Master's thesis

NTNU
Norwegian University of Science and Technology
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Department of Psychology

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Evaluation of Safety Training Using Virtual Reality: The Importance of Fidelity

Master's thesis in Work and Organizational Psychology
Supervisor: Karin Laumann & Mina Saghafian
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Preface

This thesis marks the end of my studies and I am proud of myself to have come this far. This thesis has put me through some tough and stressful times. However, I have also been incredibly inspired and motivated. Thank you to RelyOn Nutec and the participants for joining and participating in this project. This project piqued my interest as it was concerned with the use of VR. The use of such technology for other than entertainment purposes seemed very interesting and throughout this thesis I have learnt how such technology can be applied in so many different fields, including work and organizational psychology. I would like to thank my supervisors Karin Laumann and Mina Saghafian who have been of incredible help and given me motivation to continue and improve my thesis, in addition to their helpful guidance. The reference style used in this thesis is APA 7th edition.

There are many people who have helped, inspired and motivated me throughout my studies. I would like to thank all of the close friends I have met through my studies. In addition to this, I would like to thank the family members who have always cheered me on and been a pillar of all kinds of support throughout these years. Especially my brother, who has read countless of my academic papers. Finally, I would like to thank my wonderful classmates who have given me two amazing final years. Although our time was cut short by the end, I am leaving with many fond memories.

Trondheim, May 2020

Ragheeba S. Akhtar

Abstract

Virtual Reality (VR) technology has the potential to change how safety training is conducted and therefore it is important to find out how it can be further developed and improved. The aim of this study was to explore how safety training using VR was evaluated by offshore oil and gas industry workers. Their evaluations were considered important since safety is a major concern in this industry and the goal was to provide valuable insight into what is important to consider when implementing VR. 85 participants were observed and their evaluations of the VR training were gathered through open-ended questionnaires. Thematic analysis was conducted on the responses and four major themes were identified. Results showed that the VR training was mostly positively evaluated. Most participants had positive physiological and emotional experiences, whilst some experienced different kinds of discomfort as a result of the training. The VR training was mostly preferred as a supplement to traditional safety training. Further, there were varying opinions and evaluations of realism, or fidelity, in the VR. Aspects related to physical and psychological fidelity were deemed as important. Specifically, psychological fidelity could be of importance in VR training. Despite the shortcomings related to fidelity, the VR training was seen as valuable and several benefits related to learning, safety, environment and cost were identified. Overall, this study suggests that VR is a useful tool which should be used in safety training. Furthermore, physical and psychological fidelity needs to be considered when designing and developing safety training with VR. It is further suggested that specifically psychological fidelity is important to consider as it can have an impact on learning and transfer. Finally, the study proposes that VR training might work best as a supplement to traditional safety training as of now, however this can be changed with further development and research on VR.

Sammendrag

Virtual Reality (VR) teknologi har potensiale til å endre hvordan sikkerhetstrening utføres, og derfor er det viktig å finne ut hvordan denne teknologien kan videreutvikles og forbedres. Målet med denne studien var å finne ut hvordan sikkerhetstrening ved bruk av VR ble evaluert av offshore olje- og gassindustriarbeidere. Evalueringene deres ble ansett som viktige ettersom sikkerhet er en stor utfordring i denne bransjen og målet var å gi verdifull innsikt i hva som er viktig å vurdere når VR implementeres i sikkerhetstreninger. 85 deltakere ble observert og deres evalueringer av VR-treningen ble samlet gjennom spørreskjemaer med åpne spørsmål. Tematisk analyse ble utført på responsene og fire hovedtemaer ble identifisert. Resultatene viste at VR-treningen ble stort sett positivt evaluert. De fleste deltakerne hadde positive fysiologiske og emosjonelle opplevelser, mens et fåtall opplevde forskjellige typer ubehag på grunn av treningen. VR-trening ble foretrukket som et supplement til tradisjonell sikkerhetstrening av de fleste. Videre var det forskjellige meninger og evalueringer av realisme, eller fidelity, i VR. Aspekter relatert til fysisk og psykologisk fidelity ble ansett som viktig, spesielt psykologisk fidelity kan være av betydning i VR-trening. Til tross for mangler knyttet til fidelity, ble VR-treningen sett på som verdifull og flere fordeler relatert til læring, sikkerhet, miljø og kostnader ble identifisert. Totalt sett antyder denne studien at VR er et nyttig verktøy som bør brukes i sikkerhetstrening. I tillegg må fysisk og psykologisk fidelity bli tatt i betraktning når sikkerhetstrening med VR utformes og utvikles. Videre foreslås det også at spesifikt psykologisk fidelity er viktig å betrakte, ettersom dette kan ha innvirkning på læring og treningsoverføring. Til slutt foreslår studien at VR-trening fungerer best som et supplement til tradisjonell sikkerhetstrening per nå, men dette kan endres med videre utvikling og forskning på VR.

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Introduction

Workplace safety is vital in every industry as it is both a judicial and a moral responsibility for organizations. Organizations in Norway are obligated through the law to provide a safe work environment for their employees as it is specified in the Working Environment Act (2005 §3-1);*"in order to maintain safety at the workplace, the employer shall ensure that employees are informed of accident risks and health hazards that may be connected with the work, and that they receive the necessary training, practice and instruction"* (Working Environment Act, 2005 §3-1).

Certain industries such as the construction, process, mining and offshore oil and gas industry can be more exposed to hazards because of the nature of their work (Grassini & Laumann, 2020). One way to mitigate adverse outcomes related to hazards is by providing safety training (Lippin et al., 2000; Robson et al., 2012). Research shows that safety training is an effective way to reduce risks in the workplace which makes safety training vital for industries, especially those with an increased risk of workplace hazards (Robson et al., 2012). However, organizing and attending trainings can be both time consuming and expensive (Salas et al., 2012). To meet current and future challenges related to safety, development and competition, organizations are bound to always provide effective training for their employees. Therefore, advancement within the field of training is increasingly relevant and important for organizations within different industries (Hancock, 2008).

Technological advancements could potentially change the way safety trainings are conducted (Guo et al., 2012). One technology that has begun to be applied in many different areas, including safety training is virtual reality (VR) (Doerr et al., 2007). The use of VR in training is not unheard of as VR has traditionally been used successfully in different kinds of training, such as flight simulators for pilot training and surgical simulations for medical training (Chung, 2000; Haque & Srinivasan, 2006). However recent technological developments have changed VR and made it more applicable and affordable in many ways (Brown & Green, 2016; Doerr et al., 2007). Specifically, the development of head-mounted displays (HMD) has transformed VR as one is completely surrounded by the virtual environment (Brown & Green, 2016; Doerr et al., 2007; Santos et al., 2009). Simulation-based trainings such as VR trainings have shown promise and are therefore increasingly of interest for both researchers and organizations (Kaplan et al., 2020).

One way as specified to ensure the employees safety is through providing necessary training and research shows that training is important for acquiring and developing necessary skills related to work safety (Salas et al., 2012; Robson et al., 2012). Organizing and providing training is expensive for the organizations and there are many factors that need to be in place for a training to be successful (Salas et al., 2012). VR has the potential to change how safety trainings are conducted and technological advancements could potentially reduce both the time and cost affiliated with safety trainings (Hancock, 2008; Kaplan et al., 2020). It is therefore very important to conduct research and utilize the technology one has access to, and at the same time it is important to evaluate what works and does not work.

Although VR training is gaining more interest, empirical findings on VR's usefulness in training and performance are lacking as they are spread throughout many disciplines within research (Fletcher et al., 2017). While researching for this thesis, this scarcity became even more apparent within the research field of safety training. Nonetheless, research shows promise for the prospects of VR in safety training (Fletcher et al., 2017). A review on the use VR in training found that most studies focus on technological specifications instead of which features increase effectiveness and performance (Fletcher et al., 2017). However, VR is also very expensive to develop and therefore designing VR trainings can be very costly for developers and organizations. Thus, more research is needed to evaluate the use of VR in safety trainings to find out which features of VR can potentially enhance and improve training.

Thesis Background and Description

This thesis is a part of a larger project at NTNU and of their collaboration partners are RelyOn Nutec. RelyOn Nutec is a global company that provides trainings for safety and survival for different industries. I was introduced to this project by my supervisor in spring 2019. I subsequently joined the project as I was interested in how VR was being implemented in safety trainings as VR is usually associated with entertainment purposes. My interest grew further as I got interesting insight through meetings with RelyOn Nutec and how they had added VR in their curriculum as a part of their refresher course for offshore workers. Specifically, they had added VR fire extinguisher training to train workers on fire safety and extinguishing. It was therefore of interest to find out how the training was being evaluated to ensure quality and gain insight.

The research question of this thesis is as follows *"How is safety training using virtual reality evaluated by offshore oil and gas industry workers?"*. With this I want to explore how

this relatively new form of safety training using VR is evaluated by workers in a high-risk industry. I believe that as safety is a major concern in such industries, their evaluations on this subject matter are extremely vital for further evaluation and development of VR's use in work safety. Safety training and its development is important within the field of work and organizational psychology as it concerns the safety and health of employees and industries. Such research can hopefully lead to development within the field of training and safety training in work and organizational psychology. The goal of this thesis is to give valuable insight into what is important to consider when implementing VR in safety training, how it is evaluated and the reasons for these evaluations.

The structure of the thesis is as follows, empirical findings and theories, methodology, results and discussion. The first section empirical findings and theories will give an overview of the research in the field of VR and training. The section will start with an introduction to basic concepts within VR and findings related to these concepts. This will be followed by research on training and safety training in organizations and relevant theories. Finally, empirical findings on safety training using VR will be presented which will be followed by findings on acceptance of VR technology. The next section methodology will present the qualitative method that was chosen and the reasoning for the decisions that were made during data collection and analysis, as well as ethical considerations. The results section will present the results of the analysis and these will be explained through data extracts from the data material. Finally, the discussion will discuss the findings in relation to previous empirical findings and theories. This will be followed by a discussion on methodological considerations and implications of the research. Lastly, suggestions for future research will be proposed followed by a conclusion of the thesis.

Empirical Findings and Theories

The aim of this thesis is to find out how VR training is evaluated by offshore oil and gas industry workers. This section will start with a presentation of VR, important concepts related to VR and empirical findings related to these concepts. This will be followed by theories and empirical findings related to training and safety training. Finally, I will present research on safety training conducted with VR and findings related to acceptance of VR technology. The empirical findings and theories have been chosen based on their capacity and ability to shed a light on relevant topics and answer the research question.

Virtual Reality

VR refers to a medium which consists of interactive computer-generated simulations (Sherman & Craig, 2003). VR can be defined as a digitally constructed reality where the goal is to replace the physical environment and sensory experiences with digital creations (Loomis et al., 1999). This allows VR to simulate a reality which opens the possibilities to do and experience things that might not be possible in the real world (Slater & Sanchez-Vives, 2016). The virtual environment that is simulated can be either real or an imaginary environment (Sherman & Craig, 2003). Within these simulations the user is able to interact with the environment as the user is able to affect this simulated world.

Researchers also make a distinction between different types or levels of VR (Ma & Zheng, 2011; Bamodu & Ye, 2013; Halarnkar et al., 2012). Researchers divide between three levels, these are non-immersive, semi-immersive and fully immersive (Bamodu & Ye, 2013: Halarnkar et al., 2012). The non-immersive level is usually generated on a desktop computer. This level requires the least amount of hardware or other processes. Simple flight simulators are an example of this type of VR. In the semi-immersive level, the real environment surrounding the user plays an important role in experiencing the VR. An example of this is the cave automatic virtual environment (CAVE) depending on the complexity of the system. The CAVE is a cube-shaped room where the user is surrounded by projected images which can be controlled by the user. Finally, the fully-immersive level is experienced when the user is completely surrounded by the virtual environment and uses equipment that transfers the user's movement into the virtual environment. This level of VR can be experienced with the use of head-mounted display (HMD) (Bamodu & Ye, 2013: Halarnkar, 2012). This thesis is focused on the fully-immersive level of VR.

Some of the key defining aspects of VR include interactivity and sensory feedback (Sherman & Craig, 2003). Interactivity refers to the VR system responding to the user's actions, in other words a user can interact with the environment. Sensory feedback refers to the VR system sensing the participant's position and actions and providing feedback based on these. Traditionally it was the visual sense that received feedback, however modern VR systems also provide feedback to other senses as well, such as auditory and tactile feedback (Schuemie et al., 2001; Våpenstad et al., 2013).

There are different ways to interact with the simulated VR, but modern VR is concerned with the use of HMDs (Santos et al., 2009). The HMD is worn on the head and consists of a screen that shows the virtual environment in 3D (Sherman & Craig). This is done by obscuring the user's perceptions of the real environment which gives the feeling of being physically present in the virtual world (Lepecq et al., 2009). In other words, the real physical environment is removed and the user sees only the virtual environment. The HMD can have many different sensors including a tracking system which allows the users movement in the real world to be replicated in the virtual environment (Sherman & Craig). HMD is also said to be most immersive type of VR (Bamodu & Ye, 2013).

One key feature of the HMD is visual motion, which is something the user controls by rotating the head or moving within the virtual environment. Thus, an action such as rotating the head is replicated in the virtual environment. In addition to the HMD, the user can also interact with the environment by using a physical device which is connected to the VR (Sherman & Craig). This physical device could be something simple as a handheld object which represents an object in the virtual world (Sherman & Craig). Such devices can allow users to perform actions in the virtual environment. Thus, both the HMD and physical devices can be helpful tools to interact with the simulated VR.

Evaluation of VR

Evaluation of VR systems is necessary in order to continuously improve the technology and its experiences (Hein et al., 2018). VR can be evaluated by using concepts such as presence, immersion and fidelity (Hamstra et al., 2014; Hein et al., 2018; Slater, 2003). Although, these concepts are in many ways related to each other, each of them represents an important aspect of VR, which is important to consider when evaluating VR. These concepts have been used interchangeably and defined in many different ways in research (Hamstra et al., 2014 Jensen &

Konradsen, 2018; Lombard & Jones, 2015). Therefore, it is important to explain what these concepts represent and how these differ from each other. Hence, I will shortly summarize these concepts and how they are related to each other to assure a clear understanding, before presenting them in detail in the following sections.

In the context of this paper, presence is a subjective evaluation of being in another place (Lombard & Jones, 2015). This concept measures how present users feel in the VR, commonly referred to as a sense of "being there". Immersion refers to the technology related to VR (Slater, 2003). VR systems can be different and can thus have different technological features. Immersion is thought to increase the feeling of presence (Baños et al., 2012; Slater, 2003). Fidelity is the evaluation of how realistic the virtual environment is (Hamstra et al., 2014). Fidelity is also thought to increase the feeling of presence, whilst immersion can affect the evaluation of fidelity of the VR (Hamstra et al., 2014; Yu et al., 2012). Thus, these concepts are important aspects that can and should be considered when evaluating VR as they might help explain user evaluations and assist in developing the technology.

Presence in VR

One key concept that can be used to evaluate VR is called presence (Hein et al., 2018). The concept of presence has been conceptualized and defined and measured in many ways (Lee, 2004; Lombard & Jones, 2015). This has led to a lack of consensus between researchers and has made it difficult to compare and evaluate the research that has been published (Lee, 2004). Nonetheless, there is some consensus about the concept as feeling or experiencing being present in another place (Hein et al., 2018; Lombard & Jones, 2015).

In an attempt to create one common definition of presence the International Society for Presence Research (2000) proposed the following *"Presence is a psychological state or subjective perception in which even though part or all of an individual's current experience is generated by and/or filtered through human-made technology, part or all of the individual's perception fails to accurately acknowledge the role of the technology in the experience."*. This definition considers presence as one construct, however most researchers view presence as a dimensional construct. Researchers have also differentiated between different types of presence as well, such as social presence, co-presence and physical presence, (Lepecq et al., 2009; Lombard & Jones, 2015; Schubert et al., 2001). Social presence concerns the feeling of being together or a social interaction in the virtual world. Physical presence concerns the feeling of

being present in a virtual environment and co-presence is a combination of both (Bulu, 2012: Hein et al., 2018).

Presence in the context of this paper will follow Slater and Wilbur's (1997) definition which concerns physical presence. They define presence as a psychological state which is a subjective description of said state. Presence can thus, according to this definition be subjectively evaluated. The subjective description of presence is more specifically the persons evaluation of the virtual environment as being "place-like" which includes that the environment is subject to suspension of disbelief. The subjective description also includes the degree to which the persons feels "being there" (Slater & Wilbur, 1997)

As mentioned, presence is measured in many different ways and this had led to several questionnaires of presence that have both their similarities and dissimilarities (Lessiter et al., 2001; Schubert et al., 2001; Witmer & Singer, 1998). The constructs of presence that are measured are many and all of these affect the sense of presence according to research. Some of the constructs that are measured in these questionnaires are related to participants evaluation of realism, sense of being in the VR and simulator sickness (e.g. nausea, disorientation). One questionnaire that measures some of these constructs is based on Schubert and colleagues' three-component model of presence (2001) and it has been referred to as a complementary continuation of Slater and Wilbur's (1997) definition of presence (Hein et al., 2018).

This model views presence as a subjective experience which emerges as a result of the mental model that is created of the virtual space (Schubert et al, 2001). Through a comprehensive factor analysis, they identified three different constructs that create this mental model. These are spatial presence, involvement and realness. Spatial presence refers to the feeling of being or existing in the virtual environment. Involvement refers to how attentive one is in the virtual environment and realness refers to the user's evaluation of the virtual environment's realness compared to actual known reality. Presence emerges when the user's actions in the real world are translated into the virtual word, whether they are related to navigation, manipulation of objects or other interactions in the virtual environment (Schubert et al, 2001).

Immersion in VR

One important aspect that is important to mention is the distinction between immersion and presence. Some researchers have used these terms interchangeably, whilst some researchers have clearly distinguished between them (Jensen & Konradsen, 2018; Slater, 2003; Schubert et

al., 2001). In the context of this thesis, immersion refers to the technology and its aspects such as graphics, whilst presence is what one feels because of such technology (Slater, 1999; Slater, 2003). For example, when an individual reacts to the simulated world in the same way he or she would have reacted to the real world, then that individual is experiencing presence. In addition, several studies have shown that increased immersion leads to an increased feeling of presence (Baños et al., 2012; Gorini et al, 2011; Juan & Perez, 2009; Krijn et al., 2004).

This distinction between immersion and presence is in accordance with Slater and Wilbur's (1997) definition of presence and the three-component model of presence (Schubert et al., 2001). This distinction is important to further reduce the broad terminology that is already used for the concept of presence. Moreover, this distinction allows researchers to distinguish and evaluate the technological aspects of VR and how it relates to the psychological aspect, which is presence (Slater & Wilbur, 1997). Also, this might make it easier for researchers to find possible characteristics related to immersivity that might enhance the feeling of presence (Hein et al., 2018). Thus, this distinction carries itself with many benefits for research and researchers.

Fidelity in VR

The aspect of realism is important in VR and one concept used to measure realism is called fidelity (Hamstra et al., 2014). In the context of virtual reality, fidelity can be defined as the extent to which the environment created in the VR matches a real environment (Hamstra et al., 2014; Norman et al., 2012). In other words, how realistic is the virtual environment compared to a real environment. Fidelity can impact the perception of realism, presence and learning outcomes (Hamstra et al., 2014; Yu et al., 2012). Fidelity is another concept which has been described by many sub-categories and can thus be measured in many different ways (Hamstra et al., 2014).

Researchers have distinguished between low to high level of fidelity in research (Hamstra et al., 2014). Generally, low fidelity systems are those that are less realistic than high fidelity systems. However, a review found that the same system can be described as a low or high-fidelity system depending on the feature that is emphasized (Hamstra et al., 2014). Thus, researchers can describe VR systems differently as well, depending on the aspect that is being measured. This however makes sense considering research that shows that not all aspects of the VR are as important as others, and this can depend on the purpose of the VR (Cummings &

Bailenson, 2016). Thus, classifying a VR system as low or high fidelity might be too simplistic as fidelity requirements may vary depending on the context (Alessi, 1988).

Thus, it could be important to focus on relevant sub-categories. This thesis will focus on physical, and psychological fidelity. Physical fidelity describes the virtual simulation and is the degree to which the virtual environment looks, sounds and feels like the equivalent real environment (Alexander et al., 2005; Kozlowski & DeShon, 2004). Research shows that VR can provide sensory experiences related to different senses (e.g. visual, haptic, auditory, thermal) and these affect the physical fidelity or perception of realism (Schuemie et al., 2001; Yu et al., 2012). Psychological fidelity describes the virtual simulations effects on the users and the degree to which the virtual environment produces the psychological factors experienced in the equivalent real environment (Alexander et al., 2005; Kozlowski & DeShon, 2004). Furthermore, high physical and psychological fidelity means that there is high similarity to the equivalent real environment.

User Experience in VR

The VR experience is not necessarily positive for everyone. Research has found that participants can feel unsafe in the VR while using HMD since they do not have access to their actual surroundings (Reiners et al., 2014). Additionally, a number of symptoms have also been frequently reported after being in the VR (Jensen & Konradsen, 2018). These are commonly referred to as simulator sickness and include headaches, nausea and disorientation (Davis et al., 2014). A review found that simulator sickness is understudied in safety trainings with VR (Grassini & Laumann, 2020). Although the frequency of reporting such symptoms has varied in studies, they are still of concern as they can amongst other things affect learning attitude and outcomes, and lead to a negative attitude towards the technology (Fernandes et al., 2016; Kleven et al., 2014; Polcar & Horejsi, 2015). Thus, VR can be a somewhat uncomfortable experience for some users.

On the other hand, studies have also reported participants having a positive experience in the VR (Jensen & Konradsen, 2018). One review on the use of HMDs in VR showed that participants across several studies generally perceived the VR experience to be positive, exciting and useful for their learning (Jensen & Konradsen, 2018). In addition, a study showed that the VR experience can trigger positive emotions such as joy and satisfaction (Fernandes et al., 2016). Thus, the VR experience can be different for users, but its negative consequences are

important to be aware of. In addition, there is also a need for more research on long-term effects of VR use (Grassini & Laumann, 2020).

Factors Influencing Presence and Fidelity

There exists a variety of factors that affect the feeling of presence. Research has found that technological aspects such as lagging graphics and other visual shortcomings can limit the sense of presence felt by the users (Pan et al., 2016). Another study showed that being aware of other people spectating while the participants were wearing an HMD affected the sense of presence they felt (Fernandes et al., 2016). Whether one is standing or sitting can also affect presence as findings show that standing up while using VR led to an increased sense of presence (Reiners et al., 2014). Research has also shown that experiencing symptoms related to simulator sickness can negatively affect the sense of presence (Jerome & Witmer, 2004; Keshavarz & Hecht, 2012). A study also found an association between personality traits and presence (Janssen et al., 2016). Specifically, people with more reserved or anxious personalities did not have a positive experience in the VR and felt a lesser sense of presence. These findings demonstrate the variety of factors that can influence users' sense of presence.

Although, increased immersion is generally related to an increased feeling of presence, some technical features affect presence more than others. A meta-analysis on the effects immersive technology has on physical presence, found that some technical aspects are not as important as others (Cummings & Bailenson, 2016). The meta-analysis found that there are three features that affect presence the most. These are tracking level, field of view and stereoscopy (3D depth). On the other hand, features such as sound, image quality and resolution, did not affect users' sense of presence as much. Thus, there are many features and factors that can affect users' sense of presence, however, the influence varies depending on the features.

Fidelity can also be influenced by different factors related to immersivity. Interaction and room for action can increase the perceived realism in VR (Fox et al., 2009). In addition to this, adding sound features, such as spatialized sound can also affect the perception of realism positively (Zahorik, 2002). Another aspect that can increase perceive realism is haptic feedback. Research shows that adding a physical object in the virtual environment to provide haptic feedback can increase perceived realism in the VR (Hoffman, 1998; Moody et al., 2008). Thus, adding different features to the virtual environment can increase the perceived realism. However, research also shown that higher fidelity simulations are not necessarily better than lower fidelity

simulations (Ragan et al., 2015). In addition, it is very expensive to develop or add features to virtual environments (Brown & Green, 2016). Thus, increased realism for certain elements in the simulations might be a better approach than adding less important elements (Ragan et al., 2015).

The Role of Presence, Immersion and Fidelity on Learning

Presence and immersion are important factors that can influence the VR experience and as mentioned earlier, the degree of immersion can increase the degree of presence. According to research, immersion can affect factors such as learning outcomes. A review on the use of HMDs in VR by Jensen and Konradsen (2018) identified several studies that showed that immersion and presence can positively influence learning outcomes, specifically skill acquisition. A study that compared different VR systems showed that increased immersion led the participants to spending more time on the task that they were learning (Alhalabi, 2016). Another study found that participants took the VR simulations more seriously because of increased immersion (Reiners et al., 2014). This meant that participants were amongst other things more careful when approaching dangers in the simulation. In other words, increased immersion can have a positive effect on participants when approaching learning tasks using HMDs.

When it comes to acquiring cognitive skills, it is not necessarily beneficial to have highly immersive VR systems (Alhalabi, 2016; Jensen & Konradsen, 2018). Less immersive technologies (e.g. desktop monitor) can be sometimes be more beneficial than highly immersive technologies (VR). However, this might not be the case concerning acquisition of psychomotor skills. Such skills are usually trained by repeating actions that are being trained, until one is satisfied with the learning outcome (Jensen & Konradsen, 2018). It is also assumed that increased fidelity (realism) can positively affect learning of psychomotor skills (Jensen & Konradsen, 2018). One study concerning visual scanning found that users in more realistic scenarios were better able to learn the necessary skills and perform the tasks, compared to users in less realistic scenarios (Ragan et al., 2015). Another study found similar results, however, the researchers did not observe improvement of skills outside of the VR (Sportillo et al., 2015).

One study found that users were able to learn a particular skill in the VR, and some of these users were also able to perform this skill outside of the simulation (Kahlert el al., 2015). In other words, they were able to transfer skills learned in the VR into the real world. Research also shows that for skill learning and retention, it might be important to have relevant contextual information, such as the experience of stress or anxiety to be present (Driskell et al., 2001;

Morris et al., 2004). Findings show that the experience of stress is related to skill retention and could thus be an important aspect to consider when it comes to facilitating skill acquisition. However, research also indicates that critical context relevant information is sometimes absent in simulation-based trainings (Alexander et al., 2005). These findings demonstrate the importance fidelity and relevant contextual information can have on learning tasks concerning acquisition of psychomotor skills.

Research has also found that higher fidelity systems can increase the feeling of presence and improve performance (Buttussi & Chittaro, 2017). Also, research shows that high fidelity systems lead to better memory retention than low fidelity systems (Chittaro & Buttussi, 2015). In other words, increased realism plays a role in retention. Another aspect that is linked to memory retention is presence. Research shows that arousal of emotions, especially negative emotions are linked to presence (Riva et al., 2007). Arousal of emotions can in turn increase memory retention (Finn & Roediger, 2011; Kensinger, 2009). Thus, presence, fidelity and emotional arousal are intercorrelated in some ways and play a role in learning and retention.

One comprehensive review on which factors facilitate learning outcomes in high-fidelity simulations such as VR, found that repetitive practice and variation in scenarios facilitated learning (Issenberg et al., 2005). Repetitive practice gave the trainees the opportunity to be focused and engaged with task repetition to improve their skills. This could lead to skill acquisition in shorter amounts of time as it is easier to get repetition in a simulation. Variation in scenarios gave the trainees a broad variety of situations to consider. This provided them with the option to improve their skills within different scenarios. Thus, variation in scenarios also facilitated the trainees learning in high-fidelity simulations (Issenberg et al., 2005). Hence, repetitive practice and variation in scenarios are important features of high-fidelity simulations such as VR.

Research also shows that immersion can also hinder learning outcomes. One study found that some participants can become distracted because of increased immersion, which in turn can draw their attention away from the learning task (Fernandes et al., 2016). Another study found that participants can become very fascinated and intrigued by the virtual environment, which again took their attention away from the task at hand (Moesgaard et al., 2015). Similarly, another study found that increased immersion in the VR distracted the users from the learning task, even though they felt an increased sense of presence in the VR (Makransky et al., 2019). Although

these studies were more concerned with cognitive skill acquisition, these findings still demonstrate that increased immersion does not necessarily lead to increased learning.

Workplace Training

The goal of workplace training is to achieve or modify skills, knowledge and attitudes by going through a planned and strategic learning experience (Millhem et al., 2014; Salas et al., 2016). By going through this process, one is supposed to achieve the ability to use or perform the intended skills or actions in the relevant environment. Thus, training is supposed to develop the employees' skills and abilities which will help the organization to meet its current and future needs (Salas et al., 2012). Training provided by organizations can be compulsory or non-compulsory depending on the nature of the training (Salas et al., 2012). Such training can for example provide certifications, consist of tests and examinations, or it could be more informal in nature (Salas et al., 2012). Training is time-consuming and expensive and therefore it is important that the training that is provided is successful and leads to learning (Salas et al., 2012).

Workplaces that have an increased risk for adverse outcomes provide safety training to mitigate these (Lippin et al., 2000; Robson et al., 2012). Safety training refers to planned and strategic efforts aimed at acquiring competencies related to health and safety. These can be in the form of instruction or hands-on training in risk recognition and control, use of protective equipment, emergency procedures and prevention (Robson et al., 2012). A review on the effectiveness of occupational health and safety training found that safety training is effective for risk and safety related behavior (Robson et al., 2012). Another review on the effectiveness of safety training found that such training can positively influence attitudes and behaviors related to safety and health (Ricci et al., 2016). Specifically, practical training or hands-on training is effective for learning behavior related to safety. Thus, safety training is an important form of training in relevant organizations and industries.

In their comprehensive review on the science of training, Salas and colleagues (2012) identify what needs to be in place for a training to be successful. In their review they focus on what matters before, during and after the training. Before training, organizations should conduct a training needs analysis that identifies what needs to be trained and who needs this training. The people responsible for the training also need to prepare a learning climate by scheduling and notifying employees and preparing supervisors and leaders (Salas et al., 2012). During training it is important to enable the right trainee mindset and use a valid training design and strategy.

Technology should be used as required during the training. This gives the trainers the option to enhance learning through simulations, provided that they use the technology correctly (Salas et al., 2012).

Lastly, after the training there needs to be a focus on ensuring the transfer of training and evaluating the training (Salas et al., 2012). This means that obstacles that hinder transfer should be removed. When it comes to evaluation of training it is important to clearly specify the purpose of the evaluation by determining what one hopes to accomplish by evaluating. Evaluating at multiple levels should also be considered. This could consist of measuring reactions, learning, behavior and results. It important that the evaluation is precisely linked to training needs that were uncovered during the training needs analysis (Salas et al., 2012).

Transfer of Training and Identical Elements Theory

Transfer of training is considered a very important aspect of training and there is a multitude of research on what affects training transfer (Grossman & Salas, 2011). Transfer of training can be defined as the application of skills learnt in a training environment in the work environment (Burke & Hutchkins, 2007). One theory or principle within the training transfer literature is the identical elements theory by Woodworth and Thorndike (1901) (Yamnill & McLean, 2001). According to this theory, the similarity between the training setting and the transfer or actual performance setting assures transfer. Specifically, there should be a similarity between stimuli and responses in both settings. This assumes that the higher the degree of similarity is, the higher is the likelihood of transfer. This similarity increases the training situations relevance and can also make it easier for trainees to apply what has been learnt in the appropriate work situation (van der Locht et al., 2013).

This similarity in stimuli and responses is important because it can help trigger the appropriate responses in the relevant work situation. Responses to stimuli does not only include actions, but also psychological responses and decision-making processes (Baldwin & Ford, 1988; van der Locht et al., 2013). Although, the theory has received some criticism, the importance of identical elements has been demonstrated in several studies (Goldstein & Gilliam, 1990; Lim & Morris, 2006; van der Locht et al., 2013). Generally, research indicates that learning situations that resemble the real-life situations that one is being trained on, lead to transfer of training (Grossman & Salas, 2011). Also, the literature on training effectiveness and

outcome recommends that training should be realistic (Burke & Hutchins, 2007). Thus, the aspect of identical elements is of importance in training.

Concerning transfer of training, there is also some research that shows that psychological fidelity is more important in training than physical fidelity. One review found that psychological fidelity is more critical for learning and transfer of training than physical fidelity (Norman et al., 2012). Researchers have argued that although physical fidelity is important, psychological fidelity captures essential psychological processes that are vital for learning and transfer (Kozlowski & DeShon, 2004). This is because simulations should evoke critical psychological processes which are relevant for the skills that are being learnt and having high physical fidelity is not necessarily required for that (Kozlowski & DeShon, 2004). Hence, as long as there is an appropriate level of psychological fidelity, high physical fidelity is not as important (Salas et al., 2009). Thus, psychological fidelity might play an important role regarding transfer of training.

Training Evaluation and Kirkpatrick's Model of Evaluation

Evaluation of trainings is deemed as very important as it allows organizations and other relevant actors to find out what works and modify what does not work (Salas et al., 2012). One way to evaluate training is Kirkpatrick's model of evaluation (2006). This model is extensively used by both researchers and organizations; however, it has been criticized for oversimplifying evaluation and its theoretical shortcomings (Salas et al., 2012). Nonetheless, it provides an important basis for evaluation and is extensively used as it's a simple and practical way to evaluate (Kirkpatrick & Kirkpatrick, 2006).

The model is based on four levels of evaluation which are reaction, learning, behavioral change and organizational outcomes (Kirkpatrick & Kirkpatrick, 2006). The first level is reaction which is concerned with the trainee's reactions to the training. This level measures what the trainees feel about the program and can be collected through questionnaires. The reactions need to be positive as that is essential for the training's continuation and they can affect participants motivation to learn from the training. The next level is about learning and measures whether the trainees have learnt anything from the training program. This could be measured with post-training knowledge or skill test. The third level concerns behavioral change and measures whether the intended behavioral change can be observed on the job. The final level concerns organizational outcome and measures whether the envisioned results have been reached. It is

important to measure the results based on the aims of the training (Kirkpatrick & Kirkpatrick, 2006).

Kirkpatrick's model (2006) has been criticized for including trainee reactions as an indicator of training evaluation, however research has shown that valuable information can be gathered from trainee reactions (Morgan & Casper, 2000; Salas et al., 2012). Trainee reactions are not the sole indicators for training evaluation; however, they provide information that can be a useful part of the evaluation (Morgan & Casper, 2000). Research has shown that training reactions can influence learning and post-training performance indirectly (Mathieu et al.,1992). Trainee reactions can also provide important input for the improvement of training programs. (Morgan & Casper, 2000). One meta-analysis found that trainee reactions can capture important characteristics related to the training environment, in addition they can also predict changes in motivation and self-efficacy during the training (Sitzmann et al., 2008). Another study found that trainee reactions are associated with learning and perceived transfer (Kim et al., 2019). Thus, trainee reactions can provide important input about the training and they can play a role concerning learning outcomes.

VR and Safety Training

VR has been used for training purposes for quite some time (Kennedy et al., 1989). Flight simulators have long been used for pilot training both in the military and flight academies (Kennedy et al., 1989). Medical schools have also used VR for different kinds of surgical training (Gallagher et al., 1999). The use of VR in safety training is rather new in comparison. VR for safety training purposes has mostly been used in the construction, mining and chemical industry (Sacks et al., 2013; Patle et al., 2019; Tichon & Burgess-Limerick, 2011). These industries are associated with a lot of risk and accidents, and VR allows exposure to dangerous situations without really putting workers at risk (Lucas et al., 2008; Sacks et al., 2013). This gives the workers the opportunity to learn how to assess and choose the best course of action in different situations that they might be exposed to in their work (Lucas et al., 2008). Therefore, VR can be extremely valuable in industries which have an increased risk of work hazards associated with them.

What makes safety training in VR valuable is that it can potentially provide realistic simulations of the different threats that workers can face in their work (van Wyk & de Villiers, 2019; Guo et al., 2012). Apart from exposing workers to simulated hazardous situations, VR can

also expose workers more frequently to such situations than they might encounter in their work (van Wyk & de Villiers, 2019). This could potentially make them more ready for such situations should they arise. Such training also allows the workers to see the potential consequences of their actions in the simulation (Higgins, 2017; van Wyk & de Villiers, 2019). Researchers believe and argue that VR is more cost-effective than traditional training (Grabowski & Jankowski, 2015; Patle et al., 2019). Although, VR costs a lot to develop and implement it is argued that it will be more cost-effective in the long run. This is because although VR requires a high starting cost, it could save organizations costs and time related to travel to training facilities, and training programs. One study found that VR did indeed reduce both time and costs of the training and the simulation (Cardoso et al., 2017). Thus, safety training with VR offers many potential benefits to both the workers and the employers.

Safety training with the use of VR also offers other benefits based on the "learning by doing principle" (Patle et al., 2019). A review on use of VR in safety training in the process industry identified that VR offers a more naturalistic environment which can positively influence learning transfer (Patle et al., 2019). In addition, VR can provide an increased familiarity with the learning objective and easier access to training facilities. Another review evaluating the use of VR in work safety found that VR training can indeed help employees prepare for emergency situations that might arise in their workplace (Grassini & Laumann, 2020). Also, it has been argued that VR use in safety training can improve the employees risk behavior and awareness (Grassini & Laumann, 2020; Zhao & Lucas, 2015).

Other reviews on VR in safety training also show favorable findings for its use (Bhoir & Esmaeili, 2015; Li et al., 2018). VR systems are useful for hazards identification, situation awareness and response. These findings show that trainees are able to identify higher risk levels in the VR, which is an important aspect of work safety, especially in industries associated with a higher level of risk (Li et al., 2018). Such risk identification and awareness can also improve the workers ability to respond to hazardous situation which can in turn increase their safety at work (Li et al., 2018). Thus, research has found many benefits of VR use in safety training and VR provides an opportunity to match different industries' training needs (Grassini & Laumann, 2020). Most importantly, all of this is done in a safe environment and thus such training has been identified as a valuable resource for learning about and training safety (Grassini & Laumann, 2020; Sacks et al., 2013).

Acceptance of VR technology

Although researchers recommend the use of VR in safety training and their findings show many positive results, organizations are still reluctant to use VR for safety training purposes (Bhoir & Esmaeili, 2015). Findings shows that practitioners still prefer using hands-on or traditional safety training compared to VR training (Bhoir & Esmaeili, 2015). Thus, there is a discrepancy between researchers and practitioners concerning the use of VR for safety training. Research has identified different factors that can affect acceptance of VR technology, which might play a role in the practitioners' preference for traditional training (Huygelier et al., 2019; Mütterlein & Hess, 2017).

Simulator sickness related to VR can affect the preference for traditional training as it is a common side-effect of VR use (Fernandes et al., 2016; Grassini & Laumann, 2020). Other factors that might play a role according to research are age and previous experience with VR (Huygelier et al., 2019). Research has found that younger people evaluate the VR experience more positively than older people (Plechatá et al., 2019). However, research has also found that older people can become more positive after the first exposure to VR, indicating that acceptance for VR can increase and that previous use plays a role in it (Huygelier et al., 2019; Plechatá et al., 2019). Lastly, technological deficiencies related to graphics such as resolution, field of view and lag can also impact the acceptance of VR (Mütterlein & Hess, 2017). However, more research is needed on which aspects can affect acceptance of VR technology (Manis & Choi, 2019; Mütterlein & Hess, 2017). To my knowledge, research on acceptance of VR technology is especially needed in the context of safety training.

Methodology

In the following section the methodology used to answer the research question will be presented. I will start by presenting the background of this study. This will be followed by a presentation and reasoning for the qualitative method that was chosen and description of the data collection process. Finally, I will present the ethical considerations regarding this study. Other methodological considerations will also be discussed in the discussion section.

Background of Study

The aim of this study is to explore how safety training with VR is evaluated by trainees. This project is a part of a bigger project at NTNU. I was introduced to this project in spring 2019 during a meeting with my supervisor and subsequently joined it. As the project had been in the planning phase for a while, the means for data collection were already decided by the time I joined. I was present during meetings with the collaboration partners and thus got the relevant context information I needed before the data collection phase started. I collected the data material with my co-supervisor and was therefore present at all of the training courses that were held when we were collecting data. Therefore, although I did not take any part in the planning phase, I was very present in the subsequent phases of the project. Furthermore, because I collected the data as well, I became very familiar with how the training was conducted and got an intimate knowledge of the data and its context.

Justification for Method

In a study, the research question and the purpose of the research influences the method that is used (Svartdal, 2009). It is important to choose a method that provides a sufficient amount of data and at the same time reflects what one actually wants to find out (Tjora, 2010). The purpose of this study is to gain knowledge of and explore how safety training with VR is evaluated. Therefore, a qualitative approach is suitable for understanding participants' perspectives and experiences (Kvale and Brinkmann, 2015; Tjora, 2010).

In addition, this study has an exploratory design. Exploratory designs are often used in unexplored areas of interest and are intended to provide insight and understanding around a topic or issue through qualitative exploration (Ringdal, 2007). Qualitative method is also recommended when research on the specific topic is limited (Tjora, 2010; Braun & Clarke, 2006). Since the research question is exploratory and the study has an exploratory design, the qualitative method approach was deemed as the best suited method for this study.

Philosophy of Science

Researchers working within the qualitative method should strive to be as transparent as possible (Braun & Clarke, 2006). This transparency entails that they should be open about their decisions concerning the study and why those decisions were made (Tuval-Mashiach, 2017). This transparency includes specifying how one views reality, referred to as ontology, and gathers knowledge and learns about said reality, referred to as epistemology. Specifying this would increase the readers understanding of the study and help with evaluating the research (Braun & Clarke, 2006). I am working within the post-positivist paradigm. This stance entails that there is an objective truth about reality that research can explore. At the same time, one questions how accurately one can get knowledge about reality (Guba & Lincoln, 1994). This means that one cannot be sure about whether findings represent the truth about reality, however a researcher can authenticate this reality with good methods and argue for the likelihood that the findings are true (Guba & Lincoln, 1994).

Data and Data Collection

Data was collected at the training facility of RelyOn Nutec where they provided a refresher course in safety training with the permission and consent of the organization, trainers and trainees. Data was collected in 2019 from May till October.

Context of Training

The context information was gathered through by being present and by taking field notes at the training facility. Some practical information was also gathered through the contact person. In the refresher course, the trainees received a range of different safety trainings. One of these was a fire extinguisher training with VR using HMD. They also received fire extinguisher training with traditional equipment the same day. The trainees were divided into groups of six to nine people. The safety training with VR was in a specific classroom with the associated equipment. The training started with a short introduction on fire safety and information about extinguishers. After this, the trainer demonstrated the VR training. Everyone in the classroom could see the stream from the HMD on a projector in the classroom with sound. After the demonstration, the trainees performed the VR training one by one with varying difficulties. Trainees talked together after they tried the VR training and by the end of the session. The context will be further explained in the results section.

Study Procedure

We contacted our contact person at RelyOn Nutec who provided us with the dates and time for the trainings we could attend. We showed up at the training facility before the refresher course started. This was to be introduced to the trainers and get the necessary practical information about the day. The trainees started their refresher course in a classroom. Here we presented who we were and why we were there in order to recruit them for the study. We presented the study and encouraged everyone to ask questions. After this we gave everyone, including the trainer an informed consent form which they could choose to sign if they wanted to join the study. In the consent form, the trainees could consent to answering a survey and to being observed during the training. We left the room as soon as we gave them the informed consent form to ensure that they did not feel pressured to sign by our presence in the classroom.

We collected the informed consent forms as soon as they were finished in the classroom and checked whether there were some who did not want to be observed. Before the VR training commenced in the classroom, we asked the trainer to ask again whether it was okay if we were present in the classroom and we entered if we got the confirmation. During the VR training we sat on the side of the classroom and observed and took field notes. We gave the participants surveys when they were done with the training and left the classroom after giving them the survey. When the classroom was empty again, we collected the surveys. The study procedure and the decisions that were made concerning it will be presented in more detail in the following sections.

Participants

We attended in total 10 training sessions and acquired 85 participants for the study, 65 men and 10 women (10 individuals did not disclose their gender and age). The mean age for men was 41 years (23-64) and for women was 39 years (29-58). The participants in this study were the trainees who received the fire extinguisher training with VR. The trainees were individuals who worked offshore in the oil and gas industry. The participants were from different organizations and most of them did not know each other.

Methodological Triangulation

Triangulation refers to combining different research methods to enhance the understanding of research findings (Flick, 2018). One type of triangulation is methodological triangulation which refers acquiring data by using different sources (Flick, 2014). This study

used a within-method type of methodological triangulation, which means data was collected by using two different qualitative methods: qualitative survey method and field observation.

Qualitative Survey Method. The qualitative survey method was used to gather views on the safety training with VR. This method can be defined as a study of diversity with the aim being able to determine the diversity in the subject matter of interest within the given population (Jansen, 2010). Establishing a meaningful variation within that population is what the qualitative survey aims to do. The survey in this study was an open or inductive survey. Open survey means that the relevant topics or categories will be identified through analyzing and interpreting raw data material instead of interpretation through preexisting notions or categories (Jansen, 2010). Also, the qualitative survey method fits within the post-positivist paradigm (Jansen, 2010).

The participants received the survey when they finished the fire extinguisher training with VR and they were collected shortly after. The survey consisted of six open-ended questions about VR and training with VR (see Appendix A). There are several practical reasons why the qualitative survey method was chosen. The trainees were on a schedule the whole day as it was a refresher course in security training and therefore there was a time pressure. The aim was to gather their views right after the VR training and therefore the qualitative survey method seemed the most practical and efficient option. In addition to this, the trainees were offshore workers and therefore contacting them later could have posed many problems. Many of them were not always accessible by phone or email because of the nature of their work.

Open-ended questions offer also other benefits (Braun et al., 2013; Toerien & Wilkinson, 2004). Since the participants respond to open-ended questions they are not restricted in the scope of their answer, which can lead to richness of data. Moreover, open-ended questions allow quick access to larger sample sizes than is typical for qualitative research and easy comparisons across a data set (Braun et al., 2013; Toerien & Wilkinson, 2004). Thus, the qualitative survey method provides many benefits and is consistent with the study design and the research question.

As mentioned, the survey consisted of six open-ended questions. Some of the questions were based on previous literature on training and VR and generally the questions were focused on what the trainees thought about the training. The open-ended questions included two descriptive questions which asked about whether they had any previous experience with VR and whether and when they were nauseous during the training. One question concerned how they felt during the training generally. The remaining three questions concerned their evaluations of the

training. The participants were asked to evaluate the VR training, how the VR training was compared to the traditional training and what are the advantages and disadvantages of VR training.

As this study was part of a bigger project, we also collected quantitative data. This was a survey on the same form as the qualitative survey. The quantitative survey gathered demographic information and data on simulator sickness and immersivity. My thesis is more qualitative in nature and therefore I have decided to use the qualitative data that was gathered. The qualitative data also fits my research question better that the quantitative data. I could have used data from both surveys, however because of practical limitations such as time and the scope of the thesis, I decided to only use the qualitative data.

Field Notes. Qualitative field notes are a vital component of qualitative research. Researchers are encouraged to take field notes to enhance their data material (Mulhall, 2003: Phillippi & Lauderdale, 2018). In addition, field notes provide important context information that enhances the data analysis and interpretation (Mulhall, 2003: Phillippi & Lauderdale, 2018). The participants were observed during the VR training, with their consent. It was a naturalistic observation, which means that the researcher is a passive observer in the participants natural and non-manipulated environment (Angrosino, 2016). Unstructured observation allows for a great degree of autonomy when it comes to what is going to be observed and analyzed, and how to filter the information (Mulhall, 2003). One of the benefits of unstructured observation is that it can capture the context of the situation that the data is going to be collected from (Mulhall, 2003). Another benefit is that unstructured observation can illustrate the whole picture of the intended situation (Mulhall, 2003).

As mentioned previously, participants were observed during the training with VR. I sat on the side in the classroom and took notes. There is a lot of information one can focus on during the observation and since the observing took place during several sessions, it was important to have some consistency in what was observed. Therefore, the decision was made to observe and note verbal comments that were made about the VR training, before, during and after the training within the classroom. The aim was to capture a general impression of what the trainees thought about the VR training and to gather the necessary context information by being present, which as mentioned could be helpful in understanding the survey data later and the context.

Translation

The data from the qualitative survey was translated from Norwegian to English and the whole data set was translated by me. The data was translated for two reasons. The main reason was as this was part of a bigger project, this data was going to be used by persons who are not fluent in Norwegian. The second reason was the perceived practicality in using English while analyzing as the thesis was going to be written in English.

Birbili (2000) emphasizes that it is important that researchers who translate data from one language to another describe their translation procedure and the decisions they made during the process. According Birbili (2000), there are certain issues of translation that need to be considered when translating data from one language to another. If the researcher is translating the data, then it is important that the researcher has the necessary language competency. It is important to obtain grammatical and syntactical equivalence during translation if it is possible. If verbatim translation becomes difficult, then it is important to obtain conceptual equivalence (Birbili, 2000).

Since I am fluent in both Norwegian and English, I had the necessary language competency to translate the raw data. Also, I decided to translate word-by-word to achieve the syntactical and grammatical equivalence in English. This was easy for the shorter responses to questions, however not as much for the longer responses. If I assessed that the word-by-word translation failed to capture the essence of what was said, I decided to achieve a conceptual equivalence instead. In general, most of the responses were translated word-by-word from Norwegian to English.

Thematic Analysis

In order to analyze the data, I decided to use thematic analysis. Thematic analysis is a qualitative analysis method and the aim of this analysis is to identify themes that capture the essence of the data material and that help answer the research question. This is done by systematically identifying and organizing themes that offer insight. Different versions of thematic analysis exist, and I will use Braun and Clarke's (2006) version which is called reflexive thematic analysis. In reflexive thematic analysis the researcher has a central role in knowledge production (Braun & Clarke, 2019). Transparency is another important aspect of thematic analysis (Braun & Clarke, 2006). The researcher needs to be aware and truthful about how he or she could have impacted the study. For example, I am working within a post-positivist

paradigm and this affects how I view and analyze the raw data material. Other considerations will be made clear in the reflexivity section.

One key aspect of reflexive thematic analysis is the flexibility it provides (Braun & Clarke, 2006). However, the method is still defined by clear guidelines for conducting the analysis. There are a number of choices that a researcher needs to make when using this method which concern the epistemological assumptions, theoretical framework, whether the approach to conduct the analysis will be inductive or deductive and the level at which the themes will be identified (semantic vs. latent) (Braun & Clarke, 2006). These choices and their reasoning will be made clear in the following sections.

As mentioned, one defining feature of reflexive thematic analysis is its flexibility (Braun & Clarke, 2006). This flexibility derives from amongst other things that thematic analysis is not bound to any epistemological position and theoretical framework (Braun & Clarke, 2006). This does not mean that the researcher has absolute flexibility. If using a deductive approach, it is important that the theoretical position is made clear and a good thematic analysis should make this transparent. This is because any theoretical position is associated with a number of assumptions about the data material. When using the inductive approach there is no theoretical framework that guides the research. However, as Braun and Clarke (2006) argue, no researchers can truly put aside their theoretical commitments. Thus, a researcher using reflexive thematic analysis should strive to be fully conscious about the theoretical assumptions that drive the research (Braun & Clarke, 2019).

I have chosen to work with inductive approach towards the analysis and identify themes at the semantic level. As mentioned, this means that there is no theoretical framework that guides the analysis (Braun & Clarke, 2019). In practice, this entails that the content of the data drives the analysis and its' structure. The themes are also strongly linked to the data as they are identified from the data itself. As the themes are identified at the semantic level it means that the surface meanings of data are used to describe and identify themes (Braun & Clarke, 2006). In other words, the researcher is not looking for a deeper meaning of what is said or written by the participant. Open surveys are also inductive and therefore they fit with the inductive approach towards thematic analysis.

I have chosen to use thematic analysis because the aim is to explore what people think about safety training with VR. There are many answers that need to be categorized and most

responses are descriptive and short. In addition, my thesis question, the nature of the survey questions and the length of the responses also affected the decision to choose thematic analysis and to identify themes at a semantic level. The data material consisted of open-ended questions with quite short answers and therefore it seemed best to not look for any meaning beyond what is written by the participants.

Although, the inductive approach is not bound to any framework or assumptions, it is difficult to truly put aside all the assumptions one carries. Thus, any researcher will always have certain assumptions that affect the research. In order to make sure that I was not affected by previous assumptions and minimize my personal impact on the analysis, I decided to not read much literature on the topic before I started the analysis. In addition, I kept the analysis grounded in the data set. I used Microsoft Word for the analysis and made tables and color coded during the analysis.

Reflexive Thematic Analysis Step-By-Step

In the following section the six phases of the thematic analysis as proposed by Braun and Clarke (2006) will be presented.

Phase 1 – Familiarizing Yourself with the Data. This phase, as the name suggests is about familiarizing oneself with the data. The aim is to become familiar with the breadth and the depth of the content. This is done by reading the data material repeatedly and in an active way. Reading data is time-consuming and therefore ideally the researcher should read through the entire data set at least once before starting the analysis (Braun & Clarke, 2006). As I collected the data myself, I was already familiar with the material. This familiarity was increased because I translated the answers from Norwegian to English. This gave me an in-depth view of the data as I had to really immerse myself in the answers to the open-ended questions in order to translate them accurately. As, this translating was done some time before I started the analysis, I re-read the data material once again in order to be assure myself that I had the necessary overview of the data. In order to read the data in an active way I continuously made notes, searched for meanings and patterns. These notes included ideas for coding that will be done in the following phases.

Phase 2 – Generating Initial Codes. The next phase starts the systematic analysis of the data material through coding. The aim of generating initial codes is to identify features of the data material that appears interesting to the researcher and that might be relevant to the research question (Braun & Clarke, 2006). Inclusivity is important, as it is not necessarily clear what is

relevant so early in the process. As I am using the inductive approach, the codes depended on the data material. Since I had many responses and as the responses were mostly quite short, I decided to code question by question. This means that I placed all the responses of one open-ended question in one table and then coded it. Another reason I coded question by question is that some responses were short and therefore the context of the questions made it easier to code them.

Phase 3 – Searching for Themes. The next phase after the initial coding involves searching for themes in the data material based on the coding. This includes sorting the codes from the previous phase in themes and identifying patterns in the data material. Codes can also be represented by sub-themes that explain the overarching theme. In order to find themes, I started broadly and made many potential themes based on the initial coding. This was followed by a continuous process of going back and forth through the themes and the coding in order to find the relevant themes. Themes were decided based on prevalence and whether the themes captured something important about the research question. I also made notes regarding the potential relationships between codes, themes and sub-themes. Some codes were still difficult to place in themes even though they were relevant to the research question. These were therefore placed in one theme temporarily. Similarly, to the previous phase, inclusivity is also central in this phase as it is still in the beginning of the analytical process. Therefore, I made sure to not exclude themes yet.

Phase 4 – Reviewing Themes. After all the codes have been analyzed and placed in themes, they need to be reviewed and refined. During reviewing Patton's (1990) dual criteria for judging categories was used. He emphasizes that there should internal homogeneity and external heterogeneity when making categories. This essentially means that different categories or themes should not overlap and all codes within the overarching theme should be meaningful together (Braun & Clarke, 2006).

This phase consists of two levels, reviewing at the level of the coded data extracts and reviewing at the level of the entire data set. Reviewing at the level of the coded data extracts consisted of reading the coded data within each theme to see whether these extracts form a meaningful pattern or not. If the data extracts did not fit the theme, it was reworked, a new theme was created or the data extracts that did not fit were moved to other themes or discarded. Level two consisted of evaluating the validity of the themes in relation to the whole data set. In other

words, evaluating whether the themes accurately represented the meanings of the data set or not. This reviewing was continued until I was satisfied with the thematic map. Therefore, I did a lot of re-reading of codes during this phase in order to be sure that the themes made sense in relation to the data. During this phase, changes were made, and certain sub-themes were merged.

Phase 5 – Defining and Naming Themes. This phase consists of further reviewing and refining the themes. It is vital to make sure that each theme is meaningful and defines different aspects of the data material. During this phase the themes are given names and defined. The names should easily give the reader a sense of what each theme is about. During this phase, I also did a lot of re-reading in order to review the themes. The themes had working titles to begin with and they got more detailed definitions during the re-reading. The definitions included writing a detailed analysis of what each theme tells about the data in relation to the research question. Themes were continuously reviewed and during this phase the final review is commenced. I looked thoroughly at each individual theme again and checked whether any sub-themes could be identified. This phase ended when I was satisfied with the themes and sub-themes that I had identified.

Phase 6 – Producing the Report. This is the final step of this analysis which consists of producing the actual report of the analysis. The final report should be a logical and coherent account of the data that shows what the data means in relation to the research question. The report should include extracts and examples that showcase the point that is being made about the data and the research question. Finally, the analysis should go beyond a mere description of the data. Therefore, it is also important to see the analysis in relation to theory and research on the specific field. The report will be presented in the results section and will be discussed in the discussion section.

Within-Method Triangulation

As mentioned, this study used a within-method type of triangulation. By using triangulation one can acquire richer data and it can help with justifying and supporting the findings of research (Flick, 2018). After reflexive thematic analysis was conducted on both the survey data and the field observation notes I compared the results on the level of data sets. The themes and patterns were compared to find differences and similarities. These will be presented in the results section and further discussed in the discussion section.

Ethical Considerations

This study is part of a bigger project at NTNU and was approved by the Norwegian Centre for Research Data (NSD) in May 2019 before data collection started. RelyOn Nutec were contacted concerning using their name in the thesis. Participants received informed consent forms which were reviewed and signed prior to the data collection (see Appendix B). Both the trainers and the trainees received the informed consent form. The informed consent form consisted of information about the purpose of the project and that participation was voluntary. The participants could choose whether they wanted to respond to the survey and be observed, or only respond to the survey, or only be observed.

There was also information about how their personal data would be processed and their rights concerning the data. To ensure that the trainees did not feel any pressure to sign the informed consent form my co-researcher and I left the room and collected the forms later when the trainees left the room. Before we observed, we asked the trainer to ask the participants again whether they were fine with being observed. The observation notes contained no identifiable information on the participants. Confidentiality and anonymity were maintained throughout the process. The data was stored in a secure locker and there was no personal information in the data.

Results

In the following section the results from the analysis will be presented. The aim of this thesis is to find out how VR training is evaluated by offshore workers in the oil and gas industry. In general, the participants responded very briefly to the open-ended questions. The responses varied from a few words to a full sentence. First context and descriptive information will be presented. This will be followed by a presentation of the themes and their respective sub-themes. The themes will be defined and explained by extracts from the coded data material.

Context of Training

Context information was gathered by being present, gathering field notes and getting other necessary information from our contact person at RelyOn Nutec. The participants attended a two-day refresher course at RelyOn Nutec. This was a course on basic safety training that offshore workers have to repeat every four years. On one of the two days, the trainees received fire extinguishing training with VR and fire extinguishing training with traditional equipment. Their day started with practical information in the morning and then they were divided into groups of six to nine people depending on the number of trainees present at the course. The trainees within a group did not necessarily know each other. The trainees were on a schedule the whole day and received several different safety trainings. Some groups received the fire extinguishing training with VR before the fire extinguishing training with traditional equipment, whilst some received it in the opposite order.

Training with Traditional Equipment

The traditional training was held outside in a field. The training consisted of demonstrations and hands-on training. The trainees learnt about poisoning hazards that can occur when gas is inhaled and the use of respiratory protection. The trainees were also taught how to be able to evacuate from low visibility surroundings with obstacles. Finally, the trainees had to extinguish fires with different fire extinguishing techniques. There was a burn barrel that contained the fire and the trainees had to put out minimum three fires with two different extinguishers.

Training with VR

The VR training was held in a small classroom with the equipment for the training and a projector. The trainees sat on chairs by the wall and we sat on the side where we got an overview of the whole classroom, trainees and the projector. The trainer started the session by talking

about fire safety and different types of fire extinguishers. This was followed by an introduction to the fire extinguishing training with VR. Usually the trainer would talk about the VR training and how and why it was being used. Then the trainer would give instructions and demonstrate how to use the equipment. The equipment included HMD glasses and a fire extinguisher connected to the simulation. The projector was on during the demonstrations and thus everyone could see the stream from the HMD on the projector with sound.

The simulation consisted of different scenarios. Scenarios means different situations in different rooms (e.g. bedroom, kitchen, airplane, warehouse). The aim was to locate the nearest exit, check which type of fire extinguisher is being used and extinguish the fire before the extinguisher is empty. An alarm went off in the simulation when a fire started, and the fire spread if it was not extinguished properly. Depending on what was burning and where it was burning the person using the VR needed to move around in the room to extinguish the fire (see Figure 1).

After the demonstrations the trainees completed the training one by one, while everyone was watching the stream attentively on the projector. The trainees wore the HMD glasses and held the fire extinguisher that was connected to the VR training. The trainer would usually give feedback during the training to each participant depending on what they did. For example, the trainer would ask the trainee to find nearest exit in the simulation before extinguishing the fire. Each of the trainees completed the training with varying difficulties. They started with an easy level and moved on to more difficult levels.

Some groups of trainees talked both during and after the training whilst some groups talked only after everyone had completed the training. The amount of talking varied from group to group and naturally some individuals were more talkative than others. Some groups expressed more skepticism towards the training whilst some groups talked about it favorably. After the trainees had completed the training the trainer usually gave a few concluding remarks and asked some questions. These remarks and questions varied a bit, but generally the trainer talked favorably about the VR and its future prospects. After the training was finished, the trainees received the survey and we left the room. Finally, it is important to note although the general procedure of the training was the same, this does not mean that everything else was exactly the same every time. What was said and done differed a little depending on the trainers and trainees.

Figure 1. VR fire extinguisher training

Descriptive Information

Participants were asked about previous experience with VR and 57 out of 85 respondents had never used VR before, whilst 28 participants had some experience with VR. In addition to this, they were also asked about whether they got nauseous during the VR training and 78 out of 85 respondents did not feel nauseous during the VR training. In general, people evaluated the VR training positively. Forty-one participants gave the VR training positive evaluations by describing the training as *"good", "useful"* and *"forward thinking".*

Themes

Through thematic content analysis four overarching main themes were identified. These are *"physiological and emotional experiences", "VR training as a supplement to traditional training", "perception of reality"* and *"perceived benefits of VR training".*

Table 1.

Overview of the themes and subthemes

Themes	Subthemes
Physiological and emotional experiences	Positive experiences Negative experiences
VR training as a supplement to traditional training	VR training cannot replace traditional training VR training works well as a supplement
Perception of reality	Perceptions of realism in the simulation Valuable, but not realistic enough Missing sensory experiences
Perceived benefits of VR	Provides many scenarios Provides task repetition Contributes to learning VR training is safe VR training is environment friendly Cost-efficient and practical

Physiological and Emotional Experiences

The first theme is about the participants physiological and emotional experiences during and after the training. Different experiences were identified, but in general most of them had a positive experience. This theme has two sub-themes that describe these experiences. These are *"positive experiences"* and *"negative experiences"*.

Positive Experiences. Generally, most participants had a positive emotional experience during the training. Sixty-seven of the participants described feeling *"good", "ok",* and *"fine"* during the training. There were also participants who described that they had fun and felt engaged and excited. Fourteen of the participants expressed this by using phrases such as feeling "*excited"* that it was "*fun*" and that they were "*engaged".* Additionally, 78 participants expressed not feeling nauseous as a result of VR use. These responses indicate that many had a positive emotional experience during the training and most of the participants did not become nauseous.

Negative Experiences. There were a few participants who had negative experiences. Eight participants felt that it was disorienting, stressful and that they experienced nausea. They expressed this by using phrases such as *"a little disoriented", "on edge and easily disoriented"*

and *"ok, but got a little stressed".* Participants also noted that they got *"a little nauseous during the training", "got a little nauseous and could not have done this more than 5-10 minutes", "a little nauseous/uncomfortable with the glasses on"* and *"when changing scenarios experienced confusion and nausea".* One participant also noted that *"the exercises can be irritating for the eyes".* These responses indicate that people had negative experiences during the training which included disorientation and nausea.

VR Training as a Supplement to Traditional Training

The second theme is about what people think about the VR training compared to traditional training. Participants had different opinions about this, but in general they thought that the training works best as a supplement. This theme has two sub-themes that capture the different opinions and experiences of the participants. These sub-themes will be presented in the following section: *"VR training cannot replace traditional training"* and *"VR training works well as a supplement".*

VR Training Cannot Replace Traditional Training. Five participants expressed that they do not think that VR training can replace traditional training. Participants expressed *"good...but cannot replace real training"* and *"ok, but could not feel that it was a good replacement for traditional training".* Participants also noted that it is not realistic enough to replace traditional training. They described it as *"safer, but also too far from reality to replace traditional training"* and *"if one does not have traditional training then one does not know whether the simulation is like reality or not (extinguishing effect, range, external influences like wind etc.)"*. These responses indicate that the VR training is not good enough to replace traditional training according to these participants. In addition to this, the responses also indicate that the realism aspect of VR is important and traditional training is perceived as more realistic.

VR Training Works Well as a Supplement. Generally, there were positive evaluations of the VR-training. Twenty participants thought that the VR training was good compared to the traditional training. They used phrases such as *"good", "just as good",* and *"very good".* Participants also expressed that the VR training could work well as a supplement to traditional training. Sixteen participants used phrases such as *"this can be combined with traditional training", "a good supplement"* and *"works as additional training"* to express their thoughts on the VR training. The responses also showed that a combination of both trainings could be beneficial, and that VR allows training in scenarios that might not be possible in real life.

Participants expressed that they "*should have both trainings"* and that one *"can train in situations which are difficult to train in reality"*. This indicates that they see value in this type of training and prefer to have it in addition to the traditional training.

There were also participants who thought that the VR training was similar to the traditional training. Four participants expressed they thought that the VR training was *"just as good", "very similar"* and *"feels similar"* to the traditional training. They also noted what was dissimilar from traditional training. Three participants described that the training was *"very similar, except not feeling the warmth", "do not get any feeling of warmth with VR, but very similar except of that"* and *"pretty similar, but it's missing the feeling of danger"*. This indicates that many participants evaluated this training positively and that most prefer it as a supplement.

Perception of Reality

The third theme is about participants perception of reality. Specifically, it is about whether the participants found the training to be realistic or not and why it was perceived that way. This theme also includes what the participants expressed is missing from the VR simulation, which is something that might affect their perception of reality. Thus, the following three sub-themes were identified: *"perceptions of realism in the simulation", "valuable, but not realistic enough"* and *"missing sensory experiences".*

Perceptions of Realism in the Simulation. Participants had varying opinions on whether they found the simulation realistic or not. Fourteen participants indicated that the VR training was realistic. Some participants described the VR training as *"realistic", "pretty realistic" "feels like I used a real fire extinguisher"* and *"...scenarios seem realistic".* One participant expressed that it was a *"good experience when it comes to stress".* Similarly, another participant expressed that the *"advantage is to cope with stress".* This indicates that the participants found it to be realistic enough to feel stressed in the simulation. On the other hand, six participants found it not to be realistic as they described it as being *"not very realistic"* and *"not very realistic with all the senses"*. One participant commented that *"it's difficult to trust the extinguishers abilities with computer-generated flames, it's not optimal"*. This indicates that the participant does not think that the simulation can give a realistic representation of how the extinguisher would be in reality because the flames are computer-generated. Another participant commented that *"it's difficult to achieve a realistic experience and feel the senses"*. This response indicates that there are sensory stimuli that are missing and therefore it's difficult to find the simulation to be

realistic. There were thus varying opinions on whether the VR training was perceived as realistic or not.

Valuable, but Not Realistic Enough. Responses from participants indicated that although they did not find the VR training to be realistic or realistic enough, they still found it to be valuable. Forty-six participants expressed their thoughts and generally the consensus was that VR training gives you certain benefits, but it is not as realistic as a real situation. One participant described that *"it works to an extent, but it's missing the feeling of reality"*. Which as mentioned indicates that there is value in the training, but it's not realistic enough. Participants expressed that through the VR training one *"can get many repetitions, but there is a less feeling of reality"*, *"can train in many scenarios, but it's missing a feeling of reality."* and *"pro is to cope with stress, but not as realistic when it comes to warmth".* This indicates that the VR training gives you certain benefits, but it's not perceived as realistic. Other participants expressed what was missing from the VR training, which could have affected why it was not perceived as realistic. Some of them mentioned that the graphics were not optimal. Participants expressed that the training is a *"good supplement, not very realistic scenarios, graphics should be better"* and *"good for environment, safety and cost, but could have had better graphics and be more realistic".*

Other participants expressed that although the training was good it takes away important aspects that happen in real-life situations, thus making it less realistic. Participants noted that the VR training is *" good…,but not as close to reality when it comes to other sensory input, extinguisher is too light and you don't have to take out the safety pin"* and *"focused, but got less respect for the fire than I would have during a real scenario".* Similarly, other participants commented that *"...has potential, looks like one can train the technique of fire extinguishing, but it's difficult to think about/focus on actual danger that comes with fire and smoke"* and *"it goes faster, but lacks seeing how real flames react to extinguishers".* These responses indicate the training is useful, but it is missing practical aspects such as taking out the safety pin, there is a less feeling of danger and a different experience of the flames than one would have in a real-life situation.

Missing Sensory Experiences. Thirty-six participants expressed that there were certain sensory experiences and stimuli that were missing from the VR training. As this was a fire extinguisher training many participants commented that there was no feeling of warmth, smoke,

and smell, and sounds and pressure related to the extinguisher were missing. They used phrases such as *"missing the feeling of warmth, difficulty breathing etc.", "missing smoke, smell and warmth", "cannot feel pressure/resistance in the tube/hose and", "no feeling of gas or warmth", "missing warmth, smell, air, needs more sound"* and *"sounds, smell, warmth provide discomfort that VR cannot catch".* Participants commented that this leads to a decreased feeling of danger and stress. Participants described *"the environment was better, but it's missing what really makes fire extinguishing stressful…", "...don't get a feeling of warmth, danger, smell and smoke"* and *"...no feeling of warmth so you can get too close (to the fire)".* These responses indicate because of these missing sensory stimuli they do not get an accurate representation of the situation in some ways.

Perceived benefits of VR training

The fourth and final theme concerns what the participants found to be the benefits of the VR training. There were many different benefits that were noted by the participants and each perceived benefit represents a certain aspect of the VR training. This theme has six sub-themes that portray the benefits that were identified through the analysis. These sub-themes will be presented in the following section: *"provides many scenarios", "provides task repetition", "contributes to learning", "VR training is safe", "VR training is environmentally friendly"* and *"cost-efficient and practical"*.

Provides Many Scenarios. Participants expressed that one of the benefits with VR training is that one can train in many different scenarios and situations. There were 23 participants who shared this by using phrases such as *"it's (VR) good for different scenarios", "got many scenarios in a short time", "many possibilities for different scenarios",* and that VR is *"efficient when it comes to different scenarios".* These responses also indicate that these scenarios can be provided efficiently. Other participants commented that although there are many scenarios, they do not have all the necessary aspects in the scenarios. Participants described this as *"can see many situations, but no warmth or bad air"* and *"good that one does not need equipment to burn things and this can be repeated in different scenarios, but it's missing the elements of warmth, smoke etc."*. These responses indicate that the participants appreciate that the VR training provides them with many different scenarios and that they get it in a short amount of time. Although, they note this benefit they also note certain aspects that are not as optimal in these scenarios such as the lack of stimuli as warmth and smoke.

Provides Task Repetition. Participants also thought that the VR training is beneficial for task repetition. Twenty participants commented on this aspect by expressing that the training is *"good for repetitions", "some useful when it comes to repetitive training", "efficient for repetitive training", "can train more often"* and *"this can be repeated in different scenarios".* These responses indicate that the participants find it valuable to be able to get task repetitions in the VR training.

Contributes to Learning. Participants also noted that this training can contribute to learning the method and technique amongst other things. Twelve participants expressed that the VR training was *"educational",* led to *"quick-learning", "good for training the technique"* and *"good for learning the method and to get many repetitions".* One participant also commented that watching other people performing the task contributed to their learning. The participant described it as *"easy to repeat and learn from others"*. Another participant noted that *"one gets the same understanding, but it's possible that one gets less understanding of reality (smoke, warmth)"*. This indicates that the training contributes to learning as one gets the same understanding. However, at the same time it could not contribute to learning of all the relevant features in the training. These responses indicate that the VR contributes to learning the method and technique but could not be optimal for other aspects of the training.

VR Training Is Safe. There were also some participants who thought that VR was a safe way to conduct the training. Thirteen participants expressed that they felt safe by using phrases such as *"safe and good"* and *"secure".* Some participants also commented that the VR-training is safe because it leads to less exposure to harmful aspects of fire-extinguisher training. They noted that one *"can avoid gasses, smoke and warmth",* there is less *"risk and exposure"* and that it was *"less damaging and better for health"* and *"health-promoting".* These responses indicate that participants appreciate that they feel safe during the training and that it is less harmful as they avoid being exposed to smoke and gas, which makes it better for their health.

VR Training Is Environmentally Friendly. As this was a fire-extinguisher training the environmental aspect was found to be of importance during the analysis. Twenty-three participants expressed that the VR training was environmentally friendly by expressing that the training was *"environmental"* and *"good for the environment".* Participants also expressed that it was environmentally friendly because it led to less pollution and therefore did not damage the environment as much. They expressed this by using phrases such as that the training led to lesser

amounts of *"emissions"* and *"less pollution"* in the environment. These responses indicate that participants care about the environment and therefore value the fact that this specific VR training is good for the environment.

Cost-Efficient and Practical. Some participants also found the VR-training to be inexpensive. Nine participants commented on this advantage by using phrases such as *"cheap", "cheaper"* and *"inexpensive"*. Participants also commented that the VR training requires less resources than traditional training as they commented that one advantage were the *"facilities"* and that it required *"less resources"* and that it was *"practical".* This indicates that the participants perceive that the VR training is a practical and cost-efficient way to conduct the training for them.

Field Observation

Thematic analysis was also conducted on the observation notes that were made during the VR training. This was done after the analysis on the open-ended questions to ensure that I was not influenced by my own notes prior to analyzing the participants responses. These observation notes consisted of verbal comments made about the training, during and after the VR training was completed by the trainees. In general, most participants were very quiet in the beginning and talked more as the training went on. However, not all the participants in a training group talked equally, some participants talked more than others. Therefore, the observation notes give only an impression of some of the participants opinions on the training, during and after the training. Through the analysis three overarching main themes were identified. These are *"positive evaluations"* and *"negative evaluations"* of VR training, and *"supplementary training".*

Table 2.

Overview of the themes and subthemes

Themes	Subthemes
Positive evaluations	Positive evaluations of training Positive evaluations of realism
Negative evaluations	Skepticism towards VR training Negative evaluations of realism
Supplementary training	

Positive Evaluations

This theme is about participants' positive evaluations about the training and technology. This theme has two sub-themes, and these are *"positive evaluations of training"* and *"positive evaluations of realism".*

Positive Evaluations of Training. Majority of the groups were generally positive towards the VR training and its prospects. Field notes of different trainings say, *"overall positive group", "in general very positive towards the training and can see the potential", "generally positive about it", "participants thought it (the training) was good"* and *"they were positive towards the possibilities with this training".* Participants in some groups also commented that they found the training to be to be enjoyable and cool. Field notes say*, "they find it fun and enjoyable, think it's good", "thought it was cool and fun", "trainees talked about how it's a cool technology"* and *"they mentioned that its very cool"*. Participants in some groups also thought it could be educational. Field notes say, *"people thought it was good and educational", "they could see that this is helpful for their learning"* and *"they found it fun and educational".* These notes indicate that many gave the VR training positive evaluations and found it to be enjoyable and educational.

Positive Evaluations of Realism. Trainees in some groups also made positive comments about realism in the VR. Field notes say *"they thought it was very real and cool that they were suddenly in another room", "in general impressed by the simulation and that it's cooler when it's more challenging, but that it looks real"* and *"they talked about that it felt real".* These field notes indicate that the trainees were impressed by the technology and thought it was or felt somewhat realistic.

Negative Evaluations

This theme is about participants negative evaluations about VR and VR training. This theme has two sub-themes, and these are *"skepticism towards VR training"* and *"negative evaluations of realism".*

Skepticism Towards VR Training. Participants in some groups expressed their apprehension towards the VR-training. This was expressed both before and after the VR-training was completed. Field notes say, *"they said that they might become nauseous before trying the VR"* and *"some people expressed that they were skeptical of VR".* In addition to this, some trainees expressed their skepticism by calling the training weird. Field notes say, *"some found*

the VR to be weird" and *"talked about how it's a bit weird (VR)".* These notes indicate that the trainees were a bit skeptical towards the VR training, specifically about how it might make them feel and how it is unusual.

Negative Evaluations of Realism. Participants in some groups also commented that the VR was not realistic and that it lacked certain sensory experiences. Field notes say, *"they think it's very artificial and doesn't feel real", "talked about that one should feel the warmth (fire) for it to feel real"* and *"said that it's difficult to see the distance in the simulation".* Trainees commented that the feeling of heat was missing. Field notes say, *"thought it was good, but there should be some sort of feeling of heat"* and *"they think it was good and that it would be even better if one could feel the heat"*. These notes indicate that some trainees did not find it to be very realistic and that there were certain sensory experiences that were missing.

Supplementary Training

The third theme concerns the trainees' preference for the VR training as a supplementary training. Field notes say, *"they can see why this is helpful, but that VR cannot replace real fire training", " mentioned how it works almost as good as real fire training", "they said that it worked well as a supplement to the real fire training"* and *"talked about that training with real fire is important, but that it felt real in the VR as well".* These notes indicate that although the participants found the training to be helpful it could not replace traditional fire training, and this worked better as a supplement.

Comparison of Analyses

The results from the survey data are the main findings of this study and the field observation notes were used to provide context and to provide a fuller picture of the data. The comparison of results from the two analyses led to finding complementary results as similar themes and patterns were found in the survey data and the observation notes. Generally, the observation notes supported the findings from the survey data. The preference for VR training as a supplement was expressed both in the survey data and was captured in the observation notes. Similarly, the perception of realism in the simulation was also evaluated similarly. Finally, the VR training was given generally positive evaluations in the survey data and this was also captured in the observation notes.

Thus, the content of the three main themes identified from the field notes was very similar to the content of the themes from the survey data, expect the fact that the surveys

provided a more rich, detailed and diverse data. There was however one sub-theme that was captured in the observation notes that was not present and identified in the survey data. The content in the sub-theme named *"skepticism towards VR training"* was only found in the observation notes.

Discussion

This thesis is concerned with how safety training using VR is evaluated by offshore oil and gas industry workers. As mentioned in the introduction, the aim of this thesis is to be able to give valuable insight into what is important to consider when implementing VR technology in safety training, how such training is evaluated and the reasons for these evaluations. Evaluating trainings is essential as it can provide valuable insight and help with further development of trainings (Salas et al., 2012). This section will start with a summary of the results from the analysis. This will be followed by a discussion of the results in relation to empirical findings and theories presented in the introduction. Reflexivity will also be addressed before a presentation on the implications of the research. Lastly, suggestions for future research will be presented which will be followed by a conclusion of the thesis.

Summary of Results

Four main themes were identified from the survey data and the observation notes that reflected the participants evaluations of the safety training with VR. Most participants had no previous experience with VR (57 out of 85). The first theme concerned participants physiological and emotional experiences during and after the VR training. A majority of the participants had a positive experience in the VR. Results indicated that they had positive emotional experiences and that most participants did not feel nauseous as a result of the training. There were also some participants who had negative experiences in the VR as they described feeling disoriented, stressed and nauseous because of the training.

The second theme concerned the participants evaluations of the VR training compared to traditional safety training. Some participants expressed that the VR training cannot replace traditional training, whilst most participants expressed that VR training works well as a supplement to traditional training. For some the VR training was similar to traditional training, however participants also noted the dissimilarities which reflected the aspects that they thought were missing from the VR training. The third theme represented participants perception of reality in the VR training. Some participants thought that the VR training was realistic whilst others did not find the VR training to be as realistic. It was mentioned that the simulation cannot give a realistic representation of how the situation would be in reality. It was also pointed out that there were certain sensory experiences and stimuli that were missing from the simulation. It was indicated that these in turn can lead to inaccurate representations of the situation. Although

participants had varying opinions on realism, they still found the VR training to be valuable. Most of the participants expressed that the VR training provides certain benefits, despite not being as realistic as it should be.

The final theme represented the perceived benefits of VR training. Results indicated that the VR training provides many scenarios and that it is beneficial for task repetition. It was also pointed out that the training can contribute to learning the method and technique of fire extinguishing. VR training was also perceived as a safe way to conduct the training and identified as environmentally friendly. Results showed that the VR training was deemed as a cost-efficient and practical way to conduct the training. The observation notes generally supported the findings from the survey data, however the aspect of skepticism towards VR was only identified in the field observation notes.

Discussion of Results

Overall, the findings indicate that the VR training was generally positively evaluated by the majority of the 85 participants which is in accordance with previous research findings (Jensen & Konradsen, 2018). Trainee reactions can provide information that can be a useful part training evaluation (Morgan & Casper, 2000). As mentioned previously, safety is a major concern in the offshore oil and gas industry, the participants' evaluations on this type of safety training need to be considered and is important for further development of VR use in safety training. Although the VR training was generally evaluated positively, the analysis identified aspects which need to be considered and further developed for this type of training.

Influences on Evaluations of VR

There are many factors that can affect evaluations of VR technology. Research shows that simulator sickness is one factor that can play a role in evaluation and acceptance of VR technology (Fernandes et al., 2016). Simulator sickness symptoms can lead to a negative attitude towards the technology (Fernandes et al., 2016; Kleven et al., 2014; Polcar & Horejsi, 2015). In addition to this, simulator sickness is also understudied in safety trainings with VR despite being a very common side effect of VR use (Grassini & Laumann, 2020). Therefore, it is important to explore whether it might have played a role in the trainees' evaluations concerning the VR training.

Participants responded to how they felt during the training and were explicitly asked about whether they experienced nausea, which is a common simulator sickness symptom

(Fernandes et al., 2016). The results however showed that 78 out of 85 participants did not feel nauseous or experience other kinds of discomfort because of the VR training. Simulator sickness can understandably lead to negative evaluations of VR and negatively affect acceptance of VR technology (Fernandes et al., 2016; Kleven et al., 2014; Polcar & Horejsi, 2015). Thus, since a majority of the trainees did not experience uncomfortable symptoms related to VR use, these indirect negative effects of simulator sickness probably had no influence on their evaluation of the VR training. It is important that VR is a comfortable and positive experience for users if it is to be implemented in safety trainings, because trainees should not risk becoming sick as a result of such trainings.

In addition to this, results showed that 67 participants had a positive emotional experience during the VR training. Participants expressed feeling good and some noted that they felt excited, engaged and had fun in the simulation. This finding is in line with previous findings that showed that participants across several studies generally perceived the VR experience to be positive and exciting (Jensen & Konradsen, 2018). A positive emotional experience does not necessarily mean that the participants will find the VR training to be valuable or useful for them. However, findings from this study shows that participants do find this type of training to be valuable. Therefore, a positive emotional experience could have affected the evaluation of VR positively.

Results also showed that 8 participants had negative VR experiences. Participants expressed that they felt disoriented and stressed in the VR. In addition to this, participants also reported experiencing nausea to some extent. Feeling disoriented and nauseous are common simulator sickness symptoms related to VR use, and a few participants experiencing uncomfortable symptoms is therefore not unusual (Fernandes et al., 2016; Jensen & Konradsen, 2018). As there were only a handful of people who had a negative VR experience, it could perhaps be due to personal factors rather than factors related to the technology. Research shows that personal factors can impact the VR experience, especially people with more reserved or anxious personalities can have a negative experience in the VR (Janssen et al., 2016). Therefore, personal factors may be the reason why some of the participants had a negative experience in the VR.

The fact that 8 of the participants experienced simulator sickness symptoms should be considered a reason for concern. If organizations are to implement VR in safety trainings, they

cannot risk the employees becoming sick or not feeling well as a result of the training. There may always be a need for alternative trainings for people who experience such symptoms. However, research has shown that repeated exposure to simulators, can decrease simulation sickness for some users as a result of habituation (Domeyer et al., 2013; Kennedy et al., 2000). It may be possible that these symptoms could be reduced over time, however more research is needed on this subject matter. Simulator sickness symptoms can also lead to a negative attitude towards VR and negatively affect learning attitudes (Fernandes et al., 2016; Kleven et al., 2014; Polcar & Horejsi, 2015). Therefore the 8 participants who experienced these symptoms may have developed a negative attitude towards VR technology and it could have also affected their learning attitudes, which could have influenced the outcome of the training.

Research has also shown that experiencing symptoms related to simulator sickness can negatively affect the sense of presence (Jerome & Witmer, 2004; Keshavarz & Hecht, 2012). Presence refers to the degree to which persons feel like they are in the virtual environment (Slater & Wilbur, 1997). This could mean that simulator sickness symptoms may have also negatively affected the sense of presence in the VR for the 8 participants who experienced these. Furthermore, the experience of presence may have an influence on simulator sickness. Research shows that increasing the sense of presence in the simulation can decrease simulator sickness symptoms (Maraj et al., 2017). Thus, presence might also play an important role in mitigating simulator sickness symptom, and therefore it may be important to find out which aspects might increase the sense of presence felt by users in order to decrease the occurrence of simulator sickness symptoms.

Overall, 67 of the participants had a positive experience in the VR as they did not report simulator sickness symptoms and because they experienced positive emotions. This is important for the continued implementation of VR in safety training. Research shows that trainee reactions can affect learning and motivation (Kim et al., 2019; Sitzmann et al., 2008). Since 67 of the participants had a very positive VR experience, it may have positively affected their evaluations of the VR training and may have also positively influenced their motivation and learning during training sessions. However, there were 8 participants who experienced simulator sickness symptoms and the occurrence of such symptoms as a result of VR use calls for more research on the subject matter as it can lead to negative consequences.

Safety Training with VR in Comparison to Traditional Safety Training

Results indicated that 5 participants think that the VR training cannot replace traditional safety training. This finding is supported by previous research which shows that practitioners still prefer using traditional safety training over VR training (Bhoir & Esmaeili, 2015). This finding could perhaps be related to acceptance of VR technology. According to research, there are many factors that can affect acceptance, such as age, previous experience with technology and technological deficiencies (Fernandes et al., 2016; Grassini & Laumann, 2020; Huygelier et al., 2019; Mütterlein & Hess, 2017).

Previous findings show that young people evaluate VR more positively than older people and that prior experience with VR positively impacts its evaluation (Huygelier et al., 2019; Plechatá et al., 2019). These factors can play a role in acceptance and evaluation of VR technology (Plechatá et al., 2019). The participants in this study were on average middle-aged adults and 57 out of 85 trainees had no previous experience with VR. Based on what previous findings show, it is possible that age and lack of previous experience could have played a role in their evaluation regarding VR. Especially when it concerns VR replacing traditional training as this evaluation might be related to or affected by acceptance of VR technology.

In addition, field notes also indicated the presence of skepticism towards the VR training. Participants in some groups expressed their skepticism concerning the unusualness of VR and how it might make them feel (e.g. nausea). This finding might also be related to the trainees' lack of experience with VR as 57 of them had no prior experience with the technology. However, research indicates that previous experience with VR can increase acceptance of VR technology (Huygelier et al., 2019; Plechatá et al., 2019). Therefore, it is also possible that the participants may have become more open to the VR training than they were before they tried it.

Forty-six of the participants expressed that the training is not realistic enough. Two participants also expressed that the reason VR training cannot replace traditional safety training because it was not realistic enough. This can be explained by the fidelity of the VR training. Fidelity refers to how realistic the virtual environment is compared to a real environment (Hamstra et al., 2014). These findings indicate that fidelity is important for the trainees. In addition to this, research on training effectiveness does recommend that training should be realistic in order to assure positive outcomes of the training (Burke & Hutchins, 2007). Thus, realism or fidelity is important for both researchers and practitioners.

Fidelity can be impacted by the level of immersivity i.e. technical aspects related to the VR. Different types of technical features have been found to positively impact fidelity (Hamstra et al., 2014; Yu et al., 2012). Hence, it could be possible that not finding the VR training realistic enough could be caused by technical deficiencies. In addition to this, technical deficiencies can also negatively impact the acceptance of VR technology (Mütterlein & Hess, 2017). Therefore, this could have in turn also affected VR technology acceptance in the trainees as well. This could also explain why the trainees expressed that the VR training cannot replace traditional safety training.

One of the main findings of this study is the preference for VR training as a supplement to traditional safety training. There were 36 participants who expressed that the VR training works well as a supplement. Although participants believe that the VR training cannot replace traditional training, it is still perceived as a valuable supplement. Three participants also recognized the dissimilarities between VR training and traditional training. These dissimilarities were aspects related to fidelity, which were missing in the VR that were found in the traditional training. This might shed a light on why participants prefer VR training as a supplement as they noticed lower levels of fidelity. Trainees expressed that VR allows to train in situations that might not be possible in real life. One key aspect of VR is that one is able to do and experience things that might not otherwise be possible and this finding shows that the trainees themselves recognize this as a benefit for their training (Slater & Sanchez-Vives, 2016).

Certain industries, such as offshore oil and gas industry that the participants work in, is associated with more hazards than other industries (Grassini & Laumann, 2020). Research has indicated that safety training with VR can provide realistic simulations of different threats that workers may face in their work (van Wyk & de Villiers, 2019; Guo et al., 2012). VR makes it possible to expose workers to dangerous situations that might arise without actually putting them at risk and gives them the opportunity to learn how to assess and choose the best course of action (Lucas et al., 2008; Sacks et al., 2013). As some of the participants recognize that VR allows them to train in situations that might not be possible by traditional training, it could indicate that safety training using VR is realistic in a different way than traditional safety training. Results also indicated that VR training is perceived as beneficial because participants think that they should have both type of trainings. This indicates that both trainings might have different strengths that appeal to the participants, some of which have been recognized by previous

research (van Wyk & de Villiers, 2019; Guo et al., 2012). The findings from this study shows, that fidelity is recognized as an important aspect which influences the participants evaluations of the VR training in comparison to traditional safety training.

Perception and Opinions on Fidelity in the VR Training

Study findings shows that the aspect of realism in training is important for the participants because they had different opinions on how realistic they found the VR training. Fourteen participants evaluated the VR training as realistic. This can be explained by certain factors related to immersivity, such as room for action, interaction and sound features, which have been found to influence the evaluation of realism (Fox et al., 2009; Hamstra et al., 2014; Zahorik, 2002). In the VR training, the trainees were able to interact within the VR by using a fire extinguisher to put out different types of fires. They needed to walk around in the virtual environment in order to locate the fire and fire exits, and then put out the fire. Different types of sounds were present in the VR environment, such as the fire alarm, burning effects and extinguishing sounds. Hence, being able to interact with the virtual environment and the presence of different sound features could be the reason why 14 of the trainees found the VR training to be realistic as these aspects have been found to increase the perception of realism.

Results also indicated that the VR training was perceived as realistic because the participants found the scenarios to be realistic. Having room for action, interaction and different sound features in the VR, could have also contributed to evaluating the scenarios as realistic as well, which is supported by previous research (Fox et al., 2009; Zahorik, 2002). Results also showed 2 participants thought the VR training was realistic because the scenarios were stressful. This could indicate that they see the experience of stress as important in this training. According to research, relevant contextual factors such as stress, can be important for learning skills that need to be applied in a context that is stressful (Driskell et al., 2001; Morris et al., 2004). As the trainees are training their skills for a potentially dangerous situation that they might need to manage, the experience of stress might be an important contextual factor for their learning. Therefore, this could help explain the reason why stress increases their perceived realism and why it is seen as important in this training.

Six participants did not find the VR training to be realistic. Participants expressed that the graphics in the VR were not ideal and that they could be better. When participants are expressing their thoughts on graphics and other technical features, they are talking about the immersive

aspects of the VR training (Slater, 2003). Research shows that immersive features, such as sensory experiences provided by the VR, can affect the perception of reality (Hamstra et al., 2014; Schuemie et al., 2001). This finding is in accordance with previous findings that show that immersive aspects can affect the perception of reality. In addition to this, immersive or technical deficiencies can also negatively affect acceptance of VR (Mütterlein & Hess, 2017). Therefore, their negative evaluations of graphics could have also decreased their acceptance of VR technology.

Thirty-six participants expressed that the VR training was missing certain sensory experiences. These sensory experiences included warmth, smoke, smell and sound. It was also expressed that the simulation was not reflecting reality as it did not give a realistic representation of how the flames would react to the fire extinguisher. These descriptions can be related to what is referred to as physical fidelity. Physical fidelity concerns the degree to which the virtual environment looks, sounds and feels like the equivalent real environment (Alexander et al., 2005; Kozlowski & DeShon, 2004). Thus, this indicates that certain aspects related to physical fidelity were missing in this simulation and therefore the simulation did not accurately reflect reality. In other words, these are aspects that the participants consider relevant and that should have been present in this specific VR training.

Findings also indicated that these missing sensory experiences led to a decreased feeling of stress and danger in the simulation, and resulted in an inaccurate representation of the situation in the VR, according to 3 participants. When participants are commenting on the feeling of stress and danger, they are evaluating the psychological fidelity in the VR. Psychological fidelity concerns the degree to which the virtual environment produces the psychological factors experienced in the equivalent real environment (Alexander et al., 2005; Kozlowski & DeShon, 2004). This could indicate that the experience of stress and danger are psychological factors that are not produced in the virtual environment as they are in the equivalent real environment.

However as mentioned earlier, 2 participants found the training to be realistic as they found the scenarios to be stressful. These are contradictory findings as some participants found the simulation to be stressful whilst others did not. This could perhaps be because certain realistic elements in the training, such as the ability to interact with the environment and the presence of sound features, could have increased the perceived reality and the experience of stress. However, the absence of certain features related to physical fidelity might have decreased

the perceived reality, and the experience of stress. Nonetheless, the experience of stress and danger is seen as important in this training. The results therefore may indicate that physical fidelity might be important for increased psychological fidelity as missing aspects related to physical fidelity decreased the feeling of stress and danger, i.e. psychological fidelity. As mentioned earlier, the trainees are training to manage a potentially dangerous situation and therefore relevant contextual factors can be important for their learning (Driskell et al., 2001; Morris et al., 2004).

Research shows that trainee reactions and evaluations can capture important characteristics related to the training environment (Sitzmann et al., 2008). In this case, this concerns the virtual training environment and these findings show that physical and psychological fidelity are important in training since aspects related to these affect their perception of reality. The importance of fidelity for training and learning has been recognized by previous research and the findings from this study further indicate what kind of fidelity might be important to consider in safety training (Issenberg et al., 2005 Alexander et al., 2005, Hamstra et al., 2014).

Based on these findings it could also be assumed that presence was affected. As mentioned earlier, presence refers to the degree to which persons feel like they are in the virtual environment (Slater & Wilbur, 1997). Presence is affected by the degree of realism in the VR and increased fidelity can increase the sense of presence. Perhaps the reason participants did not feel stressed is also because they did not feel a high degree of presence in the virtual environment. Findings indicate that participants did not evaluate fidelity too favorably, which may therefore indicate that they also did not feel a high degree of presence in the virtual environment.

Despite the somewhat negative evaluation of fidelity in the VR, 46 of the participants still found the VR training to be valuable. Which indicates that although the aspect of realism is identified as vital, there are also other aspects that are considered important. This is a meaningful finding as it is important that trainees find this training as valuable, despite its technical shortcomings. Previous research has identified that VR is useful and effective for safety training (Bhoir & Esmaeili, 2015; Grassini & Laumann, 2020; Li et al., 2018). Research has also shown that risk identification and awareness can improve, workers can see the consequences of their actions and most importantly, all of this is done without risking their safety (Higgins, 2017; Li et

al., 2018; Lucas et al., 2008; Sacks et al., 2013; van Wyk & de Villiers, 2019). Despite this, organizations and practitioners are still reluctant to use VR for safety training purposes (Bhoir & Esmaeili, 2015). Therefore, their positive evaluations, such as 46 participants evaluating the training as valuable, is important because it provides further reasons for why VR should be further developed and implemented in safety trainings.

Technical shortcomings are valid problems, however it is expensive to develop VR and therefore the technology's value should not be discarded just because it is not realistic enough. Furthermore, it can also be argued that traditional safety training is also not realistic to some degree. In this specific case there was a burn barrel that contained fire, which the trainees had to extinguish, whilst in the VR training the trainees had to extinguish different kinds of fires in different situations. The VR training allowed the participants to interacted more with the fire during the training session. Therefore, it should be noted that both the VR training and the traditional training are simulations of situations and they have different strengths. For instance, in the traditional training, the trainees can feel the warmth and smoke from the fire, whilst in the VR training, they are able to extinguish many kinds of fires in different situations.

Although, there are other realistic simulations available (e.g. firefighter training), they can be very expensive to develop and adding elements should depend on what is being trained and who is being trained, rather than always aiming for absolute realism. Adding more elements to the VR can potentially cause more latency (slower response in VR). Therefore, there should be a balance concerning what to add and not, which should depend on what is being trained. Both type of trainings are only simulations, and actual hazardous situations could be different regardless of the training received. Instead, both of these trainings could be beneficial for different aspects of the safety training. Furthermore, various technical shortcomings can be identified and improved upon with further research, which is why it is important that such trainings are used so that they can be further improved.

The findings related to the perception of reality indicate that high level of fidelity is considered important in safety training using VR amongst the majority of the 85 participants. However, research has shown that adding different immersive aspects in VR, which may increase perceived realism are not necessarily useful or effective (Fernandes et al., 2016). This is because the addition of immersive aspects can be distracting for users as their attention is drawn away from the learning task to the immersive aspects (Fernandes et al., 2016; Moesgaard et al.,

2015). Research has also shown that the addition of immersive aspects can facilitate learning (Alhalabi, 2016; Reiners et al., 2014). Therefore, increased realism for certain elements is recommended instead (Ragan et al., 2015). The presence felt can also be increased by adding immersive features and increasing fidelity. Therefore, it is important to find out which aspects might be relevant since increased presence can amongst other things, potentially mitigate simulator sickness symptoms (Buttussi & Chittaro, 2017; Maraj et al., 2017).

One should also discuss whether presence is actually important in VR training. Results show that the aspect of fidelity is important for the majority of the 85 participants. However, when participants are evaluating fidelity it could be argued that they are also indirectly evaluating presence. This is because if the participants felt a sense of presence in the virtual environment, they would have thought it was very realistic. Fidelity and presence are closely linked. Some questionnaires also measure realism when measuring presence (Schubert et al, 2001). Furthermore, presence represents an important aspect of VR evaluation and is important to consider when evaluating VR technologies (Hein et al., 2018; Slater, 2003).

As mentioned above, research has shown that although immersion can increase the feeling of presence, immersive elements can also distract from learning tasks and increased realism or addition of relevant immersive aspects should be considered instead. (Makransky et al., 2019). Based on the results, this study indicates that the addition of relevant aspects related to physical and psychological fidelity could be important factors for safety training. These fidelity types have been identified as important aspects in the training because this has affected their evaluations. This might perhaps be further explained and argued by research that shows why fidelity and presence is important to consider when approaching learning tasks.

The Importance of Fidelity and Presence in Learning and Training Transfer. A variety of research has shown that fidelity and presence play an important role in learning and transfer of training (Chittaro & Buttussi, 2015; Jensen & Konradsen, 2018; Kahlert el al., 2015; Norman et al., 2012). Fidelity can play a role in acquisition of skills (Jensen & Konradsen, 2018; Ragan et al., 2015). The participants in this study were learning skills which can be described as psychomotor skills. The aim was to scan the room, locate and put out the fire. Research shows that fidelity is important in learning psychomotor skills, specifically that more realistic scenarios can lead to better learning of psychomotor skills (Jensen & Konradsen, 2018; Ragan et al., 2015). Results from this study indicate that aspects related to fidelity were lacking according to

participants which could be a hinder for their learning in some ways. Therefore, fidelity is important to consider when training psychomotor skills as safety trainings can be aimed at training these.

Research has also shown that high fidelity is important because it can lead to better memory retention (Chittaro & Buttussi, 2015). One of the desired outcomes of work trainings include that they lead to learning, and memory retention understandably plays a role in that. According to research, memory retention can be improved by arousal of emotions and the presence of relevant contextual information, such as the experience of stress and anxiety (Finn & Roediger, 2011; Driskell et al., 2001; Kensinger, 2009; Morris et al., 2004). Based on the participants responses, results show that aspects related to physical fidelity were missing, which as previously implied could have decreased the experience of stress in the simulation. Therefore, physical fidelity might have not only affected the participants perception of psychological fidelity. It might have also affected their memory retention as this can be increased as a result of the arousal of relevant stress and danger. Furthermore, the feeling of presence is also linked to arousal of emotions, especially negative emotions (Riva et al., 2007). Experiencing stress and danger in this study could have led to potentially increased their feeling of presence as well. Which further demonstrates the importance of relevant contextual information and emotions in training.

However, research indicates that critical context relevant information is sometimes absent in simulation-based trainings (Alexander et al., 2005). The participants trained on a situation which would require them to extinguish fire. A situation like this, would have evoked a feeling of danger and stress in the real world, however these feelings may have not been evoked in the VR training based on the participants responses. The reason such information is important, is because it can have an effect on not only learning, but also transfer. The aim of any training should not only be to improve learning in the simulation, but also to ensure transfer of training (Alexander et al., 2005; Salas et al., 2012). Research has shown that skills can be learned and improved in VR, however that does not necessarily lead to improvement of skills outside of the VR, meaning no transfer of training (Sportillo, 2015). Similarity of relevant contextual information in the real setting and the training setting might play a role in transfer of training (Baldwin & Ford, 1988; van der Locht et al., 2013).

The principle of identical elements (Woodworth & Thorndike, 1901) states that the similarity between the training setting and the actual performance setting leads to transfer of training. The likelihood of transfer increases with the degree of similarity between the settings. The participants in this study did not directly talk about transfer, but their evaluations of physical and psychological fidelity in the VR training, can be related to the principle of identical elements. Thirty-six participants expressed that certain elements such as warmth, smoke, smell and sound were missing from the VR. These would be present in the face of a real emergency situation that required them to extinguish fires. Research shows that similarity between the training setting and the equivalent setting can make it easier for trainees to apply what has been learnt, and it can help trigger the appropriate responses such as actions, decision-making processes and psychological responses (Baldwin & Ford, 1988; van der Locht et al., 2013). Thus, the experience of stress and danger induced by these elements might be necessary to trigger the correct responses in the situation. Therefore, the aspect of identical elements might be of importance in safety training using VR, as it can help ensure transfer of training by helping trainees to apply what they have learnt and trigger the relevant responses.

Generally, research shows that training settings that resemble the equivalent real-life settings lead to transfer of training (Grossman & Salas, 2011). Based on the participants responses, this study indicates that physical fidelity and psychological fidelity in the VR is important for safety training. Moreover, results from this study also indicate that physical fidelity is important because it can increase critical psychological fidelity aspects in the VR training.

Research has shown that psychological fidelity may be a more important factor than physical fidelity in training, because it may play a more important role in transfer of training (Norman et al., 2012; Salas et al., 2009). Increased psychological fidelity is able to capture essential psychological processes that are vital for transfer (Kozlowski & DeShon, 2004). Through simulations, critical psychological processes are evoked which are relevant for learning and which ensures transfer (Kozlowski & DeShon, 2004). As mentioned previously, based on the results from this study, the feeling of stress and danger could have been important for learning. That is because those feelings could evoke critical psychological processes in the relevant situations. Therefore, in order to increase transfer of training it might not necessarily be important that physical fidelity is very high. It may be more important that psychological fidelity is optimal, as it might be more important for triggering appropriate responses. The results from

this study support this argument, since missing aspects in physical fidelity are considered important because they led to a decreased feeling of stress and danger, meaning reduced psychological fidelity.

To sum it up, this study would argue that it may be more important to focus on ensuring high psychological fidelity and only focusing on adding relevant aspects of physical fidelity in safety training using VR. There were varying opinions on the perception of reality. Some participants expressed that they found the VR training to be realistic. However, most participants expressed that the aspect of realism in the training was not optimal. Results indicated that both physical and psychological fidelity are important for the participants evaluations and that these were lacking in some ways. Results also indicate that physical and psychological fidelity can provide vital contextually relevant information that might be important for the trainees learning and transfer of skills. Moreover, psychological fidelity might be of more importance for transfer than physical fidelity. What makes safety training with VR valuable is that potentially dangerous situations that workers might face in their work, can be trained in realistic simulations (van Wyk & de Villiers, 2019; Guo et al., 2012). Therefore, it is important to find out how such simulations can be realistic enough to be effective for learning. Despite the somewhat unfavorable evaluations of realism in the VR, the trainees still found the VR training to be valuable. As trainee reactions are important and can provide valuable insight, this finding should further provide reasons for developing VR for safety trainings. Thus, all things considered, the aspect of reality plays an important role in safety training using VR.

Perceived Benefits of the VR training

Findings from this study shows that participants identified several benefits of the VR training. Twenty-three participants expressed that VR can provide many scenarios in a short amount of time and according to 20 participants it was beneficial for task repetition. This finding is in line with previous research that has identified variation in scenarios and repetitive practice as one of the many benefits of VR training (Issenberg et al., 2005). Research has shown that these aspects can facilitate learning in high-fidelity simulations such as VR (Issenberg et al., 2005). Variation in scenarios provides trainees with a broad variety of situations that they can train their skills in, whilst repetitive practice gives them the opportunity to be engaged in task repetition which can lead to skill acquisition in shorter amounts of time. Thus, these two aspects

which were identified as benefits of the VR training could have also facilitated learning for the trainees.

Results also showed that the VR training contributed to learning. Training is a time and resource consuming process which makes it very important that it leads to learning (Salas et al., 2012). Twelve participants expressed that the training contributed to learning the methods and techniques of fire extinguishing. The goal of training is to achieve or improve skills, knowledge and attitudes by going through a planned and strategic learning process (Millhem et al., 2014; Salas et al., 2016). This finding indicates that participants were able to achieve and modify skills related to fire extinguishing. Participants also expressed that observing other trainees contributed to their learning. Learning by observing others is a well-known learning strategy (Van Gog, 2009). This indicates that learning by observing others could be of importance in safety training using VR as well.

However, it is also important to mention that participants also acknowledged that although the VR training contributed to learning techniques and methods, it was not optimal for learning about other aspects of the training. Similarly, although participants evaluated variation of scenarios as a benefit to their training, they also recognized that the scenarios were not optimal. The reasoning for these evaluations provided by the participants was attributed to the lack of realistic aspects in the training. Which has been a consistent theme throughout the participants evaluations.

Another benefit of VR training identified by the participants responses concerned safety, the participants perceived VR as a safe way to conduct the training. Thirteen participants expressed that they felt safe and that they were protected from the harmful effects (e.g. hazardous gasses) of the training, which in turn made this training better for their health. This finding contradicts previous research that has shown that participants felt unsafe in the VR since they had no access to their surroundings (Reiners et al., 2014). This could perhaps be explained by the nature of safety training. Such trainings can require the trainees to be exposed to some level of risk depending on the aim of the training. However, VR allows exposure to dangerous situations without really putting them at risk (Lucas et al., 2008; Sacks et al., 2013). Additionally, this might also be attributed to the nature of the fire extinguisher training, as one is exposed to harmful gasses during traditional training. Avoiding these gasses could explain why the participants viewed the VR training better for their health. Therefore, the reason why

participants felt safe in the VR could be because traditional training might expose them to more risk.

One surprising finding from this study was that 23 participants expressed that the training was environmentally friendly. Results indicated that they care about the environment and therefore valued that the training was environmentally friendly. This finding could perhaps also be explained by the nature of this specific safety training. Fire extinguishing training requires putting something on fire which as a result releases toxins and harmful gasses in the environment. Since the participants value that the VR training is environmentally friendly it could perhaps positively affect their acceptance towards the use of VR technology in safety training. However, this is only a speculation and this link needs to be further researched.

Results also showed that using VR was perceived as a cost-efficient and practical way to conduct the training by 9 participants. Participants expressed that the training was cheaper and a practical way to conduct the training. In addition to this, it did not require many resources. Traditional safety training, whether it is fire extinguishing training or not, requires more resources to conduct the training. However, for VR training, the only resource needed is VR and its equipment. Also, the equipment itself is reusable as it does not require any new set up every time it is used. Research has found that VR is a cost-effective way to conduct the training (Cardoso et al., 2017). Many researchers also argue that VR is more cost-effective than traditional training (Grabowski & Jankowski, 2015; Patle et al., 2019). Therefore, these aspects of the VR training could explain why the participants viewed it as cost-efficient and practical.

To put it all together, safety training using VR offers several benefits, such as increased learning and through observation, variation in scenarios, task repetition, increased safety, environmentally friendly and cost-efficient and practical. However, the lack of certain realistic aspects was seen as a factor that could have hindered learning and the evaluation of scenarios.

Applying the Findings to Kirkpatrick's Training Evaluation Model

According to Salas and colleagues (2012) a training should be evaluated at multiple levels which includes measuring reactions, learning, behavior and results. As this study is concerned with trainee’s evaluations of safety training using VR, it could be thought of as encompassing the first level of Kirkpatrick's training evaluation model (2006) which concerns reactions to the training. Trainee reactions can be an indicator of training evaluation and valuable information can be gathered from trainee reactions (Morgan & Casper, 2000; Salas et al., 2012).

The VR training got positive evaluations which is line with previous findings concerning the evaluations of VR training (Jensen & Konradsen, 2018). The training works well as a supplement, and many benefits of VR training were identified. Fidelity in the VR could have been better and improved. Nonetheless, the participants still found the training valuable. In addition, most participants had a positive emotional experience because of the training, and most did not experience simulator sickness symptoms. Overall, the training was mostly positively evaluated by the participants and according to the model, this could lead to a positive effect on their motivation and assure continuation of the training (Kirkpatrick & Kirkpatrick, 2006).

The second level in Kirkpatrick's model (2006) concerns learning. The findings from this study cannot with certainty argue that learning took place as learning was not directly measured, however the findings could give an indication to how learning might have been impacted or improved. Research has found that training reactions can influence learning (Kim et al., 2019). It could be that certain aspects of the participants reactions affected their learning in some ways. The participants themselves identified learning the methods and techniques as an outcome of the training. In addition, aspects such as variations in scenarios and task repetitions in the VR training might have contributed to learning (Issenberg et al., 2005). Fidelity is another aspect that could have played a role in their learning. Aspects related to physical and psychological fidelity might have hindered their learning by impacting acquisition of psychomotor skills and memory retention (Jensen & Konradsen, 2018; Ragan et al., 2015). Thus, certain aspects of the training might have led to learning, whilst some factors might have hindered learning. Ideally, this should be measured with post-training knowledge or skill tests (Kirkpatrick & Kirkpatrick, 2006).

The third level concerns behavioral change which can be measured based on whether it can be observed on the job (Kirkpatrick & Kirkpatrick, 2006). In other words, it concerns transfer of training or learning. Similarly to the previous level, the findings from this study can only give an indication of how transfer may have been impacted, and not whether transfer would or would not have taken place. Somewhat low physical and psychological fidelity might have affected transfer in some ways, because learning situations that resemble the equivalent real-life situations, lead to transfer of training (Grossman & Salas, 2011). The importance of similarity in stimuli for transfer is identified by both the principal of identical elements (Woodworth & Thorndike, 1901) and research indicating that similarity in stimuli can help trigger the appropriate responses in the relevant work situation (van der Locht et al., 2013). Physical and

psychological fidelity was not high which could have negatively affected transfer. Additionally, as aspects related to physical fidelity were lacking, it could have led to participants missing important contextual information. This could in turn hinder the activation of appropriate psychological responses, thus being a hinder for transfer.

The final level of this training evaluation model concerns organizational outcomes and measures whether the envisioned results have been reached (Kirkpatrick & Kirkpatrick, 2006). Based on the findings from this study, the VR training could potentially affect organizational outcomes related to cost, resources and the environment. The findings from this study indicate that the VR training would require less resources than traditional safety training. In addition to this, researchers argue that VR training could be more cost-effective in the long run as it mostly requires a high starting cost (Grabowski & Jankowski, 2015; Patle et al., 2019). Therefore, VR training could be more cost-efficient for organizations over time. VR training was also considered as environmentally friendly, which could decrease the organizations impact on the environment.

Relevance of Findings

The findings from this study might be able to shed some light on what needs to be considered and improved in safety training using VR technology. Realism or fidelity is an important aspect in participants evaluations throughout the study and the importance of fidelity for learning and training has previously been demonstrated by research (Alexander et al., 2005; Jensen & Konradsen, 2018). Ensuring the transfer of training is important and therefore obstacles that hinder transfer should be removed (Salas et al., 2012). Based on the findings from this study, improving aspects related to physical and psychological fidelity might be important for safety training using VR. However, research has shown that higher fidelity simulations are not necessarily better and adding immersive features could also backfire and hinder learning (Fernandes et al., 2016; Ragan et al., 2015). Also, it is very expensive to develop VR, therefore it could be better to enhance certain features instead (Brown & Green, 2016; Ragan et al., 2015). Meaning it is important to identify which features might be important for safety training using VR. The findings from this study indicate that both physical and psychological fidelity are important, but psychological fidelity might play a more important role and could have a positive influence on learning and transfer. The specific fidelity requirements in VR could differ based on the content and aim of the safety training. For example, in the case of fire extinguisher training

adding the feeling of heat may be an important factor which provides contextual information. Therefore, the specific fidelity requirements of safety training need to be identified based on the training. Physical and psychological fidelity represent important aspects of the safety training environment that should be considered when developing safety training using VR technology.

Methodological Considerations

Reflexivity *"means turning of the researcher lens back onto oneself to recognize and take responsibility for one's own situatedness within the research and the effect that it may have on the setting and people being studied, questions being asked, data being collected and its interpretation"* (Berger, 2015, p.220). Transparency is important, and I have tried to make sure that the reasoning for all of my decisions considering the method and analysis were made clear throughout the methodology section. As a researcher, I will indubitably be influenced by my educational background, knowledge and other assumptions while reading and interpreting data. Throughout the process I have consciously tried to put aside any expectations I had about the data and the results. However, it is still possible that my expectations might have affected the way I interpreted the data.

For example, I am generally positively biased towards technology and that could have affected the way I saw the data material. However, I made a conscious effort to not let my affinity for technology affect the way I worked with the data material. Also, inductive thematic analysis requires the researcher to keep the analysis as close to the data material as possible (Braun & Clarke, 2006). This also helped me to be as objective as possible during the analysis. Another aspect that might have affected my analysis is the fact that I collected field notes. Gathering the field notes gave me the general impression of what the trainees thought as I was focusing on verbal comments about the training. However, the notes were made by me and they are undeniably subjective to some degree. In order to not let my observations influence the analysis, I decided to read and analyze the survey data first. I read and analyzed my field notes only after I was done with the survey data. In addition to this, there was considerable of amount time between the gathering of data and analyzing, thus I did not remember in detail what my notes contained.

Another aspect that can affect participants responses is the researcher's presence (Finlay, 2002). To assure that my co-researcher's and my presence was not influencing the trainees, we left the room after handing out the informed consent forms. This was done to assure that they did

not feel forced to sign it because of our presence. Similarly, in order to not influence participants responses in the survey, we left the room after handing them out. However, we were present during most trainings in order to observe and take notes and it might be possible that the trainees were affected by our presence then. On the other hand, the results from both the survey data and observation notes show that the trainees can think critically about the VR training as they give positive and negative evaluations to different aspects of the training. Thus, our presence might not have affected them as much. Also, we did specify that we wished to know what their thoughts on this VR training are and did not frame it positively or negatively when presenting the project.

Saturation concerns the decision to stop data collection as it is assessed that more data will not be necessary based on the data that is collected (Saunders et al., 2018). The decision to stop data collection for this study was based on different factors. These include the number of participants gathered, the data itself, convenience and time pressure. After attending ten training sessions, we had gathered 85 participants. First, it can be argued that this is quite a large number for a qualitative study which also led to a large amount of data that needed to be analyzed qualitatively. Also, during observations and reading through the surveys it became apparent that no new information was being gathered. Most participants, as can be seen in the results, were evaluating the VR training similarly. Also, this is a thesis, which meant there was a time constraint present. Based on these factors it was deemed that saturation was reached as it was assessed that no new meaningful codes or themes would be identified with more participants (Saunders et al., 2018).

One limitation of this research could be that the trainees might have been influenced by each other when responding to the survey. The trainees talked during and after the training and that could have led them to influence each other, when later they were responding to the survey. However, this was not something that could be controlled as we were visiting a training facility where individuals from different workplaces gathered to receive different kinds of safety training for a day. We could not ask the trainees to not talk to each other during and after the VR training. The trainer also had to talk to them during and after the training and we could not restrict them from doing that, nor did we have the authority to do so. In addition, observation could have been more difficult to conduct if we tried to restrict interaction between the trainees. Although some trainees might have been influenced by each other, the data was gathered from many different

trainee groups. In addition, many participants evaluated different aspects of the VR training similarly, indicating that certain aspects are prominent across the data. Therefore, the impact of this influence is not deemed as too prominent in relation to the overall findings of the study.

Credibility of Study Findings

Working with a qualitative method means that the researcher should incorporate certain methodological strategies to ensure the trustworthiness of research findings (Noble & Smith, 2015). Some criterions exist which can be used to assess the credibility of qualitative research findings. These are truth value, consistency and applicability (Noble & Smith, 2015). Truth value concerns recognizing and outlining personal experiences and bias that might have affected the research (Noble & Smith, 2015). I have clearly specified my personal bias concerning technology and experience, such as taking observation notes, that could have affected the data collection process and analysis. In addition, I also stated how I tried to ensure to not be influenced by my bias and experience.

Consistency concerns the trustworthiness of findings and is gained by being transparent and describing decisions that were made during the research process (Noble & Smith, 2015). Throughout the methodology section I have tried to ensure that all decisions and their reasoning was clearly explained and described. Some of these decisions were also discussed under methodological considerations. I have tried to ensure the credibility and trustworthiness of the research findings throughout the research process. Finally, applicability concerns whether the research findings can be applied to other settings or contexts (Noble & Smith, 2015). One strength of this study was its large sample size, however that does not mean that the study findings are necessarily applicable to other settings. What might be applicable to other safety training settings using VR, are the terms physical and psychological fidelity, which as discussed might play an important role in learning and transfer in safety training using VR.

Implications of Study

The findings from this study can provide some guidelines for what needs to be considered when developing VR for safety training purposes. VR has proven to be great tool that can be used in safety training which is supported by previous research and this study adds to these findings. Physical and psychological fidelity needs to be considered when designing and developing safety trainings using VR. This is because of the vital contextual information that is provided by these factors which can play a role in learning and training transfer. As fidelity

requirements can vary depending on the aim and the content of the training, it could be useful to conduct a training needs analysis to identify the relevant features that are important for learning and transfer in the training. Also, a focus on psychological fidelity is important because it might have a greater impact on learning and transfer. Thus, physical fidelity requirements can be based on psychological fidelity requirements. This can also save costs for developers and organizations as developing and adding features in VR is expensive. This may give future developers specific advice to consider when developing safety training using VR technology. Another implication of this study is the use of VR in safety training as it is today, is a valuable supplement to traditional safety training. It provides many benefits related to learning etc. and should be continued to be implemented as a supplement to traditional training.

Implications for Future Research

The aspect of realism in VR was a central part of the participants evaluations and provided future research suggestions. The findings of this study highlight the need for more research on physical and psychological fidelity and the effect these factors have on learning and transfer in safety trainings. Future research could also investigate what role physical fidelity plays in providing contextually relevant information and how this in turn can increase psychological fidelity. Research should also investigate how psychological fidelity can impact learning and transfer in safety training to provide further evidence for the link between psychological fidelity and transfer. In addition to this, future research should also investigate how the occurrence of simulator sickness can be decreased. Specifically, what kind of technological development and features can decrease simulator sickness symptoms and whether increased exposure to VR can mitigate this. Further research on these topics can provide developers with clearer guidelines on what to consider when designing safety trainings for VR.

Conclusion

The aim of this study was to find out how safety training using VR technology is evaluated by offshore oil and gas industry workers. Their evaluations on such training were considered important since safety is of immense importance in the industry and because such research could provide guidelines for further evaluation and development of VR. The purpose of this was to provide insight into how the VR training was evaluated and the reasoning behind the evaluations. Along with insight that could be of importance when implementing VR technology in safety training. The findings from this study indicate that VR use in safety training is overall positively evaluated and is considered a positive experience for most participants. Findings also indicate that VR training is a valuable addition to traditional safety training and such training could provide benefits related to learning, safety, environment and cost.

Based on the findings, the most prominent area that needs to be further researched and developed in VR for safety training purposes is fidelity. Physical fidelity and psychological fidelity both represent important aspects of the VR environment and should be considered when such training is being designed and developed. More research is needed on what role physical and psychological fidelity play in learning and transfer in VR training. However, based on previous research and the current study it could be assumed that psychological fidelity might be important for learning and transfer of training. Therefore, this study suggests that high psychological fidelity could be important for safety training using VR. In addition to this, the occurrence of simulator sickness symptoms necessitates further research on how such symptoms can be mitigated. Lastly, this study suggests that VR is a valuable tool that should be used in safety training, but it needs to be further developed. As of now, VR might work best as a supplement to traditional safety training. However, this can potentially change with further development of VR and further research on VR use in safety training.

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Appendix

Appendix A – Open-Ended Qualitative Survey

D. DIN VURDERING AV VR-TRENINGEN

1. 1. Har du noe erfaring med virtuell virkelighet (VR) fra før?

2. Hvordan vil du vurdere treningen med virtuell virkelighet?

3. Hvordan var treningen med virtuell virkelighet i forhold til tradisjonell opplæring?

4. Hvordan følte du deg under treningen?

5. Hva er fordelene og ulempene med trening ved hjelp av VR?

6. Var du kvalm under VR-treningen, og i så fall, når var du kvalm?

Takk for at du ville svare på spørsmålene!

Appendix B – Informed Consent Form

Informed consent

Are you interested in taking part in the research project

This is an inquiry about participation in a research project where the main purpose is to take a closer look at safety training with the use of Immersive Visual Technology, including Virtual Reality (VR) and Augmented Reality (AR). In this letter we will give you information about the purpose of the project and what your participation will involve.

Purpose of the project

This project aims at understanding the factors and the issues that surround new technology adoption and implementation in organizations that are planning to adopt or have already adopted a new technology. This also includes trainings using Immersive Visual Technology. We would like to see how do people evaluate safety trainings using virtual reality and what issues surround the use of this technology for training, both at the individual level and organizational level, how it was introduced in your organization, how it was perceived and adopted and how it was experienced.

The present study is part of a bigger research project, financed by the EU commission (ImmerSAFE), and it will be part of a doctoral dissertation.

The data collected will be used, in an anonymous form, for scientific purposes, including scientific publications, master thesis, scientific communication and teaching.

The participant names and other personal information will not be connected with the data and not disclosed in any way.

Who is responsible for the research project?

NTNU is the institution responsible for the project. We also have a Master's student who will assist with data collection and analysis and will be working on her thesis.

Why are you being asked to participate?

You have attended a fire extinguishing training using the virtual reality fire extinguisher. Your organization probably expects you take safety trainings. We would like to know your view on it and we would like to know how that fits your work and your organization's safety culture

What does participation involve for you?

If you chose to take part in the project, this will involve an interview that will be audio recorded. It will take approximately 30 minutes to 1 hour. Questions include topics about the experience with the VR technology itself, the influence on your learning and skill, the communication throughout the process about training using VR, the difference with prior training, your organization's emphasis on safety and safety trainings.

Participation is voluntary
Participation in the project is voluntary. If you chose to participate, you can withdraw your consent at any time without giving a reason. All information about you will then be made anonymous. There will be no negative consequences for you if you chose not to participate or later decide to withdraw.

Your personal privacy – how we will store and use your personal data

We will only use your personal data for the purpose(s) specified in this information letter. We will process your personal data confidentially and in accordance with data protection legislation (the General Data Protection Regulation and Personal Data Act).

The data will be accessible to the project supervisor (Karin Laumann, karin.laumann@ntnu.no; and the researchers directly involved with the data analysis (Mina.Saghafian@ntnu.no) and the Master's level student (Ragheeba.akhtar@ntnu.no.

Personal data will be stored in a locked cabinet separately from the rest of the collected data that will be anonymized computerized data will be stored in the university hard disk protected by a personal password. Data in physical format will be locked in secured box in the offices of the responsible researchers.

You are responsible for adhering to the code of confidentiality of your potion and your job. You may not disclose any information that is regarded as classified by your organization to the interviewer.

What will happen to your personal data at the end of the research project?

The project is scheduled to end by the end of August 2021 and all the personal data will be deleted.

Your rights

So long as you can be identified in the collected data, you have the right to:

access the personal data that is being processed about you

request that your personal data is deleted

request that incorrect personal data about you is corrected/rectified

receive a copy of your personal data (data portability), and send a complaint to the Data Protection Officer or The Norwegian Data Protection Authority regarding the processing of your personal data

What gives us the right to process your personal data?

We will process your personal data based on your consent.

Based on an agreement with Norwegian University of Science and Technology, NSD – The Norwegian Centre for Research Data AS has assessed that the processing of personal data in this project is in accordance with data protection legislation.

Where can I find out more?

If you have questions about the project, or want to exercise your rights, contact:

NTNU via Mina Saghafian (mina.saghafian@ntnu.no), and via the project leader/supervisor, Karin Laumann (karin.laumann@ntnu.no).

Our Data Protection Officer: *Thomas Helgesen (thomas.helgesen@ntnu.no)*.

The Norwegian Centre for Research Data AS, by email: (personverntjenester@nsd.no) or by telephone: +47 55 58 21 17.

Yours sincerely,

Project Leader	PhD candidate
Karin Laumann	Mina Saghafian

Consent form

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I have received and understood information about the project *[ImmerSAFE]* and have been given the opportunity to ask questions. I give consent:

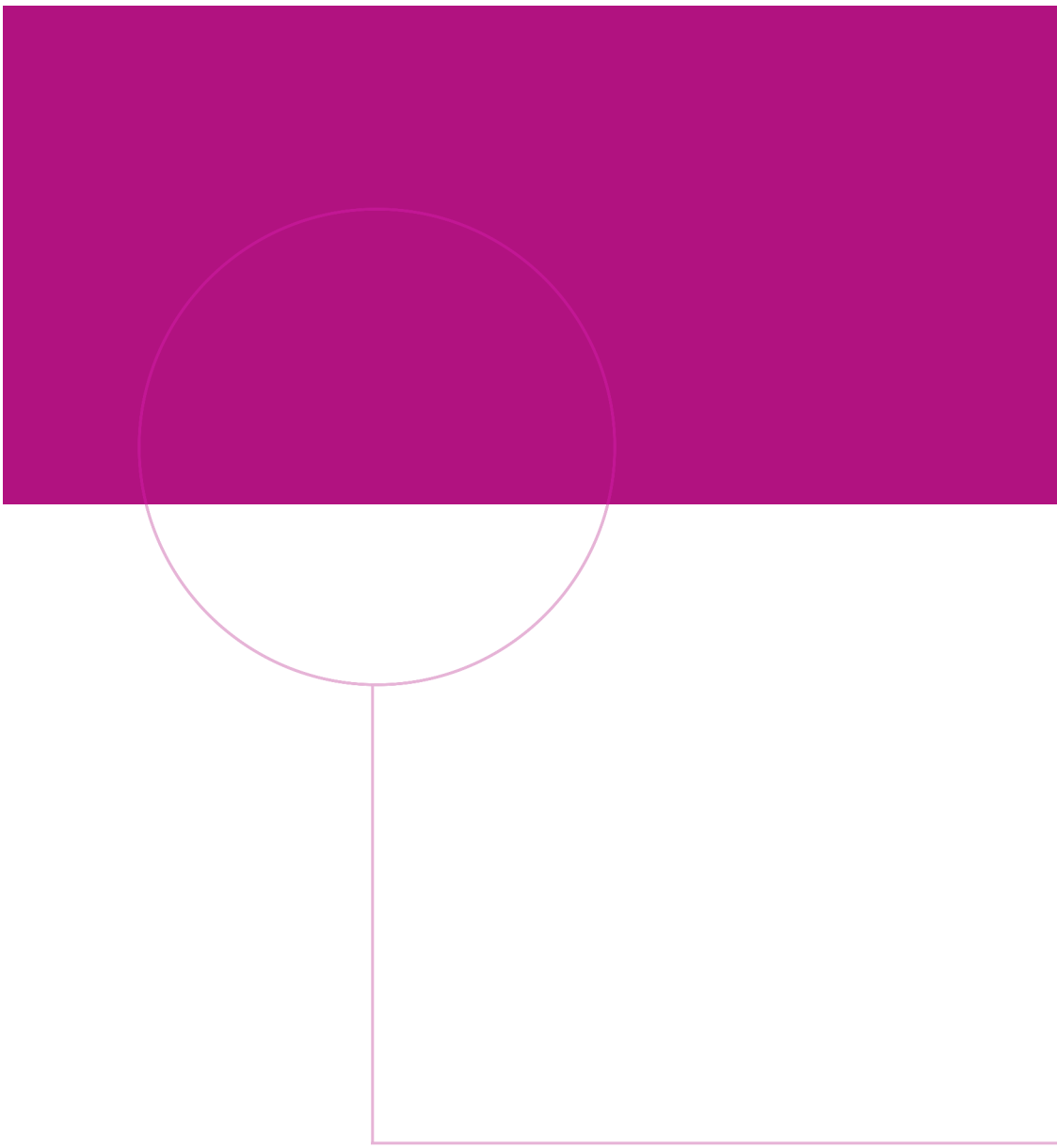
to participate in an interview

to have my interview audio recorded

to not disclose classified information

I give consent for my personal data to be processed until the end date of the project, approx. *[30. August, 2021]*

(Signed by participant, date)



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