for five years. He has to participate in simulation training a few times a year. He does not mind the simulations and sees them as a necessary tool for training. He enjoys doing his job. Tobias does not care much for technology, as he enjoys working with people instead of trying to understand technology. Covid-19 has made it difficult to perform simulation training, as the hospital has been in lockdown since the pandemic started. Any duty is not strictly necessary to perform has been halted until the pandemic calms down.

Cecilie Magdalena

Age: 40

Gender: Female

Cecilie has worked as a nurse for a long time. During simulation training, her experience is often sought after, as her experience makes her an excellent actor. However, she is not used to interacting with technology except for the necessary applications needed for communication. As she has worked as a nurse for a long time, she does not need to spend time on trainings nor form an interest in new technology.

Johanna Christin

Age: 19

Gender: Female

Johanna is a new nurse at the hospital. She has been working for almost a year at this point. The only simulation training she has engaged in is from her time as a student. Because of this, she is not used to performing simulation training. This has made her nervous about the training. In addition, she has heard that some people do not enjoy simulation training because of the large gathering of people and potentially stressful scenarios that might occur. She would like to perform the simulations as quickly as possible, with more focus on reflection and learning than simulation training performance.

I.2 User stories

- As a healthcare professional, I want to perform simulations without having to meet up physically so that I will reap the benefits of simulation training from where I am.
- As a healthcare professional, I want to participate in simulation training without the need to role-play so that I can focus on the simulation and not my performance.
- As a healthcare professional, I want to strengthen my knowledge of a situation through simulation training so that I may become a better worker.
- As a healthcare professional, I want to perform scenario training without the need for organised simulation training so that I may train at my own behest.
- As a healthcare professional, I want to perform scenario training in more realistic environments.
- As an organiser, I want to organise simulation training without extensive planning so that we can perform simulation training without much preparation.
- As an organiser, I want a mobile solution to a simulation training so that we can have simulation training wherever it is needed.
- As an organiser, I want pre-recorded simulations that can be shown to employees so that we may discuss the actions taken in the simulation.

Appendix J

Volere requirements

Requirement #: 1
Requirement Type: 9
Event/BUC/PUC #:

Description: The product should display 360 degree videos

Rationale: The user should be able to view 360 degree simulation scenarios
Fit Criterion: The user is able to select a scenario and view it

Customer Satisfaction: 5
Priority: 1
History: Created March 10 2020

Customer Dissatisfaction: 4

Requirement #: 2
Requirement Type: 9
Event/BUC/PUC #:

Description: The user should be able to interact with the 360 degree videos by, and by doing so, affect the storyline

Rationale: The application is an interactive simulation, as such, the users should be able to interact

Fit Criterion: The user is able to affect the simulation storyline through branching button selection

Customer Satisfaction: 5
Priority: 1
History: Created March 10 2020

Customer Dissatisfaction: 4

Requirement #: 3 Requirement Type: 9 Event/BUC/PUC #:

Description: The user should be able to interact with a main menu, during-simulation menu, and be able to return to the menu at the end of a simulation.

Rationale: The user should be in control of their experience and be able to navigate at their convenience

Fit Criterion: The user is able to quit and start the application at the main menu, be able to restart and quit the current simulation, and be able to return to the main menu.

Customer Satisfaction: 5
Priority: 2 Customer Dissatisfaction: 4

Requirement #: 4 Requirement Type: 9 Event/BUC/PUC #:

Description: The user should be able to quit the simulation

Rationale: The user might feel uncomfortable or sick during simulation, and should be able to pause and quit if necessary.

Fit Criterion: The user is able to pause and quit at any time during the simulation.

Customer Satisfaction: 2
Priority: 2 Customer Dissatisfaction: 2

Requirement #: 5 Requirement Type: 9 Event/BUC/PUC #:

Description: The user should be able to receive a summary of their actions at the end of a simulation

Rationale: This is to allow the user to reflect over their actions

Fit Criterion: The user is presented with a list of choices at the end of the simulation

Customer Satisfaction: 2
Priority: 3 Customer Dissatisfaction: 2

Requirement #: 6	Requirement Type: 9	Event/BUC/PUC #:

Description: The user should be able to select two different simulation scenarios.

Rationale: The user should be able to select a scenario based upon their simulation training needs.

Fit Criterion: The user has the options to select which simulation their desire to choose.

Customer Satisfaction: 2
Priority: 3

Customer Dissatisfaction: 2

Requirement #: 7	Requirement Type: 11	Event/BUC/PUC #:

Description: It should be usable by anyone with or without technical experience.

Rationale: It should be easy to use even though their technical experience is low.

Fit Criterion: Users should not report issues relating to the use and interaction with the product.

Customer Satisfaction: 4
Priority: 2

Customer Dissatisfaction: 4

Requirement #: 8	Requirement Type: 13	Event/BUC/PUC #:

Description: It should be usable by people between 18 and 60 ish.

Rationale: Age and experience should not affect the usability of the product.

Fit Criterion: Age makes no difference in the use of the application.

Customer Satisfaction: 3
Priority: 3

Customer Dissatisfaction: 4

Requirement #: 9

Requirement Type: 13

Event/BUC/PUC #:

Description: It should be understandable without instructions

Rationale: The product should be operational without having to educate users users

Fit Criterion: The product itself would learn users all they need to know

Customer Satisfaction: 3

Priority: 3

Customer Dissatisfaction: 2

Requirement #: 10

Requirement Type: 11

Event/BUC/PUC #:

Description: It should be a safe experience.

Rationale: The user should be able to use the application with issues.

Fit Criterion: No issues occur during testing.

Customer Satisfaction: 3

Priority: 2

Customer Dissatisfaction: 2

Requirement #: 11

Requirement Type: 11

Event/BUC/PUC #:

Description: It should be usable without frustration.

Rationale: The user should be able to use the application without frustration.

Fit Criterion: No frustration happens while using the application.

Customer Satisfaction: 3

Priority: 2

Customer Dissatisfaction: 2

Requirement #: 12

Requirement Type: 13

Event/BUC/PUC #:

Description: It should be usable at work.

Rationale: The product should be usable at the hospital

Fit Criterion: No problem should occur while testing the product at the hospital

Customer Satisfaction: 3

Priority: 2

Customer Dissatisfaction: 2

Appendix K

Original Scenarios

The first scenario is displayed first, and the second scenario is displayed last.

Scenario – grensesetting med ulike handlingsalternativer

Hentet fra opprinnelig scenario:

- En pasient under tvang med hypomani oppsøker personalet på kveldsvakten onsdag, lukket avdeling, klokken er 2200, det er rolig på enheten rett før nattevakten kommer. Pas ønsker en sigarett fra personalets «nødrasjon», har røyket opp sine tildelte sigaretter denne dagen, men ønsker en til før natta. Får ikke nye før fredag. Etter enhetens regler er det ingen røyking etter 2030, nødrasjon gis bare ut hvis pas kan betale. Pas har ikke betalt de siste 7. MT nr 1 sier nei, henviser til regler og at pas allerede har fått tildelt dagens rasjon, MT nr 2 speiler forståelse for pas sin frustrasjon, skjønner at pas ønsker å røyke, ønsker å finne en løsning. Pas viser ingen forståelse for miljøterapeut nr 1 sitt nei, ignorerer MT nr 2, blir høylytt, sint, men ikke fysisk aggressiv mot personal, går ned gangen mot rommet, sparker til en stol, roper høyt, MT nr 2 følger etter, på avstand, signaliserer ønske om å ivareta pas., ikke være alene i en vanskelig situasjon

- Grensetting riktig i følge regler, men her ikke deeskalerende, det burde personalet vite. Mulig løsning er å gi sigaretten, speile at man skjønner pas frust, at man ønsker en god løsning, prøver å finne alternative løsninger for at noe slikt ikke skal skje igjen, forklare hvorfor det er en vanskelig sit for personalet, et problem på systemnivå
- Essens: Speile og stå i en situasjon

Alternativ 1: best-case, personale er rolige, oppmerksomme, imøtekommende, empatiske, klarer å avlede og utsette og samtidig gi gode og tydelige forklaringer, klarer å overtale pasienten til å ta en samtale på rommet eller tilby annet alternativ.

Alternativ 2: konfronterende, irettesettende, pasienten blir sint og truer, ender med utagering og alarm utløses.

Alternativ 3: personalet er utydelig, svarer ikke på spørsmål, kommer med hvite løgner, ser på mobilen. Pasienten blir irritert, hever stemmen og sier at personalet ikke bryr seg.

Scenario: Selvmordsvurdering av innlagt pasient preget av psykose symptomer

Tema: Hvordan vurdere selvmordsfare hos en pasient som ikke kan svare deg på spørsmål du stiller

Hvor/hvem: Behandler vurderer pasient som er innlagt på Enhet for førstegangspsykose under tvungen psykisk helsevern

Læremål:

-Eksempel på ulike måter å forsøke å få informasjon nok til å gjøre en vurdering

-Forstå noe om hvor viktig komparent opplysninger kan være for å forstå en helhet

Beskrivelse:

Pasienten er en mann på 20 år som i går ble innlagt PSA med førstegangspsykose. Har siste halvår isolert seg mer og mer, vil ikke gå på skolen lengre og vil ikke være sammen med andre. Dusjer sjeldent, spiser lite og er for det meste bare på rommet sitt. Har tidvis kommet med utsagn slik som «de kommer til å ta meg uansett» og «dere forstår ikke at de vet alt». Mor har sett at pasienten på rommet sitt har dekket til vinduet og har teipet kamera på pc og mobil rundt i huset. Mor ble spesielt bekymret da hun fant en boks med samlede tabletter i nattbordskuffen hans…

I møte med behandler er pasienten klart preget av paranoid beredskap, han er redd, mistenksom, svarer lite på det som spørres om, ser mye rundt seg i rommet. Behandler forsøke å spørre om selvmordstanker, men pasienten er mer opptatt av om rommet er avlyttet og hvem behandler har snakket med. Pasienten ønsker ikke være i samtalen, sier at «han ikke har tid», «han må ut herifra.»

A 1.

Appendix L

Observation one

Nine participants were observed during the first phase of user testing. The results are structured into four tables. Here L.1 contains data from participants 40, 54, and 58. L.2 contains data from participants 66, 76, and 89. Lastly, L.3 contains data related to participant 93 and 94. The table is structured into six parts. First, the task is the current task the user is trying to perform. The numbering represents the tasks they need to complete:

1. Explore the "instructions" and "about" pages in the main menu.
2. Start and go through the simulation.
3. Start and go through the simulation and choose other options from before.
4. Exit the application.

The *participant* is the person who is currently undergoing testing. The *execution time* relates to how long the participant spent completing the task. *Does an error occur?* states if the application behaved unpredictably and caused something negative to happen. *Problems with execution* states whether the participant had problems completing a task or spent considerable time solving it. *Unexpected event* denotes unanticipated occurrences. Lastly, *solution/comments* are comments made by the participant or researcher related to their performance on the task.

Task	Participant	Execution time in min.	Does an error occur?	Problems with execution	Unexpected event / problems	Solution/Comment
1	40	0.58	No	No	No	Participant adjusts sound
2	40	3.23	No	No	No	-
3	40	3.33	No	No	No	-
4	40	0.36	Yes	Yes	"Exit" button did not work	Asks participant to press "A" on the controller. Then the participant exits via the "Exit" button in the application.
1	54	0.5	No	No	No	Participant asks if "A" and "X" on the controller correspond to buttons in the menu. Researcher confirms.
2	54	3.58	Yes	No	Application freeze. No buttons work	Ask the participant to press "A" and then move on.
3	54	2.45	Yes	No	Problems restarting scenario	Ask the participant to press "A" and then re-start.
4	54	0.17	No	Yes	"Exit" does not respond instantly	Asks participant to press "Exit" again.
1	58	0.46	No	No	No	-
2	58	3.41	No	No	No	-
3	58	3.07	No	No	"Restart" and "back" button do not work	Ask participant to press "A" on the controller and start again.
4	58	0.02	No	No	No	-

Table L.1: Data from participants 40, 54, and 58

Task	Participant	Execution time in min.	Does an error occur?	Problems with execution	Unexpected event / problems	Solution/Comment
1	66	0.56	No	No	Startup problems. Loose wire to headset causes problems	The participant is asks to sit as calmly as possible.
2	66	3.54	No	No	-	-
3	66	3.17	No	No	Restart does not respond. Presses restart again and ends up in the main menu. Starts the simulation from there	-
4	66	0.1	No	No	-	-
1	76	2.21	No	Yes	Spends a long time opening the introduction. Manages without assistance.	-
2	76	3.51	No	No	No	-
3	76	2.47	No	Yes	No	Uses "A" and "X instead of point and click.
4	76	0.3	No	No	No	-
1	89	0.41	No	No	No	-
2	89	4.19	No	No	No	-
3	89	4.0	No	No	No	-
4	89	0.5	No	No	No	-

Table L.2: Data from participants 66, 79, and 89

Task	Participant	Execution time in min.	Does an error occur?	Problems with execution	Unexpected event / problems	Solution/Comment
1	93	1.4	No	Yes	Trying to click on the image of the controller	Ask the participant to press on «Introduction» and «About» in the menu
2	93	4.29	No	No	No	-
3	93	3.27	No	No	No	-
4	93	0.35	Yes	No	"Exit" does not work	Ask participant to press "Back" and then "Exit"
1	94	1.03	No	No		-
2	94	4.05	Yes	No	Not able to end and restart	Participant is asked to press "A" and end again.
3	94	3.10	No	No	No	-
4	94	0.01	No	No	No	-

Table L.3: Data from participants 93 and 94

Appendix M

Thematic analysis for interview one and two

Two large images of the thematic analysis can be viewed on the next pages. Figure M.1 is the thematic analysis for data collection one, and figure M.2 is the thematic analysis for data collection two.

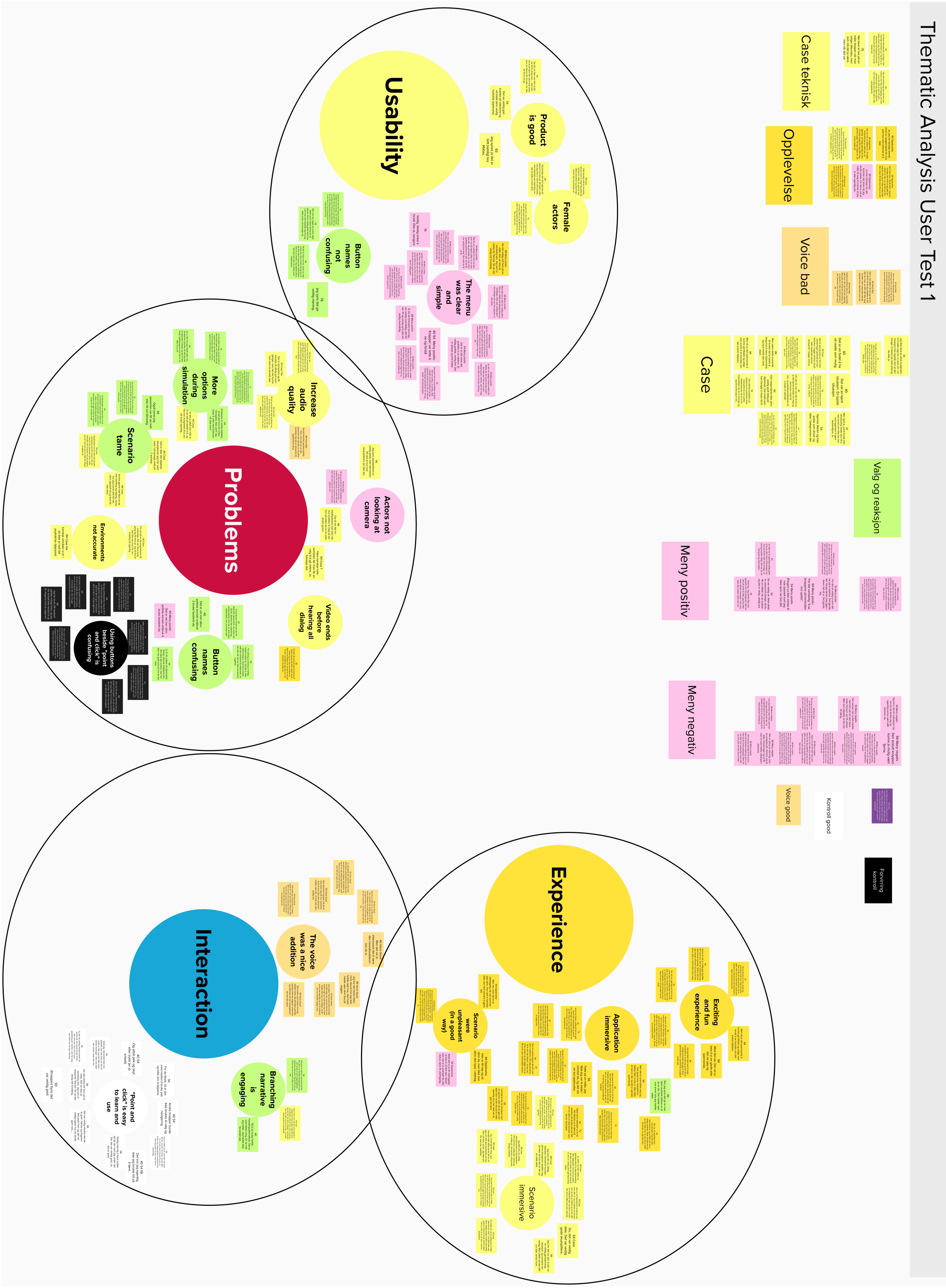

Figure M.1: Thematic analysis 1

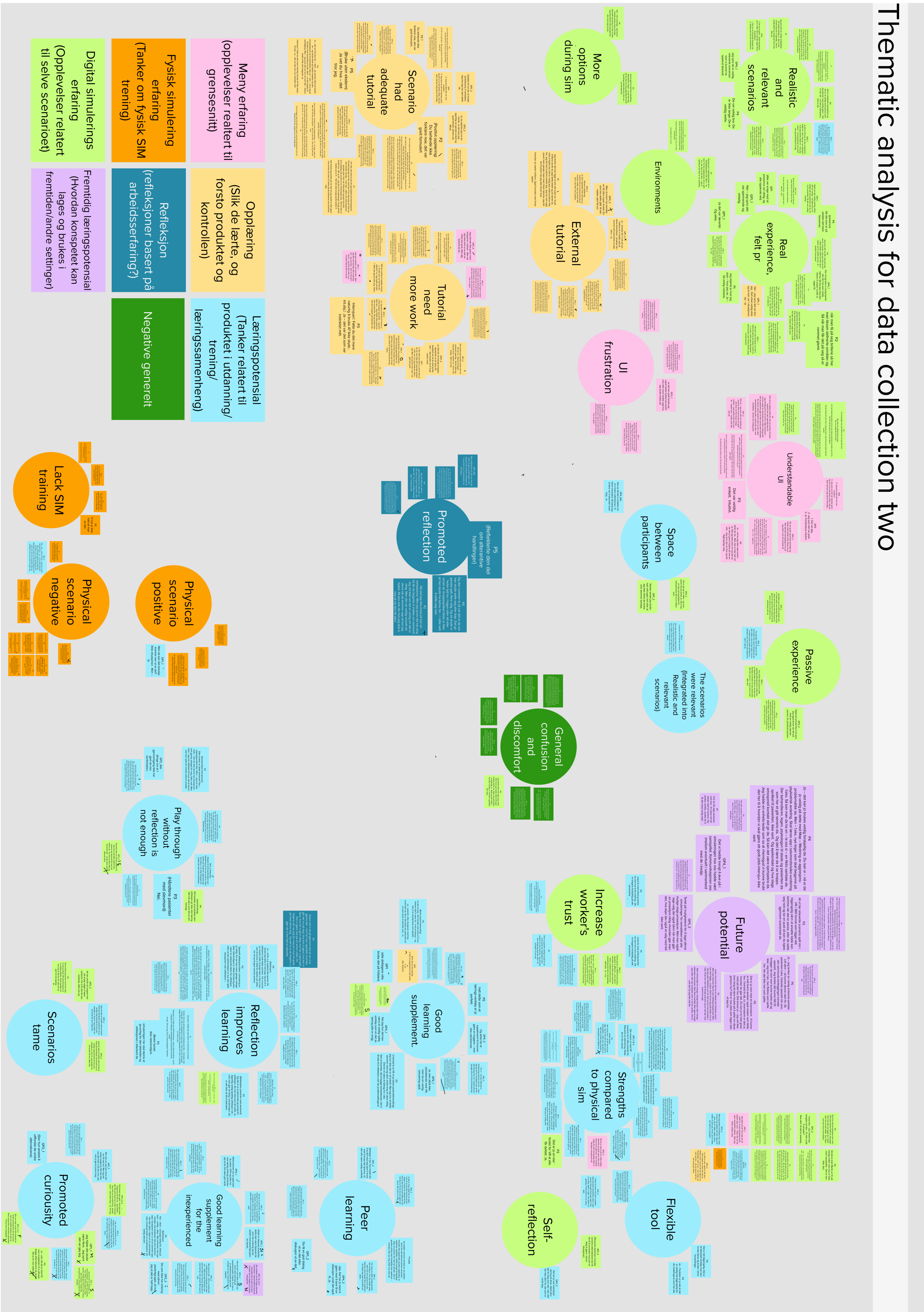

Figure M.2: Thematic analysis 2

Appendix N

Observation two

17 participants were observed during the first user testing phase. Their data are structured into three tables. Here N.1 contains data of participants P1, P3, P4, and P5. Table N.2 contains data of the participants in group interviews GP1 and GP2. Lastly, N.3 contains data from the participants in group interviews GP3 and GP4.

The table is structured into six parts. The task is the current task the user is trying to perform. The numbering represents the takes the users need to complete:

1. Explore the "instructions" and "about" pages in the main menu.
2. Begin and complete the first simulation.
3. Begin and complete the second simulation.
4. Exit the application.

The *participant* is the person who is currently undergoing testing. The *execution time* relates to how long the participant spent completing the task. *Does an error occur?* states if the application behaved unpredictably and caused something negative to happen. *Problems with execution* states whether the participant had problems completing a task or spent considerable time solving it. *Unexpected event* denotes unanticipated occurrences. Lastly, *solution/comments* are comments made by the participant or researcher related to their performance on the task.

In tables N.2 and N.3, *Does an error occur?*, *Problems with execution* and *Unexpected event* were removed to provide space for comments relating to each participant.

Task	Participant	Execution time in min.	Does an error occur?	Problems with execution	Unexpected event / problems	Solution/Comment
1	P1	1.3	No	No	No	-
2	P1	3.41	No	No	No	-
3	P1	4.44	No	No	No	-
4	P1	0.06	No	No	No	-
1	P3	0.38	No	No	No	-
2	P3	3.09	No	No	No	-
3	P3	3.58	No	No	No	Participant does not remember how to pause.
4	P3	0.03	No	Yes	No	-
1	P4	0.36	No	No	No	-
2	P4	3.4	Yes	No	Participant accidentally leaves the application.	The researcher explains what needs to be done to get back in.
3	P4	4.3	No	No	No	-
4	P4	0.02	No	No	No	-
1	P5	1.11	No	No	No	-
2	P5	4.46	No	No	No	-
3	P5	4.44	No	No	No	-
4	P5	0.36	No	Yes	No	Had trouble exiting but did so without help.

Table N.1: Data from participants P1, P3, P4, and P5

Task	Participant	Execution time in min.	GP_1	GP_2	GP_3	Solution/ Comment
1	GP1	3.48	OK	Spends a considerably long time on this and needs minor information during the task	OK	-
2	GP1	5.30	OK	OK	OK	-
3	GP1	5.20	OK	OK	OK	-
4	GP1	0.17 +	OK	OK	OK	-
1	GP2	2.29	Asked whether to point or press "X"	Initial problems navigating the menu	Initial problems navigating the menu	It all work out for everyone eventually.
2	GP2	5.0	Asked if she could pause the simulation. Did not remember how to pause. Needed an explanation of what to do during the scenario. This caused GP2_1 to fall behind the others.	OK	Exited the application instead of pressing the back to menu button.	The researcher explained how the application worked to GP2_1. "Just follow along and tap on the options that come up.". Helped GP2_3 to return to the menu
3	GP2	5.10	Started later than the other participants because of previous holdup.	OK	OK	GP2_2 & 3 restarted the simulation to select other options.
4	GP2	0.02	OK	OK	OK	-

Table N.2: Data from participants GP1 and GP2

Task	Participant	Execution time in min.	GP_1	GP_2	GP_3	Solution/ Comment
1	GP3	2.09	Couldn't figure out how to use the controller. Eventually gets help from group.	OK	OK	-
2	GP3	4.0	OK	OK	Exited the application instead of pressing the back to menu button.	Helped GP3_3 to return to the menu
3	GP3	4.3	OK	OK	OK	-
4	GP3	0.02	OK	Restarted SIM 2	OK	-
1	GP4	2.41	Needed explanation on how to use controller.	OK	OK	-
2	GP4	5.55	Asked group what they were supposed to do.	Became dizzy. Became distracted by the sound of the other participants	Asked if they were supposed to stand still.	Researcher told participants that he will observe and see if they understand what to do.
3	GP4	4.51	Started later than the other participants because of previous holdup.	OK	OK	GP2_2 & 3 restarted the simulation to select other options.
4	GP4	0.02	OK	OK	OK	-

Table N.3: Data from participants GP3 and GP4

Appendix O

How to install the application

Because of the large size of the .OBB, the installation process becomes a bit more extensive. However, this guide is supposed to make the installation process.

What you need is the product files:

- SSHFSim.APK
- main.1.com.MatiasMasterProject.SSHFSimulering.obb

These files will be installed on the quest using the SideQuest application. To install applications using SideQuest, a dedicated guide should be [10]. This guide will instruct on how to install SSHF simulation application.

1. If an older version of the application is installed, uninstall it.
2. Install the SSHFSim.APK file.
3. Start the application on the quest, and then quit the application. This will hopefully generate some folders on the quest.
4. Navigate to “Manage files on the headset” button and click it. See Figure O.1.
5. Find the folder at: "sdcardAndroidobbcom.MatiasMasterProject.SSHFSimulering". If the folder is not there, then create it by using the plus icon to the lower right
6. Upload the OBB file from called main.1.com.MatiasMasterProject.SSHFSimulering.obb. See Figures O.2, O.3, and O.4.

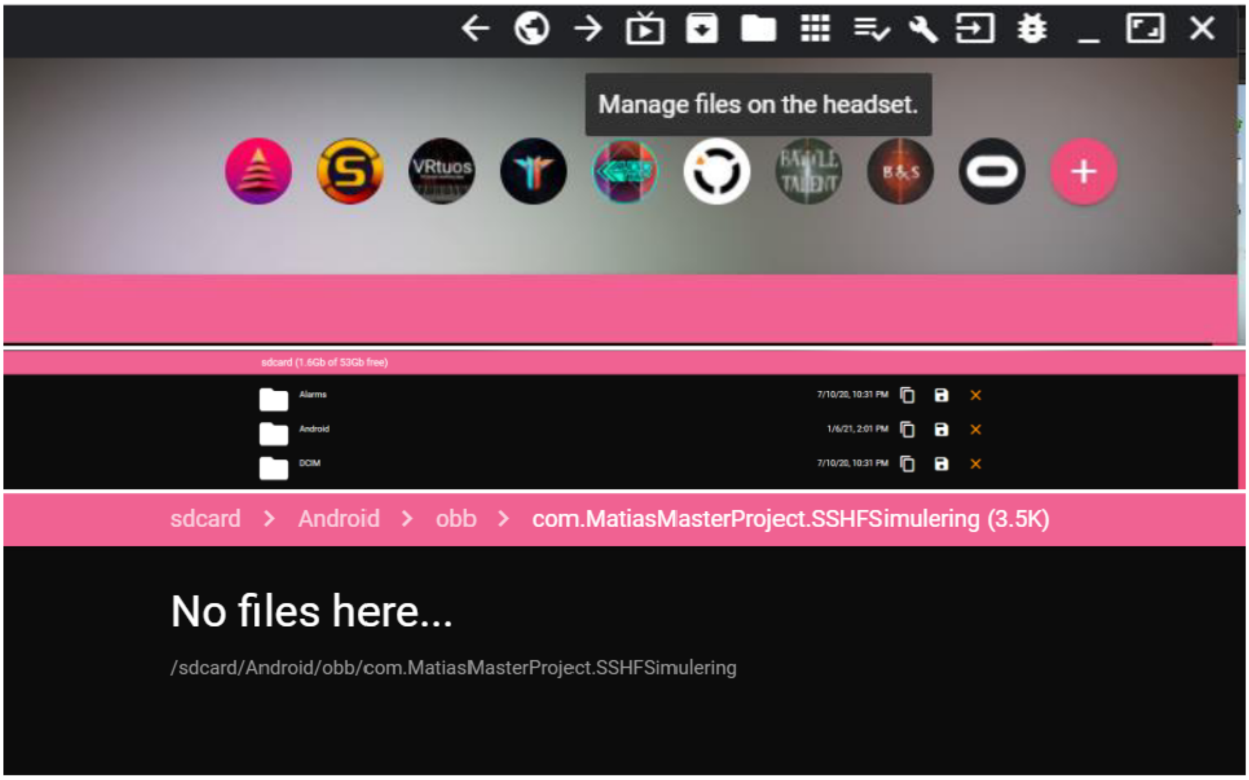

Figure O.1: Image 1

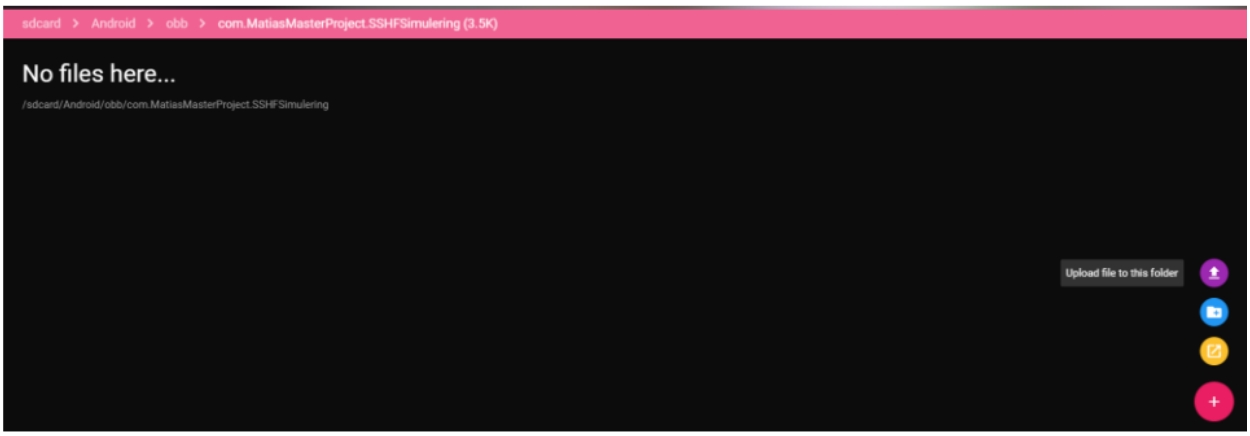

Figure O.2: Image 2

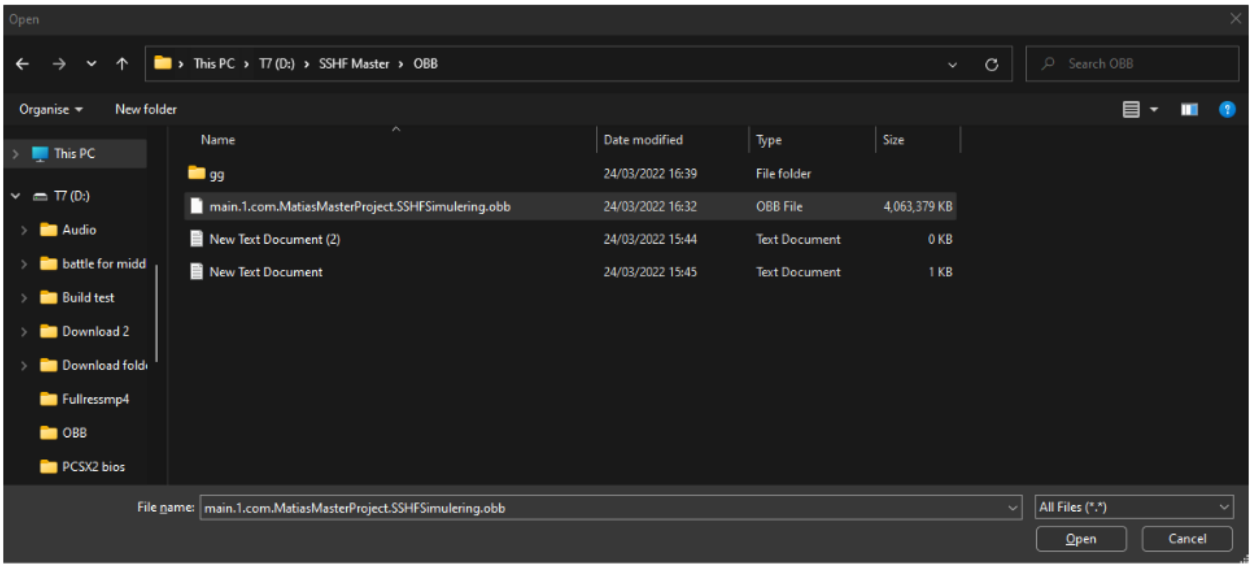

Figure O.3: Image 3

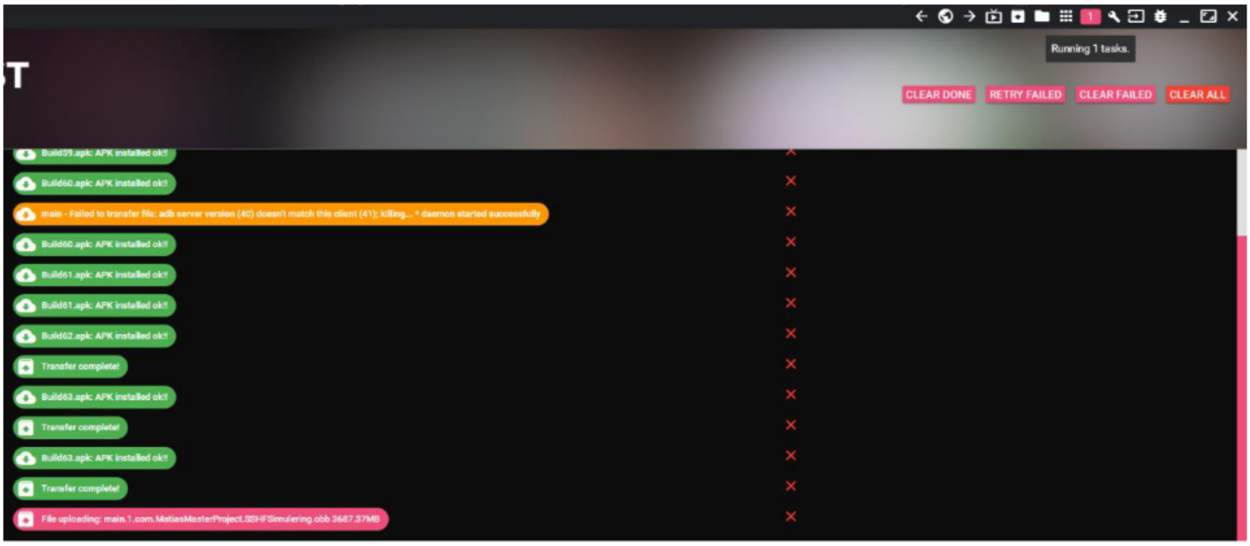

Figure O.4: Image 4

Appendix P

Scripts

The transcribed documents may help identify the participants. I want to protect the people who participated in the interview and keep the code secret. Therefore, this is unavailable in the master's report.

Appendix Q

Transcribed interviews

The transcribed documents may help identify the participants. I want to protect the people who participated in the interview and keep the code secret. Therefore, this is unavailable in the master's report.