A virtual reality approach to train learning and mastery in cardiopulmonary resuscitation skills

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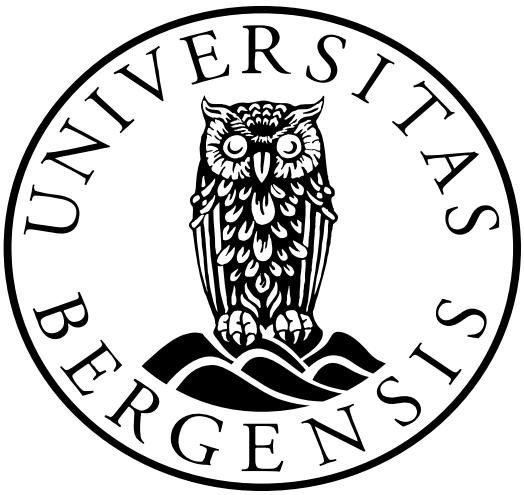

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Abstract

Cardiopulmonary resuscitation (CPR) courses and regular refreshers are of vital importance for saving lives, but they can be challenging to organize and expensive to provide. Virtual reality (VR) programs have been developed to manage or solve such challenges. In this master's thesis, a VR approach was used to train learning and mastery in CPR. It was investigated if VR can be better suited for conducting a CPR session than conventional methods of teaching or training. The aims were to reinforce positive attitudes, self-efficacy, and situational awareness in CPR. This was a between-groups experiment with 32 participants, who were mainly health professional students with CPR courses. Participants were evenly randomized into either a virtual training method where they were immersed in 360-degree 3D CPR videos, or a conventional training method that viewed the same videos on a computer monitor in 2D. Both groups improved in positive attitudes and self-efficacy in CPR, but there were no significant differences in these effects between the groups. Furthermore, both groups had moderate CPR situational awareness scores but there was not a significant difference in situational awareness between groups. These findings did not provide sufficient support to show VR being better suited for CPR training, but VR can be a useful supplement to CPR courses and training as it was not less effective than the conventional group. Furthermore, the extraneous cognitive load of using VR may have negatively impacted positive attitudes and self-efficacy in CPR for the virtual group. Consequently, further research is necessary to investigate the positive outcomes and usefulness VR can provide for CPR skills and training.

Keywords: virtual reality, cardiopulmonary resuscitation, attitudes, self-efficacy, situational awareness, situation awareness rating technique, cognitive load

Sammendrag

Hjerte-lunge-redning (HLR) kurs og regelmessige oppfriskninger er av livsviktig betydning for å redde liv, men de kan være utfordrende å organisere og kostbare å tilby. Virtuell realitets (VR) programmer har blitt utviklet for å håndtere og løse slike utfordringer. I denne masteroppgaven ble det brukt en VR-tilnærming for å trene læring og mestring i HLR. Det ble undersøkt om VR kan være bedre egnet til å gjennomføre en HLR økt enn konvensjonelle metoder for undervisning eller trening. Målene var å styrke positive holdninger, mestringstro og situasjonsbevissthet i HLR. Dette var et mellom gruppeeksperiment med 32 deltakere som hovedsakelig var helsepersonellstudenter med HLR kurs. Deltakerne ble jevnt randomisert til enten en virtuell treningsmetode som ble aktivt fordypet i 360-graders 3D HLR videoer, eller en konvensjonell treningsmetode som så de samme videoene på en datamaskin monitor i 2D. Begge gruppene forbedret seg i positive holdninger og mestringstro i HLR, men det var ingen signifikante forskjeller i disse effektene mellom gruppene. Videre hadde begge gruppene moderate HLR situasjonsbevissthetsskårer, men det var ikke en signifikant forskjell i situasjonsbevissthet mellom gruppene. Disse funnene ga ikke tilstrekkelig støtte til å vise at VR er bedre egnet for HLR trening, men VR kan være et nyttig supplement til HLR-kurs og trening da den ikke var mindre effektiv enn den konvensjonelle gruppen. Videre kan den utenforliggende kognitive belastningen ved bruk av VR ha negativ påvirket positive holdninger og mestringstro i HLR for den virtuelle gruppen. Følgelig er ytterligere forskning nødvendig for å undersøke de positive resultatene og nytten VR kan tilføre HLR ferdigheter og trening.

Nøkkelord: virtuell realitet, hjerte-lunge-redning, holdninger, mestringstro, situasjonsbevissthet, situation awareness rating technique, kognitiv belastning

Preface

This master's thesis is the result of a collaboration between the University of Bergen and BRAK VR. I have a background working in healthcare so I am very fascinated by innovative VR developments that can facilitate better healthcare outcomes. In this thesis, I have had the exciting opportunity to research such themes. I would like to thank Geir Nes for his cooperation and the opportunity to research such interesting topics. I would also like to thank the participants at Alrek, HVL, UiB, and VID who took the time to participate in my study.

The greatest gratitude goes to Bjørn Sætrevik and Floris van den Oever who have been constructive and invaluable throughout this process. Thank you so much for the good advice and time you have spent and set aside. This process has been very interesting and educational, but also challenging. The two of you have made the process much easier.

Finally, I would like to thank my family and friends who have given me support and motivation with my work.

Forord

Denne masteroppgaven er resultatet av et samarbeid mellom Universitetet i Bergen og BRAK VR. Jeg har en bakgrunn fra helsevesenet, så jeg er veldig fasinert av innovative VR utviklinger som kan tilrettelegge for bedre helsetjenester. I denne avhandlingen har jeg hatt den spennende muligheten til å forske på slike temaer. Jeg vil takke Geir Nes for samarbeidet og muligheten til å kunne forske på slike interessante temaer. Jeg vil også takke deltakerne ved Alrek, HVL, UiB og VID som tok seg tid til å delta i min studie.

Den største takknemligheten går til Bjørn Sætrevik og Floris van den Oever som har vært konstruktive og uvurderlige støttepersoner gjennom hele prosessen. Tusen takk for de gode rådene og tiden dere har brukt og satt av. Denne prosessen har vært veldig interessant og lærerik, men også utfordrende. Dere to har gjort prosessen mye enklere.

Til slutt vil jeg takke familie og venner som har gitt meg støtte og motivasjon med arbeidet mitt.

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Abbreviations for key terms

Abbreviation	Meaning
Theoretical terms	
VR	Virtual reality
CPR	Cardiopulmonary resuscitation
SE	Self-efficacy
SA	Situation awareness
VT	Virtual training
CT	Conventional training
SART	Situation awareness rating technique

Introduction

CPR is an indispensable skill that saves lives (Ro et al., 2016). Even though CPR is a vital skill necessary to save lives, there are challenges in both conducting CPR courses (Hsieh et al., 2016) and challenges for increasing CPR course availability in contemporary society (Han et al., 2021). This is worrisome as the CPR skill requires regular refreshers and training to reinforce or at least retain the skill (Tíscar-González et al., 2019).

VR can be beneficial for managing or solving such worrisome challenges in conducting CPR courses (Omlor et al., 2022). VR is a technology that can generate virtual environments, programs or simulations displaying scenes and objects that can appear very authentic (Bertram et al., 2015), immersive (Chiu, 2020), and realistic (Moskaliuk et al., 2013). This enables the user to experience VR situations as real-world occurrences (Howard et al., 2021). VR environments and programs can be developed or customized to cultivate learning and training outcomes (Bertram et al., 2015). Consequently, it can be used to supply courses (Huang et al., 2022), improve learning or knowledge (Huang et al., 2022), and allow for frequent practice (Bertram et al., 2015) and training across various disciplines and skills (Howard et al., 2021). As such VR can have positive ramifications for assessing, retaining and reinforcing CPR learning and mastery (Omlor et al., 2022) along with CPR performance and skills (Pei et al., 2019).

Methods that allow for learning and training in authentic real-world contexts like VR enable users to approach and foster problem-solving, which leads to better learning and training outcomes (Herrington et al., 2014). VR simulations are such a method that can promote positive attitudes and strengthen self-efficacy (SE) in CPR (Omlor et al., 2022), which are crucial to achieve learning and mastery in CPR. If knowledge is obtained in applied settings such as drills or practice, it becomes easier to retain, recall and apply them when necessary to solve problems (Herrington et al., 2014). VR environments can immerse users in such applied settings and situational awareness (SA) can be measured to be certain that users properly perceive the desired

information and factors, comprehend the situations and can predict scenarios for how the situations may unfold (Bolton et al., 2021). Furthermore, VR can be used to train SA (Chiu, 2020) which is necessary to properly manage acute situations that can occur such as for CPR incidents (Nas et al., 2020).

There is a need to study how VR can be used in CPR courses. Norwegian bystanders often provide CPR assistance to people in need, even if they do not know them or possess CPR certifications (Norwegian health registry, 2021). In 86% of cases, Norwegians provide CPR by the time the ambulance arrives (Norwegian health registry, 2021). With Norway and other countries trying to increase CPR prevalence and proficiency in their cities and general populations (Ro et al., 2016), it was considered important to examine Norwegian CPR attitudes, course prevalence, and their perceived proficiency in CPR. Furthermore, it was considered relevant to study how VR could be used in CPR courses, learning, and training. This master's thesis examined if and how VR can aid as an alternative method or supplement in increasing positive attitudes toward CPR, increasing CPR proficiency, and increasing the prevalence of CPR. A VR method for CPR training will be compared to a conventional method.

Cardiopulmonary resuscitation

This section will introduce CPR as a vital skill and its necessity in contemporary society. CPR is a critical part of basic life support and the first line of response to a cardiac arrest before other measures such as a defibrillator or advanced life support is considered (Seo & Cho, 2021). CPR is an emergency procedure or skill performed by combining mouth-to-mouth assistance and chest compressions, to ensure sufficient oxygen and blood flow continue (Lactona & Suryanto, 2021). The procedure is an imperative skill that can save lives during emergencies such as stroke, respiratory arrest, trauma, drowning, and airway obstruction (Nori et al., 2012).

CPR needs to be performed quickly within a brief time frame, which makes it necessary for people to make swift decisions and generally for CPR courses to be more available. Conducting CPR assistance and performing it within 1-2 minutes can be very beneficial for increasing survival rates and positive outcomes (Desiani et al., 2017), but brain death commonly occurs 4-5 minutes after a cardiac arrest (Seo & Cho, 2021). An immediate engagement and willingness to supply CPR assistance are therefore important for relieving those in need. A crucial challenge is that even the emergency medical services (EMS) in developed countries with good emergency networks, find it difficult to arrive within 10 minutes (Pei et al., 2019). To manage this challenge many countries and communities promote CPR assistance advocacy and programs, that empower citizens to provide aid to those in need (Ro et al., 2016).

As there is a short duration of opportunity to aid those who need CPR help, bystanders are considered essential for providing aid in such situations until EMS arrives (Norwegian health registry, 2021). Norwegian bystanders provide CPR assistance in 86% of incidents before EMS arrives but such rates are exemplary and not common globally (Norwegian health registry, 2021). Bystander assistance increases the likelihood of survival by more than twice, for those who receive bystander aid (Rajan et al., 2016). This shows the importance of early CPR assistance and the importance of a bystander's willingness to perform CPR (Rajan et al., 2016). A bystander's ability to perform CPR (Seo & Cho, 2021) is essential for improving the survival rate of out-of-hospital cardiac arrest (OCHA), health, and neurological outcomes (Rajan et al., 2016).

Challenges in retaining cardiopulmonary resuscitation skills

This section will introduce challenges in keeping CPR skills. There have been studies about the difficulty in retaining CPR skills even for health professionals, who undergo extensive CPR courses and training (Tíscar-González et al., 2019). International CPR guidelines

recommend basic life support training every 2 years including performing it on a manikin (Ro et al., 2016). Though it is recommended at least every 2 years, CPR knowledge and skills deteriorate after 3-6 months and international studies have reported a lack of knowledge about CPR among healthcare professionals (Tíscar-González et al., 2019).

CPR knowledge and psychomotor skills have low retention, which makes it important to conduct periodical CPR training to keep the skill (Nori et al., 2012). Frequent CPR training is found to be necessary to reinforce competency and ensure effective CPR for nurses (Tíscar-González et al., 2019). A perceived inability to perform CPR had a major effect on the decision-making of bystanders on whether to administer CPR (Swor et al., 2006). Those with more recent CPR training were more likely to perform CPR (Swor et al., 2006). For both bystanders and health professionals, a failure to perform CPR may occur if they lack a belief in their own capabilities (Desiani et al., 2017). Major factors for CPR performance are attitude, knowledge, awareness, and self-efficacy (Desiani et al., 2017). Even if a person has a CPR course and training, this does not necessarily mean that they perceive themselves as capable of performing it in an adequate manner (Ro et al., 2016).

Challenges for cardiopulmonary resuscitation courses and teaching

This section will describe the challenges in conducting CPR courses. Conventional or traditional CPR courses are conducted in a classroom-based face-to-face environment (Han et al., 2021). An instructor leads the course by talking about first-aid or showing videos (Omlor et al., 2022). Physical compressions and CPR training are practiced on a manikin with an instructor close by and often in the presence of others (Hsieh et al., 2016).

Restrictions (Lactona & Suryanto, 2021) and limitations (Hsieh et al., 2016) to CPR activities hamper the ability to conduct courses, refreshers, and face-to-face training (Lactona & Suryanto, 2021). Restrictions under the COVID-19 pandemic for example caused a negative

impact on the CPR competencies, skills, and performance of nursing students at various higher institutions (Lactona & Suryanto, 2021). Mainly caused by cancellations, difficulties, or limitations in supporting their clinical practice programs at hospitals (Lactona & Suryanto, 2021).

Limitations in CPR courses can be due to a lack of available instructors to oversee courses or course takers challenges in signing up or for undergoing courses (Hsieh et al., 2016). The instructions given in courses can also vary with instructors not following a defined curriculum and not correcting course takers when they are training in CPR use (Han et al., 2021). Challenges can be the inconvenience of having to plan when to take the course and fitting it into one's time schedule makes people and particularly students refrain from signing up for CPR courses (Han et al., 2021). Psychological factors may also limit course taking or mastery of the CPR skill, such as learning disorders, or performance anxiety in an unfamiliar setting (Hsieh et al., 2016). The limitations and challenges have dire implications for CPR mastery, properly retaining the skill for future use, and increasing course taking.

Self-efficacy

This section introduces SE and its relevance for CPR. "*Perceived self-efficacy is concerned with people's beliefs in their capabilities to produce given types of attainments*" (Bandura, 2006, page 307). SE represents the amount of effort and persistence that people exert to perform a task successfully (Jia et al., 2014). SE is considered the most significant predictor of behavioral intentions strongly tied to belief, attitude, and behavior (Pei et al., 2019). Doubt and uncertainty can arise in a person, which can result in critical time wasted and worse CPR performance (Moon & Hyun, 2019). When a person is motivated and perceives themselves as capable of performing specific actions such as learning or performing CPR, this facilitates a stronger intention to achieve those results (Alaryani et al., 2021). SE increases the likelihood of intentions becoming actions and achieving desired results (Moon & Hyun, 2019). Higher levels

of SE can therefore increase the willingness and prevalence of CPR assistance (Pei et al., 2019).

For healthcare in general, health professionals with low levels of SE can often lead to worse performance thereby causing adverse patient outcomes (Roh et al., 2012). SE is correlated with knowledge, willingness, and attitudes toward first-aid behavior (Pei et al., 2019). Knowledge and SE are crucial factors that influence the delivery of CPR and can predict a person's CPR ability (Desiani et al., 2017), and influence how quickly and well CPR is performed (Ro et al., 2016). A higher SE level in CPR strengthens CPR skills (Moon & Hyun, 2019). Thus, it is important to constantly evaluate and ensure adequate SE in CPR for health professionals (Roh et al., 2012).

Simply having a CPR course certificate do not ensure proper CPR assistance or that people feel capable of handling CPR situations that can arise (Roh et al., 2012). People need to undergo refresher to reinforce knowledge (Tíscar-González et al., 2019) and promote self-efficacy to ensure proper CPR (Roh et al., 2012). Measures to increase the SE and people's self-evaluation during courses are therefore important to ensure interest in and willingness to learn CPR (Pei et al., 2019). Furthermore, to ensure effective and quick CPR assistance and performance to people in need. Self-evaluation measures for SE in CPR can be conducted for educational lessons or training exercises to enable people to subjectively evaluate their self-perceived attitudes, motivation, knowledge, performance, and skills (Pei et al., 2019).

It is essential to have SE in CPR to be able to perform CPR in a satisfactory manner without doubt or uncertainty. Training systems for improving SE can supply proficiency or failure experiences. Failures can decrease SE, particularly if SE has not been established (Ding et al., 2020). There is therefore a necessity to educate and promote knowledge in a way that ensures SE for people who may have to perform CPR (Desiani et al., 2017).

Situational awareness

This section introduces SA and its relevance for CPR. SA is a psychological concept and skill (Bolton et al., 2021) that first appeared in aviation psychology, to describe the required cognitive processes of pilots during flight (Zhang et al., 2021). If a situation and its connecting elements are not adequately understood when making decisions, dangers arise that are detrimental to safety and performance (Bolton et al., 2021). SA described how commonplace accidents or failures in performing tasks in acute and challenging occupations such as for pilots, are connected to decision-making failures perpetuated by a lack of SA (Zhang et al., 2021; Endsley, 1995). SA is supposed to illustrate and portray the top-level cognitive processes of cognition, understanding, and prediction that an individual or team has (Zhang et al., 2021; Endsley, 1995). It is considered an important skill for enabling individuals and teams to assess, understand and handle situations and tasks (Bolton et al., 2021).

There is no unified definition of SA (Zhang et al., 2021), but Endsley's three-level information processing model is an established conceptual model that is commonly used to describe SA (Anbro et al., 2020). In the model, SA is thought to be a state of knowledge with three distinct levels. Each level displays a better grasp of knowledge than the former level (Kaber et al., 2013). The first level is about perceiving all the important aspects of things occurring in an environment (Kaber et al., 2013), it is about being aware and conscious of them (Bolton et al., 2021). The second level is about understanding the aspects and things in the environment, their circumstances, and what has led to their occurrence (Kaber et al., 2013). The third level is about bringing together experience and knowledge (Zhang et al., 2021), with gathered information in level 1 and understood information in level 2 to make predictions (Salmon et al., 2007). This enables the making of mental models where one can forecast and predict various scenarios as to how the situation may unfold (Salmon et al., 2007).

SA is a critical skill that can be used to identify and manage dangers or problems (Kaber et al., 2013), it helps to constrain and handle accidents like when CPR is needed. SA enhances the process of making good decisions and achieving desired outcomes (Bolton et al., 2021). SA is particularly important for successfully handling situations where multiple things must be kept track of simultaneously (Taç & Tavacıoğlu, 2019), where different tasks may arise and affect the attention of the operator, and situations with time constraints that require rapid management and decisions (Taç & Tavacıoğlu, 2019). Effective learning and training programs can help foster experiences that can be used to achieve and support SA, but it is important to have feedback on performance (Chiu, 2020). As it helps to promote an understanding of why errors occur and information that might be overlooked. For these reasons, SA can be an important aspect of CPR, and programs can be used to reinforce SA.

Virtual reality as a learning and training method

This section will introduce what VR is and how it can be used for courses, learning, and training. Technological devices such as VR can improve performance by supplying authentic and realistic environments, where affective and cognitive processes can be engaged in solving realistic learning and training tasks (Herrington et al., 2014). In this study, I used the definition of VR proposed by Howard et al., (2021, page 2): "*Three-dimensional digital representation of a real or imagined space with interactive capabilities*", though the extent of interaction can vary from system to system (Howard et al., 2021). It also "*stimulates a user's physical presence and environment in a way that allows the user to interact with it* (Israel, 2022, page 1). A minimum of the two senses; sight and sound, are needed to undergo and experience VR (Lele, 2013).

Learning and training in VR can be cheaper, safer, and easier than training in real-life settings (Moskaliuk et al., 2013). Virtual environments and programs can be made to cultivate

learning and training (Bertram et al., 2015) by having settings, situations, and videos customized to achieve given learning outcomes or reinforce skills (Howard et al., 2021). VR can immerse those undergoing it, enabling users to process information in a more active and encompassing approach (Howard et al., 2021), which they perceive more realistically (Moskaliuk et al., 2013).

VR can be useful for achieving or reinforcing skills in occupations, including occupations that are acute, challenging, and demanding (Chiu, 2020). Virtual environments can be made to have intricate levels of sensory information (Adamovicha et al., 2009) which can make the experience of using VR seem real and cause agency, though it is an artificial and controlled environment (Adamovicha et al., 2009). This makes it possible for people to watch CPR videos in VR and still undergo VR training without doing any physical tasks (Xie et al., 2021). VR may thus serve as a suitable and efficient way to educate and train personnel in CPR.

Virtual reality for cardiopulmonary resuscitation skills and teaching

This section will introduce how VR can be suitable for supplementing or improving current education and teaching in CPR. There have been calls for innovation in CPR courses (Lactona & Suryanto, 2021) and methods of teaching (Omlor et al., 2022). To increase and reinforce CPR courses an "*innovative method with perhaps simplified techniques needs to be developed*" about bystanders (Swor et al., 2006, page 600).

Teaching methods that are consistent, productive, and suitable for CPR are needed (Hsieh et al., 2016). Which can reinforce CPR skills and enable CPR availability by allowing for mass training in flexible conditions (Hsieh et al., 2016). Measures that can be implemented so that training quality and the course cycles promote positive CPR and first-aid behavior (Pei et al., 2019). Knowledge and SE significantly decrease after 3 months among nursing students (Moon & Hyun, 2019), which shows the importance and need for continuous learning and

training environments. To ensure that the desired outcomes are achieved, they can be measured with self-evaluation measures (Pei et al, 2019), such as for the research variables.

Various self-instruction courses have been developed to overcome shortcomings in CPR courses and to enable CPR availability (Hsieh et al., 2016). Which does not require instructors and allows people to learn CPR at home. A self-instructional method such as VR seems like a suitable method for CPR, as it can potentially supply approaches that can increase CPR courses prevalence and reduce the required resources for courses. VR environments could enable health professionals to reinforce their CPR knowledge and skills routinely and more flexibly than traditional CPR teaching and training (Omlor et al., 2022).

Virtual reality interventions for cardiopulmonary resuscitation performance can be more effective at improving the knowledge of people than traditional methods (Chen et al., 2020). VR interventions can offer better CPR outcomes than classroom instructions such as for education and generating knowledge (Chen et al., 2020) or improving compression rates (Nas et al., 2020). VR situations can potentially be designed to train the research variables SE and SA, and this can lead to attaining or reinforcing them at a faster rate than what would be possible under traditional settings (Chen et al., 2020). Another advantage is that the virtual scenarios can be made to train at specific competence/expertise levels and ensure the progression sought to reach SE and SA (Chiu, 2020). Chen et al., (2020) provides the additional advantage that interactive VR environments make it easier to understand how concepts and themes are related to each other.

VR may be useful for attaining or reinforcing SE in CPR. The use of VR can challenge and cultivate users by giving an active training and learning effect, which is experienced more realistically (Nissim & Weissblueth, 2017). Student teachers had increased SE through VR learning environments, which made them more innovative and creative (Nissim & Weissblueth, 2017). Social workers experienced a structured and intertwined process by using VR in

experiential education (Hsiao, 2021). This had the effect of enabling them to learn in a relaxed manner. VR was able to be applied flexibly and showed that high SE can improve learning motivation (Hsiao, 2021). Omlor et al., (2022) the VR condition self-assessed CPR expertise higher, however without significant differences. The students in the VR conditions significantly rated their learning atmosphere, comprehensibility, and overall recommendation of the course significantly higher. With positive feedback for VR as a tool for teaching or supplementing current methods. Wong et al., (2018) found that CPR instructors showed a belief that VR could be more engaging for younger people, which was believed to be necessary to make them interested and motivated to undergo courses.

VR may be useful in attaining or reinforcing SA in CPR. Videos can be made that are immersive and provide awareness and understanding of CPR (Chiu, 2020). Behavioral skills can be improved by learning or training in VR. Fire safety behavioral skills were developed and improved with VR training, which could be transferred and used effectively in real environments (Çakiroğlu & Gökoğlu, 2019). Training in VR simulations can be a good method for improving decision-making and the ability to make situational assessments (Kaber et al., 2013). A study also showed that communication accuracy significantly increased while SA increased with a VR intervention showing positive improvements for SA among nurses (Anbro et al., 2020). VR scenarios should similarly be able to increase SA, decision-making, and behavioral skills for CPR. Nas et al., (2020) had two conditions, one underwent instructor-led face-to-face training while the other underwent VR training by using a smartphone app. There were improvements for both conditions, but the VR group had lower overall CPR performance scores. Performing better at compression rate but worse in compression depth compared with the alternative traditional condition.

Challenges in improving cardiopulmonary resuscitation skills with virtual reality

This section will introduce how immersive VR environments face challenges in providing desired learning, mastery, and training outcomes due to extraneous cognitive load which can hinder or limit these outcomes. Walshe & Driver, (2019) found that 360-degree videos enabled broader reflection among teachers, improved confidence, and promoted positive feedback from teachers about the importance of learning and teaching. Another study by Gold & Windscheid (2020) had supporting findings, that 360-degree VR classroom videos elicit a significantly higher degree of presence, enabled by the ability to freely focus, and explore the VR simulations and videos. Wong et al., (2018) found that CPR refreshers could be more accessible with VR, while being cost-effective and having the positive effect of reducing distractions during CPR teaching as VR is so immersive. However, some studies have uncovered that VR interventions can cause higher cognitive load and extraneous cognitive load on users (Huang et al., 2022).

Cognitive load can have a negative effect on VR interventions due to users being overwhelmed or disrupted by too much or uncessary information. Cognitive load is thought of as the total processing burden or mental resources, needed to process and organize information in the working memory (Parong & Mayer, 2020; Sweller, 2011). VR environments can appear so authentic and realistic that they cause users to become distracted by irrelevant features (Huang et al., 2022). Users also risk becoming overwhelmed by all the information that the VR environments (Parong & Mayer, 2020) or program delivers (Makransky et al., 2020). Flawed approaches to presenting information cause attentional disturbances and unnecessary information to appear (Anmarkrud et al., 2019), which causes a higher extraneous cognitive load (Huang et al., 2022).

Immersive VR environments can debilitate or limit desirable learning and mastery outcomes (Huang et al., 2022), while it can also adversely interfere with prior held knowledge

(Anmarkrud et al., 2019) as uncovered in the studies by Huang et al., (2022), Parong & Mayer et al., (2021), Makransky et al., (2019) and (Birrenbach et al., 2021). Huang et al., (2022) found that immersive VR caused a higher level of extraneous cognitive load than regular videos. It did not negatively affect the situational interest of subjects, but it had a negative association with SE and learning with such results in their study.

Negative effects on SE without it affects situational interest has also been found in other studies. Parong & Mayer et al., (2021) similarly found that VR often causes a higher extraneous cognitive load than other methods of learning such as watching videos for instructions or lessons in a classroom environment. Another study by Makransky et al., (2019) also produced similar effects. Immersive VR can have a distracting effect on learners when it comes to science learning. With worse learning outcomes compared with traditional digital slides for presentations. Birrenbach et al., (2021) had supporting findings that showed that students who used VR as an educational tool for the safe performance of COVID-19 diagnostics experienced far greater enjoyment and satisfaction with their condition than the alternative conventional condition that was given instructions and watched instruction videos. As mentioned by Omlor et al., (2022) this might be caused by inexperienced users experiencing a novelty effect due to interest in VR, which has become more accessible, but users are not used to VR yet. That can contribute to explaining the difference between positive feedback in studies and the lack of significant differences between conditions in VR interventions for CPR.

Cognitive load and extraneous load mainly occur in VR since people are unfamiliar with its devices, or because it is more challenging or demanding to use. Devices and interactions in VR can be more challenging to use than for example a simple mouse and keyboard (Huang et al., 2022). This can be solved by enabling familiarity with the VR devices and environment, and providing an instructional interaction method for users which reduces extraneous load (Albus et al., 2021). While experiencing presence in VR can enable positive motivational

effects such as for SE and better learning outcomes, if virtual environments are too emotionally arousing, they can cause distractions (Parong & Mayer, 2020). Israel et al., (2022) found that there was a higher acceptance and satisfaction with passive VR experiences. In passive VR experiences the user is an observer that does not affect or make choices in the VR environments compared with active VR experiences where the user is an active participant that makes choices (Israel et al., 2022). This shows that passive VR experiences can be a better method for learning than active experiences, being able to better hinder the emergence of extraneous cognitive load.

Those immersed in VR can experience a negative phenomenon called VR sickness (Chang et al., 2020), simulator sickness (Saredakis et al., 2020), or cybersickness with symptoms like motion sickness such as disorientation and fatigue (Chang et al., 2020). It is attributed to the hardware, content factors, or individual human factors (Chang et al., 2020). The occurrence affects the VR experience of users and can influence studies conducted, which is why it should be planned for in the design phase (Saredakis et al., 2020). VR interventions or simulations in over 10 minutes have been found to increase the prevalence of virtual sickness in some studies (Saredakis et al., 2020). However, Saredakis et al., (2020) discovered contrary in their study that durations of up to 20 minutes did not notably increase the occurrence.

Research question and hypotheses

The aim of this experiment is to assess and examine if a VR approach of training can be useful for CPR learning and mastery compared with conventional CPR training. The research question is: What effect does VR training have on SE and SA for CPR skills compared with conventional training? From this, I derived two hypotheses: H1) VR training will result in higher levels of SE for CPR skills than conventional training. H2) VR training will result

in higher SA for CPR skills than conventional training. A preregistration (https://osf.io/nyqwj/) of these hypotheses and our study method is available on OSF.

Method

Research design

In this study, I tested how participants experienced VR training for CPR compared to their conventional CPR training. As described in the preregistration, this study was a between-groups experiment. There was one manipulated variable; the training method where participants were randomized into either the virtual training (VT) method or CT (CT) method. The VT condition used a VR head-mounted display and earphones to immerse them in 360-degree 3D CPR videos. The CT condition viewed the same videos on a computer monitor in 2D and listened to the built-in computer speaker. The manipulation/intervention was done on a group level and the effects were measured by comparing groups.

Participants

There were 32 participants, 17 women and 15 men in the study sample. The participants were equally divided into both groups. The age of the participants ranged from 19-33 years, and there was a similar age distribution for both conditions. Our pre-registered aim was a target sample of 50 participants, with 25 in each condition. Due to difficulties in recruiting participants the target sample was reduced to a minimum of 30 participants. The data collection period was from February 2022 until the end of March 2022. All participants conducted their participation in Bergen as planned in the preregistration and participants could choose timeslots anonymously in an online Excel spreadsheet. The next paragraphs describe our sampling activities and our sample.

Our initial approach was to seek cooperation with security guard companies or the Norwegian home guard. As they were unable to cooperate with us during the planned data

collection period, the decision was made afterward to move from a homogenous sample to a more general sample group. Health professional students were targeted as they take CPR courses during their education, but the sample was also expanded to include Norwegian university students or employees as they can possess CPR knowledge or skill even without having a CPR certification.

Associations, companies, and educational institutions that had employees or students who had or would undergo CPR training were approached. To maintain sufficient similarities between participants, recruitment efforts were targeted toward activities such as holding presentations for larger classes and stands at educational institutions. Administrators, coordinators, and lecturers were also asked to forward an invitation text about the study to their students. In total, six stands and 14 presentations were held. Data collection was conducted in similar rooms or labs restricted to only the researcher and participants during use.

Materials

Three outcome variables were measured: self-efficacy, situational awareness, and subjective experience of training method. The forms and questionnaires used in this study were modified and translated in cooperation with advisors Floris van den Oever and Bjørn Sætrevik. Translating forms and questionnaires from English to Norwegian and vice versa, was also conducted with help of a high school teacher in Norwegian. The forms and questionnaires used in this study, and the frameworks/templates they build on are shown in Table 2.

Table 2

Forms and questionnaires used in the research study

Measures	Outline and permission
Briefing and informed consent	See Appendix F for the briefing and informed consent form used in this study.
Sociodemographic questionnaire	Tíscar-González et al., (2019) developed a demographic/work characteristics questionnaire that has free to use approval (see Appendix B). It was used as a framework to make a sociodemographic questionnaire for this study, it was modified to create a new category for educational level and added time alternatives for certain items such as time since the participant partook in a CPR course. See Appendices G (Norwegian version) or H (English version) for the sociodemographic questionnaire used in this study.
Attitude and SE questionnaire	The first outcome variable was self-efficacy. A chapter on constructing SE scales by Bandura, (2006) was inspected while evaluating items suitable for measuring SE. The framework for the attitude and SE questionnaire used in this study was based on an attitude questionnaire by Tíscar-González et al., (2019) which has a free to use approval (see Appendix C). While the questionnaire of Tíscar-González et al., (2019) measured attitude, there were items in the questionnaire that seemed suitable for measuring both attitudes and SE. Their questionnaire measured factors within attitude such as personal responsibility, leadership, decision-making, knowing when to start and stop CPR, and organizational responsibility. Relevant items for measuring positive attitudes and SE in

CPR were examined to ensure relevancy and relevant SE items were added. The attitude and SE questionnaire had a 7-point Likert scale where the scale ranges from “completely disagree” (scored 1) to “completely agree” (scored 7). Positive tendencies were taught to be scores closer to 6 and 7, with a score of 4 being the midpoint. The attitude and SE questionnaire used in this study can be found in Appendices I (Norwegian version) or J (English version).

SART

The second outcome variable was situation awareness. The framework for measuring SA was based on the SART (Situation Awareness Rating Technique) by Taylor, (1990; 2011) which was originally developed to assess the SA of pilots. It has free to use approval. The SART questionnaire has a 7-point Likert scale ranging from, where the scale ranges from “low” (scored 1) to “high” (scored 7). See Appendix D for the original SART survey and description. SART items were modified to better measure the participant’s perceived SA in CPR after watching the videos. See Appendix K for the modified SART used in the study.

Short interview

The third outcome variable was subjective experience of training method. This was measured with a short interview at the end of the experiment. This data was used for exploratory analyses and there were no preregistered (https://osf.io/nyqwj/) hypotheses associated with it. BRAK VR gave permission to use their course evaluation questionnaire of VR. See Appendix A for the course evaluation questionnaire. Three questions were chosen and modified to measure a subject’s evaluation of participation and group condition. See Appendix L for the short interview and debriefing form.

Debriefing	The debriefing form was developed in collaboration with Floris van den Oever and Bjørn Sætrevik. See Appendix L for the debriefing form.

Situation awareness rating technique

In this study, the modified SART (see Appendix K) was used to measure SA. Advances in VR have allowed researchers to study SA more objectively, in addition to ensuring high precision and reliability (Anbro et al., 2020). Subjective assessments of SA and the situation awareness rating technique (SART) specifically are often used as it is well suited for evaluating SA after participation and is easy to administer (Bolton et al., 2021). SART has a focus on the SA of the individual, with 10 dimensions/questions and each of them belongs to one of three domains: attentional demand, attentional supply, or understanding (Taylor, 1990; 2011). Each question is rated on a seven-point rating scale, with 1 being the lowest and 7 the highest (Taylor, 1990; 2011). The domains are evaluated by rating the questions within each of them.

Attentional demand is the attentional resources needed to deal with given information, situations, or variables within the situations (Taylor, 1990; 2011). It has three dimensions, consisting of questions 1-3. They are: (1) how changeable the situations can be (instability of situation), (2) the number of things/variables that requires one's attention (variability of situation), (3) how complex/complicated the information or situations are (complexity of situation) (Taylor, 1990; 2011). Attentional supply is the attentional resources a person has or possesses to deal with the given information, variables, or situations (Taylor, 1990; 2011). It has four dimensions, consisting of questions 4-7. They are: (4) the degree of readiness for dealing with an activity or situation (arousal), (5) the amount of spare mental ability to deal with new variables that can occur (spare mental capacity), (6) the degree to which a person is focused on the

situation (concentration), (7) the amount of dividing one's attention to deal with the situation (division of attention) (Taylor, 1990; 2011). Understanding has three dimensions, consisting of questions 8-10 (Taylor, 1990; 2011). They are: (8) if the amount of information/knowledge given is understood (information quantity), (9) the degree to which the information/knowledge is communicated in an effective way (information quality), (10) how familiar or known the information and situations are (familiarity) (Taylor, 1990; 2011).

The dimensions/questions in each of the domains are combined and then, a composite SART score is calculated by the formula: SA = Understanding – (Attentional demand – Attentional supply) (Taylor, 1990; 2011).

Procedure

The videos chosen for the studies were about how to perform CPR and what to be aware of. Advisor Nes, who was involved in developing the videos, gave recommendations for which videos were most relevant for our study. Five out of 16 videos (see Appendix E) in a certified first-aid course were chosen for CPR relevance: videos 2, 3, 4, 5, and 6. Course takers could either watch the videos on YouTube (Førstehjelp VR 360º, YouTube URL: https://bit.ly/3YIF42Q) or watch them in VR. Afterward the course taker must undergo a practice session on a manikin with a certified CPR instructor present.

Videos two, three, and four were about establishing awareness about your surroundings. They also learned about first aid to help them differentiate between first-aid assistance and CPR. Videos five and six were specifically about how to perform CPR and what to be aware of during the procedure. In the videos, you are placed/view different situations, where a person may need assistance or help. The videos were intermittently stopped, and rhetorical questions were asked by a voiceover, with added information presented as text before continuing. The videos chosen had a combined duration of 11.5 minutes. When one video ends the next one

continuously starts, and every participant watched the videos consecutively without breaks. See Appendix E for more information about the videos used in the study.

The overall structure of the experiment started with the participant anonymously signing up to take part at an available time slot in an Excel form, which had written instructions about where to meet and how to contact the researcher. A coin was flipped before the participant arrived, to randomize their group condition. The participant was picked up, welcomed, and asked how they heard about the study. The participant was then read a briefing on informed consent by the researcher and then asked to re-read the same informed consent form. After informed consent the participant was handed two pre-measurements to fill out: a sociodemographic questionnaire and an attitude and SE questionnaire. The participant was told to look at both pages and to ask for clarification if a question seemed ambiguous or unclear. After filling in the two measurements, the participant was told which group they were assigned and what training they would undergo.

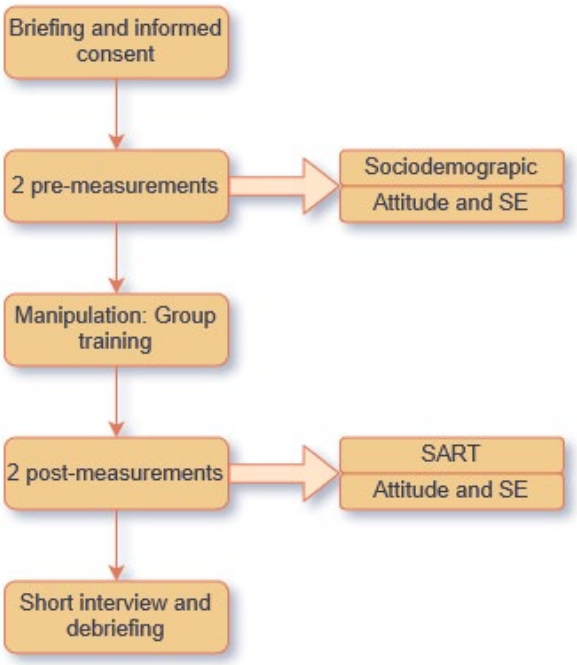
Participants in the VT condition were told how to access the virtual CPR videos and adjust the sound to comfortable levels. The VT participant was then told to watch videos two, three, four, five, and six. The VT participant was also told that the questions in the videos are rhetorical and that they did not need to be answered. Participants in CT were asked to adjust the sound of the built-in computer speaker to a satisfactory level, then watched the videos on the 2D computer monitor in full screen. They were also told that the questions in the videos are rhetorical and did not need to be answered. The researcher watched the CPR videos with participants in the CT groups, if the participant had any questions the researcher answered.

Two post-measurements were handed out: the attitude and SE questionnaire, and the modified SART questionnaire. Both the attitude and SE questionnaire and the SART questionnaire had a 1-7 Likert scale. After the post-measurements, a short interview was performed consisting of two questions, and an extra question to the VT condition. The extra question was

not asked of CT participants, since it would make their participation longer and be of less relevance to them. The extra question is about how the participants in the VT condition experienced VR training, compared with how they have usually learned or have been taught skills. Debriefing was conducted last after the short interview. Figure 1 illustrates the step-by-step process of participation.

Figure 1

Step-by-step process for participation



There was only one participant at a time to ensure that each participant could watch the videos without experiencing distractions, that each would take part in similar settings, and that each participant would be able to give their independent thoughts about their experience in the short interview. The participation environments at separate locations were similar and the computer monitors that CT subjects watched the videos on were the same size. The VR equipment was sanitized after each use and facemasks were used when recommended by health authorities.

Statistical analyses

In accordance with the preregistration (https://osf.io/nyqwj/), descriptive analyses were conducted to describe demographic variables. Then, independent samples t-tests were conducted to compare the CT and VT groups in the outcome variables: self-efficacy, situation awareness, and subjective experience of the training method. Means were calculated for the items in the attitude and SE questionnaire for each participant. Some items were reversed to measure attitude and SE, answering positively would really be negative for attitude and SE. The sum scores of items in the post-measurement have been subtracted from the sum score of items in the pre-measurement to calculate the sum change score for each training method group. Afterward, an independent samples t-test was used to compare groups on the outcome variable SE.

I calculated a composite SART score to see if there was a significant difference between groups. The scores were then used to conduct independent samples t-test to compare groups for the outcome variable SA. The short interview measured the outcome variable subjective experience of training method. The answers of participants were categorized by how often something was described or said, to create generalizable descriptions for both participation and their training method. Three analyses that were not preregistered were conducted. In the first one attitude and SE were examined to see if the sample experienced better attitudes and a higher SE, compared with before participation. The second was an independent samples t-test conducted on each of the three SART domains to examine differences at the domain level. The third was separating attitude and SE items to see if this could explain insignificant differences between groups

Data deviation from preregistration

After eight subjects had participated, two of them asked the researcher about clarification for the sixth question in the attitude and SE questionnaire, The question "how would you rate the capacity of most people to perform CPR?" After contemplation and discussion with other advisors, the question was changed to clarify the question and avoid participants misinterpreting the question. The question was changed to "most people have the capacity to perform CPR."

Ethical clearance and considerations

NSD and REK were contacted, and the study was assessed by both to not need approval. The study was registered in RETTE before data collection, which is the internal data management system of UiB. One participant underwent participation before preregistration was completed. However, their data was not analyzed before preregistration (https://osf.io/nyqwj/). A feature on the booking website Calendly caused a mistake where the name, phone number, and e-mail of three participants who scheduled bookings were sent to the researcher. After their participation, their collected data was deleted, and Calendly was not further used. Further personal data has not been collected from participants.

Data was collected on written forms and by conducting a short interview. The answered forms and surveys were stored in an office cabinet in a restricted lab. The answers from each short interview were written down on a computer and the file was uploaded to a Teams folder which only the author and the advisors Bjørn Sætrevik and Floris van den Oever could access. The uploaded file had no traceable information. Participants were asked not to share information about their participation with others who might participate until data collection was completed. All participation was voluntary, and participants were not given rewards such as

goods or payment for participation. Participants were given a debriefing after participation and reaffirmed their rights including their right to withdraw consent.

In the briefing and informed consent form and the debriefing, the occurrence of VR sickness is mentioned. Two participants reported experiencing mild dizziness after removing the VR head-mounted display. Both participants said they were fine and did not want to withdraw their consent, but simply report it as asked. The participants answered all the questions in the surveys or questionnaires and no participants were excluded. The researcher was careful about ensuring that the exact same information was available and given to each participant both before and during participation. Geir Nes was an external advisor for this study and has been our contact person in Trygg Grunn.

Results

Demographic and work-related characteristics and distribution

This section describes the characteristics and distribution of those who participated, for both the sample and for each training method. The completed education level among those who took part was comparable between conditions. The differences between them are that VT had all three participants who completed vocational school and the sole participant who had finished a master- or professional studies. The CT group in comparison had three more students who completed single subjects or a year-long study and the sole participant who had finished folkehøgskole. The participants in both methods had similar work positions, but VT had one more part-time worker and the sole two SUE in full-time work positions. CT had one more SUE and two more SUE in part-time work positions. The work experience between training methods was comparable but slightly skewed toward the VT method. VT had the sole two participants with 16-20 years of work experience, three more participants with 5-10 years of work

experience, and fewer participants with less than 2 years of work experience. See Table 3 for more information.

Table 3

Demographic and work-related characteristics and distribution

	Sample (N=32)	VT (N=16)	CT (N=16)
Age (mean; SD)	26; 3.96	26.4; 4.26	25.6; 3.74
Gender			
Female	17	8	9
Male	15	8	7
Other	0	0	0
Education			
High school	8	4	4
Folkehøgskole	1	0	1
Single subject or year-long study	11	4	7
Vocational school	3	3	0
Bachelor's degree	8	4	4
Master's degree- or profession degree	1	1	0
Work position			
Student under education (SUD)	13	6	7
SUD and part-time work	8	3	5
SUD and full-time work	2	2	0
Part-time work	3	2	1
Full-time work	6	3	3
Work experience			

Less than 2 years	8	3	5
Less than 5 years	5	3	2
5-10 years	11	7	4
11-15 years	6	1	5
16-20 years	2	2	0
Outcome variables			
SE (mean; SD)	4.41; 4.04	4.19; 3.62	4.63; 4.53
SART (mean; SD)	28.29; 6.18	28.69; 7.06	27.88; 5.35

29 out of 32 participants in the sample had courses in CPR. The category last CPR course was similar for both methods, but the longest period since courses was 10 years ago for a participant in the CT method. 19 participants used a defibrillator during their CPR courses. Only three people had used a defibrillator within the last 12 months. The VT method had a decent spread among the categories for time since defibrillator use, while CT had more people in 3-5 years since defibrillator use and the sole one for 10 years. Only two in VT and one in CT had performed CPR on someone in need. The perceived CPR necessity and importance were high for both methods, with an almost identical score. This was despite the CT method having an anomaly score of 3 from one participant. See Table 4 for more information.

Table 4

CPR courses, defibrillator used, and need for CPR training

	Sample (N=32)	VT (N=16)	KT (N=16)
1. Had CPR course			
Yes	29	14	15
No	3	2	1
If yes, when?			
0-2 months	5	2	3
3-4 months	0	0	0
4-5 months	1	1	0
5-7 months	2	0	2
8-12 months	3	3	0
1-2 years	10	4	6
3-5 years	5	2	3
6-10 years	3	2	1
2. Used defibrillator in courses			
Yes	19	10	9
No	13	6	7
If yes, how long ago?			
0-2 months	4	2	2
3-4 months	0	0	0
4-5 months	1	1	0
5-7 months	1	0	1
8-12 months	3	3	0
1-2 years	7	2	5

3-5 years	2	2	0
6-10 years	1	0	1
3. Performed CPR on person in need			
Yes	3	2	1
No	29	14	15
4. CPR courses is a necessity and important			
Score 1: Completely disagree	0	0	0
Score 2: Disagree	0	0	0
Score 3: Partly disagree	1	0	1
Score 4: Neutral	0	0	0
Score 5: Partly agree	0	0	0
Score 6: Agree	5	4	1
Score 7: Completely agree	26	12	14
4. Sum score	6.72	6.75	6.69

Confirmatory analyses for testing hypotheses H1 and H2

Our two hypotheses predicted a positive connection between the differences in training methods. The VT method would have higher levels of SE (H1) and SA (H2) than the CT method, as described in the preregistration (https://osf.io/nyqwj/).

Assumption checks were conducted for each hypothesis followed by an independent samples t-test. To test the first hypothesis (H1), the assumption that the data was normally distributed was confirmed; a normality test (Shapiro-Wilk) showed that SE was $p = .222$ so the null hypothesis could not be rejected. The homogeneity of variances test (Levene's) was

conducted to test the assumption that variances for the samples were equal across groups, SE was $p = .426$; the null hypothesis could not be rejected. With the assumption tests satisfactory an independent samples t-test will be performed for H1. The independent samples t-test result for H1 was, $t(30) = -.302$, $p = .618$. VT ($M = 4.19$, $SD = 3.62$) attaining a lower mean score than CT ($M = 4.63$, $SD = 4.53$). The group averages go against H1, but the group differences were not statistically significant.

To test the second hypothesis (H2), the Shapiro-Wilk normality test showed a SART composite score of $p = .321 > .05$ p, so the null hypothesis could not be rejected. Levene's homogeneity of variances test was $p = .209 > .05$ p, therefore the null hypothesis could not be rejected. With the assumption tests satisfactory an independent samples t-test will be performed for H2. The independent samples t-test result for H2 was, $t(30) = .367$, $p = .358$, with VT ($M = 28.69$, $SD = 7.06$) attaining a better mean score than CT ($M = 27.88$, $SD = 5.35$). The group averages were in the direction of H2, but the group differences were not statistically significant.

Exploratory analyses

Attitude and Self-efficacy

Attitude and SE scores before and after manipulation were compared. The attitude and SE scores for the whole sample increased from 1697 points pre-manipulation ($M = 53$, $SD = 5.76$) to 1838 points post-manipulation ($M = 57.4$, $SD = 4.72$). The sum increase after manipulation for the sample was 141 points, for each participant it was ($M = 4.41$, $SD = 4.04$). The VT group had a pre attitude and SE score sum of 847 ($M = 52.94$, $SD = 5.78$), and post sum score of 914 ($M = 57.13$, $SD = 3.65$). Comparingly CT had a pre sum score of 850 ($M = 53.13$, $SD = 5.92$) and post sum score of 924 ($M = 57.75$, $SD = 5.70$). This section separates the scores on these variables to carry out a more detailed analysis by looking at individual items and statistically comparing the scores before and after the manipulation within attitude and SE.

The sample scores were examined, and the condition scores were compared at the item level to analyze causes for the CT group performing better than VT. Seven of the 11 items had a net increase of 10 points or higher for the sample. Item one had an increase of 33 points with 20 points for VT and 13 to CT, item eight also increased by 33 points similarly with 20 points for VT and 13 for CT. Item six increased by 16 points with seven points to VT and nine to CT, item 11 with 14 points where 10 went to VT and four to CT. Item nine with 13 points three of which went to VT while 10 went to CT, item 10 also increased by 13 points for this item VT decreased by one point while CT gained 14 points. Item two with 12 points of which eight went to VT while four went to CT. The four remaining items had a low increase or no change. Item three increased by four points with VT decreasing by two points while CT gained four, item seven increased by two points one point for each condition, item five increased by one point for VT and item four did not change for either group.

To summarize group differences the VT condition scored higher than CT on five items: one (consider oneself to be sufficiently CPR-trained), two (self-perceived CPR responsibility to perform CPR if necessary), five (other people than EMS can perform CPR well), eight (comfortable with the self-perceived personal ability to perform CPR) and 11 (CPR teaching can improve). The CT group scored higher than VT on four items; three (the workplace should supply CPR activities and), six (people can perform CPR), nine (CPR learning is difficult) and 10 (retaining CPR skill is difficult). Both conditions had an equal score for items four (only EMS should initiate CPR) and seven (onlookers can affect self-CPR). VT scored seven more points for item one, seven more points for item eight, six more points for item eleven, four more points for item two, and one point more for item five. The CT group scored fifteen points more for item ten, eight points more for item three, seven points more for item nine, and two points more for item six.

To further examine why there were no significant differences between the training methods for the variable SE and why the results went against H1, a test was conducted to test H1 for attitude and SE separately. Attitude encompasses the items 3, 4, 5, 6, and 11 in the attitude and SE questionnaire, while SE make up the items 1, 2, 7, 8, 9, and 10. This was not a pre-registered analysis. Assumption checks were conducted for each hypothesis followed by an independent samples t-test.

The Shapiro-Wilk normality test showed that attitude was $p = .114$, while SE was $p = .212$; so, neither were rejected. Levene's was used to test if variances are equal among the groups, which they were with attitude $p = .960$ and SE $p = .443$, therefore neither were rejected. With the assumption tests satisfactory an independent samples t-test will be performed for H1. The independent samples t-test result for attitude was, $t(30) = -.394$, $p = .652$. VT ($M = 1.00$, $SD = 1.21$) attained a lower mean score than CT ($M = 1.19$, $SD = 1.47$) for attitude. For SE, the independent samples t-test result was $t(30) = -0.210$, $p = .582$. VT ($M = 3.19$, $SD = 3.02$) attaining a worse mean score for SE than CT ($M = 3.44$, $SD = 3.69$). The group differences were not statistically significant, thus opposing H1.

Situation awareness

To further examine why there were not significant differences between the training methods on SA, a test was conducted to test H2 on each of the three SART domains; attentional demand, attentional supply, and understanding. Shapiro-Wilk found that the attentional demand sum was $p = .228$, attentional supply sum $p = .031$, and understanding sum $p = .044$. Attentional demand was not rejected, while attentional demand sum and understanding sum got rejected, as the scores were in violation of the assumption of normality. Levene's established discovered that attentional demand sum was $p = .011$, attentional supply sum $p = .952$, and understanding sum $p = .022$. The attentional supply sum was not rejected. Attentional demand sum

and understanding sum were rejected as the assumption of equal variances between groups could not be upheld. As a result of the attentional demand sum not passing Levene's, and attentional supply sum not passing Shapiro-Wilk, they were analyzed by using Welch's. For the understanding sum which did not pass either test, Mann-Whitney U was used.

There was almost a significant effect for attentional demand sum, $t(21.1) = 1.556$, $p = .067$, with VT ($M = 9.00$, $SD = 3.79$) reaching a better mean score than CT ($M = 7.38$, $SD = 1.75$). Cohens d was .550, which showed a medium effect. There was a significant effect for attentional supply sum, $t(29) = 1.933$, $p = 0.032$, with VT ($M = 20.94$, $SD = 4.19$) reaching a better mean score than CT ($M = 18.31$, $SD = 3.46$). Cohens d was .684, which showed a medium effect. There was no significant effect for understanding sum, $t(127)$, $p = .485$, with VT ($M = 16.75$, $SD = 1.77$) reaching a lower mean score than CT ($M = 16.94$, $SD = 2.64$).

Interviews

As planned in the preregistration (https://osf.io/nyqwj/), an individual short interview was performed at the end of the study on each participant. The purpose was to examine the subjective experience of training method of participants and compare it at a group level. Participants in the VT condition answered three questions, and participants in the CT group answered two questions. The questions asked were:

1. How did you experience your participation in this study? (How has your participation been in this study from start to finish)
2. How has your own understanding or competence been affected by the training program you have undergone?
3. Do you think VR training has advantages or disadvantages compared to other ways of learning such as classroom instruction and demonstration?

Self-efficacy

While the CT group experienced their participation as more of a refresher, participants in the VT condition seemed to have enjoyed their participation more and experienced more of an increase in SE when comparing conditions. This indicates support for H1.

Sixteen participants expressed that they experienced their CPR skills being refreshed by taking part in the study. Six of those who experienced a refresher were in VT and ten were in CT. Most of them emphasized that the CPR refresher was good and/or spoke of the importance of CPR refreshers in general. With similar sentiments as participant 11 (CT) "*It has been refreshed, did not learn much new, but remembered and was reminded of things gone through before.*" Nine other participants gave descriptions that indicate that their SE had increased. Six of those who described an increase in SE were in VT and three in CT. The consensus for those who talked about increased SE was similar to what participant 17 (VT) said about their own increased competence/understanding "*It has been improved. Gotten clarified in which situations to do what*."

The VT condition enjoyed their participation more than the participants in CT, though both conditions expressed a similar interest or educational gain from participating. Eleven participants described their participation as interesting and/or educational. Six in the VT group and five in the CT group. As participant 7 expressed "*Thought it was interesting. Exciting topic.*" Ten participants found their own participation to be fun and/or exciting, nine in VT and one in CT. As described by participant 16 (VT) "*Educational. Comfortable. I thought it was an exciting way to learn since you could focus on what you wanted in the VR videos.*"

Situation awareness

Fifteen out of sixteen participants in VT described/talked about how realistic the VR situations were, and how it felt like being in the situation., participant 14 in VT did not express

that specifically nor did any of the participants in CT. Participant 2 (VT) described it as: "*There were more realistic situations with VR glasses compared with for example classroom teaching. It becomes more realistic, and you can see situations in a different way.*" Participant 10 (VT) similarly said "*I feel like I had a basic understanding from before that contributed, but there are situations that you do not think about. VR made it easier to review situations and recognize them.*" The descriptions that participants in the VT condition gave about the situations in the videos and their experience going through them seem to show support for H2.

For the videos, there was similar feedback from both groups. Eleven participants gave positive feedback on the videos that participants watched, five were in VT and six of them were in CT. Most said similar comments like participant 4 (CT) "*Good videos for those who do not know CPR, for those who know CPR it becomes a kind of refresher.*" However, two participants in each group gave feedback that the videos were lacking. Seven participants considered their participation to be clear or very clear meaning that their participation was considered structured and/or intertwined. Four in the VT group compared with three in the CT group. An example is participant 16 in the VT group, who thought there was a "*Clearer overview*" which made it more structured.

Discussion

The research question I tried to answer was what effect does VR training have on SE and SA for CPR skills compared with conventional training? Hypothesis 1 sought to determine if VR training will result in higher levels of SE for CPR skills than conventional training. Hypothesis 2 similarly sought to determine if VR training will result in higher SA for CPR skills than conventional training. A preregistration of the purpose, research question, and hypotheses is available on OSF at https://osf.io/nyqwj/.

Summary of findings

The group averages go against H1. There was an increase in positive attitudes and SE in CPR for the sample and for both conditions. When comparing groups there were no significant differences for positive attitudes and SE in CPR. But the CT group had higher increments of attitude and SE than the VT group, for the combined attitude and SE questionnaire and when examining attitude and SE as two different variables in exploratory analysis. The sample had the highest increases in attitude and SE items related to CPR learning and mastery. There were no significant differences in attitude and SE items between groups. But VT had better improvements in CPR mastery outcomes such as sufficient training, comfortability with own abilities, and considering it a personal responsibility to perform CPR on people in need. The CT group scored higher for CPR learning outcomes such as for ease of learning and retaining CPR skills (see Appendices I or J for more information). Support for H1 was conveyed in the short interview findings of this study, which was conducted to examine the subjective experience of the training method and compare it at a group level. The VT condition may have experienced more of an attitude and SE enhancement than CT who thought of their intervention as more of a refresher.

The group averages go in the direction of H2. There were no significant differences between the conditions for the SART composite, but the VT group had higher SA scores. When analyzing the three SART level domains there was almost a significant effect for attentional demand in the VT group, there was a significant effect for attentional supply in the VT group, but there was not a significant effect for understanding and furthermore understanding scores slightly favored the CT group. Support for H2 can be found in the short interviews where the VT group described their experience as more immersive and interesting than those in the CT group. The findings suggest that an extraneous cognitive load may have affected learning and training outcomes, in addition to interfering with previously held experience and knowledge.

Interpretation of the findings

Attitude and self-efficacy

The attitude and SE group averages go against H1. To discern the causes and explanations for why the group averages go against H1, similar literature is examined, and short interviews are used to bring context that helps to explain the results.

For the attitude and self-efficacy questionnaire, there were insignificant but improved scores for all items except number four which was about only health professionals performing CPR and which had exceptionally low scores in both conditions in the pre-manipulation measurement. Two other attitude items three and five also had close to no change, while SE item 7 similarly had close to no change. While the VT group has better CPR mastery outcomes the CT group has experienced ease in their learning condition which had a better effect on perceived ease in retaining CPR skills.

The descriptions and reflections in the short interviews supply support to the notion that the VT group participants experienced presence and immersive CPR environments. Presence seems to have been experienced based on feedback in interviews for the VT group which should have enabled positive motivational effects such as for SE and better learning outcomes (Huang et al., 2022). It was thought that presence and immersive CPR environments would captivate VT participants, with the narrative voice structuring how to approach and solve each situation thereby improving learning, mastery, and understanding (Parong & Mayer, 2020). This was thought to result in better positive attitudes and SE in CPR for the VT group.

The experience of being put into acute and authentic situations can however hamper learning and mastery if the virtual environments are too emotionally arousing (Parong & Mayer, 2020) but there have not been any such findings in this study. Structured information for how to solve authentic CPR challenges was assumed to enhance learning and mastery

outcomes thereby reinforcing knowledge and skills. Similar to the effect by Chen et al., (2020) where interactive VR environments can make it easier to understand how concepts and themes are related to each other. Despite this, the VT group had lower group scores for attitude and SE than their CT counterparts.

Realistic and immersive environments can have a negative effect by placing users in authentic but demanding situations (Huang et al., 2022). The effects of being "put" into the situations instead of watching them in a fixed and neutral method on a monitor can cause distractions and hamper desired mastery outcomes. The CT group viewed the same videos as VT, but by watching on a monitor they might have experienced the CPR videos more impersonally than VT and with less distractions. While this does not give the CT group the same acuteness and realism as those in the VT condition, it could have allowed them to take in the information easier.

If self-perceived skills are not considered sufficiently good it can have a negative effect on SE impacting performance and skill mastery (Ding et al., 2020). This is a result of confronting or experiencing potential gaps in one's knowledge or skills, which can have a debilitating effect. Testing attitude and SE in CPR can be good for uncovering gaps and shortcomings to ensure that CPR capabilities are kept intact. While both groups experienced a clear but insignificant increase in positive attitudes and SE in CPR, it seems like the VT condition experienced more of a reality check of their capabilities and knowledge. But there are implications that extraneous cognitive load may have impacted the VT condition, which will be discussed in the extraneous cognitive load section.

Situation awareness

The SART group averages supply support for H2 but there was no significant composite group difference. This requires further examination of the three SART dimensions attentional

demand, attentional supply, and understanding. Furthermore, the short interviews are illuminated to interpret the findings.

The VT group evaluated their condition as almost significantly more attentionally demanding than CT based on their attentional demand group scores in SART, along with descriptions and reflections given in the short interviews. In the interviews, fifteen out of sixteen participants in VT described/talked about how realistic the VR situations were, and how it felt like being present in the situation. The attentional supply had a significant effect on the VT condition compared with CT. Watching the videos was more attentionally demanding for the VT group than CT, but the participants in VT experienced having a higher attentional supply to handle watching the videos.

The higher attentional supply for VT group could have been an effect of VR enabling better motivational factors (Parong & Mayer, 2020) and information processes (Chen et al., 2020), which is also supported in the interviews. As expressed in the short interview by the VT group, VR provided more clarity to situations, supplying a better overview, or information being simpler to connect to earlier knowledge. Or as Chen et al., (2020), found it can also be explained by VR environments making it easier to understand how concepts and themes are related to each other. For the understanding factor, there were no significant differences between conditions, but the CT group had a marginally higher score than VT. For the understanding domain, this can be explained by the VT condition having a more introspective experience seeing the videos and thinking more about their own capabilities and potential agency or focusing on what they find interesting. Alternative to the CT group who could consume the information that came up in a more inactive environment.

The contradicting findings between H1 and H2 are interesting. SA enhances the process of making good decisions and achieving desired outcomes (Bolton et al., 2021). This makes it contradictory that attitude and SE was higher for CT. This might be the effect of extraneous

cognitive load as explained in the section Extraneous cognitive load. VR is useful in attaining or reinforcing SA in CPR. Virtual environments and programs can be specifically made to cultivate learning and training by having customized settings, situations, and videos where the user's attention is directed will reinforce knowledge and skills (Howard et al., 2021). The virtual environment and videos used in this study seem to have accomplished this, showing increases in SA in both the questionnaire and interviews.

Extraneous cognitive load

Results in this study may have been influenced by the extraneous cognitive load of VR. Immersive VR can be disruptive to learning and mastery (Huang et al., 2022), and adversely interfere with prior held knowledge (Anmarkrud et al., 2019) because of higher levels of extraneous cognitive load that can distract users (Huang et al., 2022). In this study there were insignificant differences between groups, but the CT group had higher attitude and SE scores in CPR while VT had better scores in SA for CPR. Huang et al., (2022) had similar findings with extraneous cognitive load which is negatively associated with SE and learning but does not necessarily affect situational interest for VR subjects.

Another study by Makransky et al., (2019) also showed that immersive VR can cause high scores for presence or situational placement, but lower scores for learning and a high extraneous cognitive load. The higher motivational factors such as fun and interest expressed in the interview by the VT group, should have improved attitude and SE scores more for the VT condition. But it can be explained by Makransky et al., (2020) who found that even with higher motivational attributes, immersive environments can overload and distract users. This can cause worse learning outcomes even though there are high motivational and situational scores. Which seems quite similar to the effects expressed in this study for the variables attitude, SE, and SA.

Extraneous cognitive load might have played an effect as shown with the domain understanding in SART scoring insignificantly lower for the VT group than CT. Despite attentional demand being significantly higher for VT and attentional supply almost being significant. This shows that though the group experienced more resources to deal with the information enabled by attentional supply, the attentional requirements were also higher caused by attentional demand, which ended up affecting understanding.

In this study, I tried to limit the extraneous cognitive load of VR in four ways: by giving the participants a passive VR experience, avoiding too long combined video durations for the manipulation, ensuring familiarity with the VR device, and controlling for VR sickness. The first way of limiting extraneous cognitive load was that VT participants underwent a passive VR experience in immersive environments, as they did not affect or make choices in the VR environments. This should have resulted in the device being easier to use than an active VR experience, thereby increasing acceptance and satisfaction with the virtual device and decreasing extraneous cognitive load (Israel et al., 2022). The second way to limit the effect of extraneous cognitive load was that the videos shown to both conditions had a combined video duration of 11.5 minutes, which was considered an acceptable period.

The third way of limiting the effect of the extraneous cognitive load was for participants in the VT condition were given instruction on how to use the VR device to ensure familiarity and decrease extraneous cognitive load as recommended by Israel et al., (2022) and Albus et al., (2021). The fourth way to limit the effect of extraneous cognitive load was by controlling for VR sickness and measuring it in this study, with two participants mentioning a slight dizziness after the VT manipulation. Both were asked but neither requested to withdraw consent, but desired to give feedback that it had happened as requested and said during debriefing that it disappeared quickly.

While attempts were made to limit the extraneous cognitive load of using VR in this study, it may have influenced the results. The extraneous cognitive load of using VR for training can be disruptive to learning (Huang et al., 2022). VR has become more accessible but still most participants expressed surprise over how far it had developed, which increases the risk of distractions or disruptions when exposed to immersive VR environments. However, this may decrease as people become more familiar with VR (Albus et al., 2021). Thus, I believe VR may be a more useful tool for training CPR for people with more experience with VR than the participants in this study.

Enjoyment, interest, and satisfaction for virtual reality interventions

VR as an educational tool may have a benefit due to it being more enjoyable than conventional 2D. Ten participants in this study described their own participation to be fun and/or exciting in the interviews, nine in VT and one in CT. Despite there being such disparity, CT had better scores for attitude and SE. The VT condition in this study seemed to find greater enjoyment and provide more extensive reflections about their participation experience than the CT group. Similar to Walshe & Driver, (2019) it was found that the use of 360-degree videos enabled participants to supply more detailed reflections about their learning experience, which facilitated a positive attitude about VR as a supplement in future CPR learning and teaching.

Birrenbach et al., (2021) had supporting findings that showed that students who used VR as an educational tool experienced far greater enjoyment and satisfaction with their condition than the alternative conventional condition that was given instructions and watched instruction videos. Findings supported by Makransky et al., (2020) which showed increased interest but lower learning. This is consistent with the findings of Wong et al., (2018) and Birrenbach et al., (2021), where it might be a novelty effect due to interest in VR. To summarize, using immersive VR environments as a method for learning, teaching, or training seems to supply

better motivational effects than alternative methods. Such as for fun, enjoyment, and satisfaction. VR being an innovative technology can play a role, but its usability and authenticity are assumed to be the major causes. So, while VR may not result in higher SE, attitude, and SA, it may still be a useful supplement to CPR courses.

Limitations

The are four limitations that should be considered when interpreting the findings. Firstly, the choice was made to move from a homogenous sample group to a more general sample group. Because I could not find enough participants in security guard companies or the Norwegian home guard, the population focus was changed to mainly health professional students. Because of this double target population, potential effects may have become less visible. However, this may also improve the generalizability of the study. Secondly, even after this change the sample of 32 participants is small for doing between-subject comparisons, which limits finding significant effects if the effect is there. This was due to constraints in recruiting participants during the COVID-19 pandemic and afterward challenges in getting participants to sign up for participation in the study. However, the 32 participants were equally randomized into both groups and the groups were similar.

Thirdly, I choose to include attitude items in the SE questionnaire since they were included in the pre-existing questionnaire and were preregistered. While this may have been a less adequate measure SE, it could aid in showing attitude changes about CPR. Fourthly, participants did not perform physical compressions as part of the study or their training method. This was due to practical considerations such as the data collection being conducted during the COVID-19 pandemic and economic requirements. It would be difficult for participants to perform mouth-to-mouth on a manikin when health guidelines and restrictions and requirements were issued to wear a face mask. Acquiring a defibrillator and manikin for the duration of data

collection would be costly and difficult, as well as getting an available instructor who could oversee those performing CPR at given timeslots and evaluate their CPR performance. On the other hand, considering the proliferation of CPR training without physical compressions, VR is a fitting alternative to compare to other methods without physical compression, such as 2D instructions.

Lastly, extraneous cognitive load was not measured concretely as measures were taken to limit it. It seems to have played a role as a variable that has a negative effect on motivation and SE, while not negatively affecting SA. This goes to show that even with enacted measures to deal with extraneous cognitive load, it can still have a noticeable effect.

Theoretical implications

The findings of this study have two main theoretical implications. The first is that the research on VR should take its benefits and drawbacks into consideration. Virtual environments and programs can be specifically made to cultivate learning and training by having customized settings, situations, and videos where the user's attention is directed will reinforce knowledge and skills (Howard et al., 2021). The degree to which SA can be attained and improved by using systems or devices needs to be properly contemplated in the design process (Kaber et al., 2013). Effective training programs can help foster experiences that can be used to achieve and maintain SA, but it is important to have feedback on performance (Chiu, 2020). As it helps to promote an understanding of why errors occur and information that might be overlooked. Virtual scenarios can be made to train at specific competence/education levels and ensure the progression desired for attaining SE and SA (Chiu, 2020).

The second main theoretical implication is the possible relevance of extraneous cognitive load in VR use. Extraneous cognitive load seems to have influenced CPR attitudes, SE, and SA scores for the VT condition. Though the VT condition in the study underwent a passive VR

intervention, the time duration and information given during the videos might have caused a negative effect. As such, I suggest further research comparing VR to conventional systems for CPR take an extraneous cognitive load into consideration in the study design.

Besides these two main theoretical implications, there are four topics that may be interesting to pursue in further research. Firstly, I suggest carrying out similar research with a more homogeneous group of more experienced and competent participants. The experience and competence of the participants might have influenced the findings in this study. Secondly, further research could investigate how well the information learned by undergoing the respective training methods compares over time. Do people remember what they learned better after VR training or after conventional training? Thirdly, further research could investigate the value of adding VR to CPR training with physical compression. Fourthly, participants in the VT group expressed that VR could be a positive supplement to current CPR courses and improve the courses by making CPR situations more authentic and realistic than watching videos about it.

Practical implications

The findings of this study have seven practical implications. Firstly, conducting physical compressions and mouth-to-mouth was not part of the study. But such physical training is an important part of certified CPR courses. If this study had included physical training on a manikin, it could have resulted in different results and outcomes, both positively and negatively. Secondly, extraneous cognitive load can have a negative effect on achieving H1, thereby providing worse outcomes for attitude and SE in CPR as shown in this study with insignificant but worse scores for the VT group. This seems to occur since people are not accustomed to VR and become distracted by unnecessary information. To limit extraneous cognitive load, self-measures can be made to measure if it occurs, or interviews can be conducted after VR to gain feedback on changes that can be made to avoid causing unnecessary extraneous cognitive load.

If this is done, then there are positive implications for improving attitude and SE further with the use of VR.

Thirdly, though VR did not have a significant effect on H2 in this study, it provided positive effects for SA and increasing situational interest. Which are positive indications regarding use of VR in CPR courses for SA outcomes and motivational factors such as enjoyment, interest, and satisfaction. If videos are shortened, VR environments are simplified and there is less information to take in, it is unclear what effect this would have on SA. Therefore, care should be taken to ensure that improving positive attitudes and SE in CPR do not come at the expense of reducing SA. Fourthly, if seeking to use VR in other forms of educational or training interventions, finding the balance between information needed to promote motivational factors and SA, without decreasing SE for learning will be important. The information illustrated in the VR environments or videos should be contemplated and tested to avoid unnecessary extraneous cognitive load.

Fifthly, the use of VR for CPR courses or as a supplement can play a positive effect in increasing course attendance, especially since it was considered so enjoyable and interesting to use. The inconvenience of planning when to take the course and fitting it into one's time schedule makes people, particularly students, refrain from signing up for CPR courses (Han et al., 2021). Psychological factors may also limit course taking or mastery of the CPR skill, examples are learning disorders, or performance anxiety in an unfamiliar setting (Hsieh et al., 2016). The enjoyability of VR may counteract these effects. Sixthly, people with glasses had no problem using the VR equipment, they did not express any problems at all. Lastly, participants in CT were given the opportunity to use the VR equipment after participation. All except one person tried it and they expressed interest and satisfaction.

Conclusion

A lack of available instructors and the required costs to hold courses can limit or restrict CPR course availability at a time when there is a need for courses to be more accessible. Furthermore, even for courses carried out the instructions and feedback provided by an instructor can vary in the courses. Course takers can also encounter difficulties in adding CPR courses or refreshers to their time schedules. Psychological factors can also have a negative effect on course taker performance in instructor-led courses. Learning and training in VR can be cheaper, safer, and easier than training in real-life settings. Virtual environments and programs can be made to cultivate learning and training. This makes it possible for people to watch CPR videos in VR and still undergo VR training without doing any physical tasks. It can potentially supply approaches that can increase CPR course prevalence and reduce the required resources for courses. VR may thus serve as a suitable and efficient way to educate and train personnel in CPR.

In this study, there were 32 participants who were evenly randomized into a virtual training method or conventional training method. Both groups improved in positive attitudes and self-efficacy in CPR, but there were no significant differences in these effects between the conditions. Furthermore, both groups had moderate CPR situational awareness scores but there was not a significant difference in situation awareness between groups. The findings indicate that VR may not be better suited for CPR training. However, VR can still be a useful supplement to CPR courses and training as the findings show that it was not less effective than the conventional condition. Furthermore, the extraneous cognitive load of using VR may have negatively impacted attitudes and self-efficacy in CPR for the virtual condition.

Further research is necessary to investigate the positive outcomes and usefulness VR can provide for CPR skills and training. Further research on the effect of VR on SA-related training for CPR is also necessary. Expanding the research can allow for more flexible CPR

courses and training. This can increase course availability and reduce the costs necessary to hold courses. Further research can use the data from this study, available on OSF (https://osf.io/nyqwj/). Improving learning and mastery outcomes for CPR also empower course holders to provide CPR assistance quicker, thereby saving more lives.

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Appendices

Appendix A: VR course evaluation form by Trygg Grunn

Takk for at du tar deg tid til å gi oss tilbakemelding på hvordan du opplever bruk av VR. Prøv å svar så godt du kan. Undersøkelsen tar under 5 minutter å gjennomføre og gjelder for den type tjeneste du nå gjennomfører.

Hvert spørsmål er utformet med en "i hvor stor grad" skala fra 1-5 der:

1 = Ingen grad 2 = Liten grad 3 = Noen grad 4 = Stor grad 5 = Meget stor grad

1. Fikk du utbytte av å ta førstehjelpskurs i VR
1 - 2 - 3 - 4 - 5

2. I hvilken grad føler du at kompetansen fra VR gjør deg tryggere i utførelsen av din funksjon?
1 - 2 - 3 - 4 - 5

3. Sammenlignet med tradisjonell utdanning gitt på skarpoppdrag tidligere i hvor stor grad ble treningen effektivisert?
1 - 2 - 3 - 4 - 5

4. Ser du muligheter for å benytte VR til opplæring i andre militære fag enn de du har sett nå?
1 - 2 - 3 - 4 - 5

5. Hvilke andre leksjoner ser du for deg kan brukes i denne type VR-opplæring?
1 - 2 - 3 - 4 - 5

6. Var dette VR-settet enkelt å bruke?
1 - 2 - 3 - 4 - 5
7. Om du svarte 1-3 på forrige spørsmål, forklar hva som var vanskelig:

8. Er lengden pr film på kurs- og scenarier tilstrekkelig for å oppnå læring?
1 - 2 - 3 - 4 - 5

9. Tror du man kan ha nytte av å ha VR-utdanning tilgjengelig ved en vanlig områdetrening?
1 - 2 - 3 - 4 - 5

10. Om man skulle brukt VR under områdetrening, hvilke leksjoner mener du burde vært i brillen for at det skal kunne gi verdi/effekt for treningen?

Appendix B: Demographical/work characteristics survey

Gender

Female ☐ Male ☐

Work experience

<5 years ☐ 5-10 years ☐ 10-15 years ☐ 15-20 years ☐ >20 years ☐

Age

☐

Service in which you work

Medical unit ☐ Surgical unit ☐ Primary care consultation ☐ Pediatrics consultation ☐

Primary care ☐ Others:

Last time you received a CPR recycling course

<6 months ☐ 6 m- 1year ☐ 1-2 years ☐ >2 years ☐ Never ☐

Last time he had to attend a cardiac arrest

<6 months ☐ 6 m-1year ☐ 1-2 years ☐ >2 years ☐ Never ☐

How often do you consider it necessary to receive CPR recycling training?

< 6 months ☐ 6m-1 year ☐ 1-2 years ☐ >2 years ☐ Never ☐

Type of contract

Eventual ☐ Permanent contract ☐

You feel able to attend a real Cardiorespiratory arrest?

Yes ☐ No ☐

Appendix C: Attitude questionnaire

Evaluate on a scale of 1 to 5, where:

1. Strongly disagree
2. Slightly disagree
3. Neither agree nor disagree
4. Slightly agree
5. Strongly agree

Item	Attitude questionnaire
1	Do you consider yourself to be sufficiently well trained to perform CPR?
2	Do you consider that you understand the action protocol for performing CPR in your work area?
3	Do you consider yourself to be personally responsible for being able to perform CPR?
4	Do you consider it to be the responsibility of your work centre to provide you with training to perform CPR?
5	Do you consider that the person with the greatest understanding and experience in the team should be the person to LEAD CPR irrespective of whether they are a physician or a nurse?
6	Do you consider that CPR can be PERFORMED by either physicians or nurses?
7	Do you agree that you do not need to be a healthcare professional to initiate CPR?
8	Do you consider it appropriate not to start or to interrupt CPR maneuvers if started when the probability of neurological sequel is high?
9	Do you consider that the presence of family members does not influence your decision to commence CPR maneuvers?
10	Do you believe that the information YOU have about the patient may lead you to stop CPR?
11	Do you consider it necessary to identify do not resuscitate patients (for example in the hospital or even in the primary care records)?
12	Do you consider it necessary for patients at highest risk of requiring CPR to be identified in the hospital?

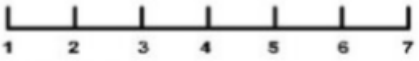
Appendix D: Situation awareness rating technique description

Domains	Construct	Definition
Attentional demand	Instability of situation	Likeliness of situation to change suddenly
	Variability of situation	Number of variables that require attention
	Complexity of situation	Degree of complication of situation
Attentional supply	Arousal	Degree that one is ready for activity
	Spare mental capacity	Amount of mental ability available for new variables
	Concentration	Degree that one's thoughts are brought to bear on the situation
	Division of attention	Amount of division of attention in the situation
Understanding	Information quantity	Amount of knowledge received and understood
	Information quality	Degree of goodness of value of knowledge communicated
	Familiarity	Degree of acquaintance with situation experience

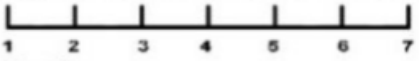
Appendix D: Situation awareness rating technique survey

SITUATION AWARENESS RATING TECHNIQUE (SART; Taylor, 1990)

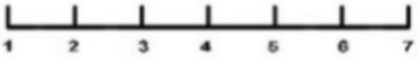
Instability of Situation
How changeable is the situation? Is the situation highly unstable and likely to change suddenly (High) or is it very stable and straightforward (Low)?



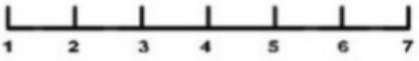
Complexity of Situation
How complicated is the situation? Is it complex with many interrelated components (High) or is it simple and straightforward (Low)?



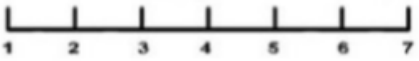
Variability of Situation
How many variables are changing within the situation? Are there a large number of factors varying (High) or are there very few variables changing (Low)?



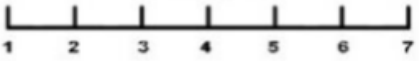
Arousal
How aroused are you in the situation? Are you alert and ready for activity (High) or do you have a low degree of alertness (Low)?



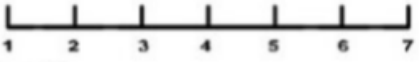
Concentration of Attention
How much are you concentrating on the situation? Are you concentrating on many aspects of the situation (High) or focussed on only one (Low)?



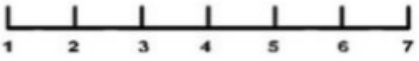
Division of Attention
How much is your attention divided in the situation? Are you concentrating on many aspects of the situation (High) or focussed on only one (Low)?



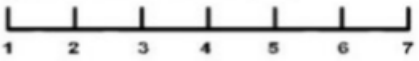
Spare Mental Capacity
How much mental capacity do you have to spare in the situation? Do you have sufficient to attend to many variables (High) or nothing to spare at all (Low)?



Information Quantity
How much information have you gained about the situation? Have you received and understood a great deal of knowledge (High) or very little (Low)?



Familiarity with Situation
How familiar are you with the situation? Do you have a great deal of relevant experience (High) or is it a new situation (Low)?



Appendix E: CPR and first-aid videos viewed by participants

Video	Video title	Translated	Duration
2	Når skal du bruke førstehjelp?	When should you use first aid?	1 min and 55 sec
3	Før du starter førstehjelp	Before you start first-aid	1 min and 39 sec
4	Bevisstløshet	Unconsciousness	3 min and 54 sec
5	Hjerte-lunge-redning	Cardiopulmonary resuscitation	1 min and 51 sec
6	Bruk av hjertestanser	Use of defibrillators	2 min and 9 sec

Note. Total duration: 688 seconds = 11.466 minutes

Appendix F: Briefing and informed consent form

I denne studien blir det forsket på virtuell trening for ferdigheter i hjerte-lunge-redning (HLR). Det blir undersøkt hvordan virtuell realitet (VR) kan brukes til å teste og trene hjerte-lunge-redning. Deltakere blir inndelt i en av to grupper. Den ene gruppen gjennomgår virtuell trening, og den andre gjennomgår konvensjonell trening. Deltakere som gjennomgår den konvensjonelle treningen, har muligheten til å bruke VR utstyret etter deltakelsen.

- Enkelte kan erfare VR-syke, som likner sjøsyke med symptomer som generelt ubehag, kvalme, hodepine og desorientering. Forekomsten av dette er lav, men vi nevner dette for å gjøre deg oppmerksom på dette i tilfelle det inntreffer.
- Personvernsopplysninger og data blir håndtert i henhold til UiBs retningslinjer og deres internsystem for prosessering av personlig data kalt RETTE. Dette for å ivareta dine opplysninger på en forsvarlig måte og opplyse om at dette foregår konfidensielt.

- Det som ønskes å måles er systemet, og ikke individuell prestasjon. Med dette menes det at man ønsker å undersøke et fenomen, og ikke individet.
- Dataene vil bli samlet ved spørreundersøkelser og et kort intervju i etterkant av deltakelsen.
- Deltakelse i denne studien er frivillig og deltakelsen kan på ethvert tidspunkt trekkes uten å måtte oppgi årsak.
- Har du noen spørsmål?

Appendix F: Briefing and informed consent form

Tittelen til studien: Virtuell trening for hjerte-lunge-redning (HLR)
Ansvarlig forsker: Samuel S. Arulanandam

Deltakeren leser:
Jeg erklærer heretter at jeg er informert om årsakene, metodene, målene, belastningene, og (om relevant) risikoer ved denne studien.

- Jeg forstår at jeg kanskje opplever VR-syke, som likner sjøsyke, med symptomer som generelt ubehag, kvalme, hodepine og desorientering.

- Jeg vet at data og resultater blir lagret, brukt og publisert privat med henhold i UiBs retningslinjer og deres internsystem for prosessering av personlig data kalt RETTE.
- Jeg forstår at det som måles her er systemet, ikke min prestasjon.
- Jeg forstår at data vil bli samlet inn ved bruk av spørreundersøkelser og et kort intervju.
- Spørsmålene mine har blitt besvart på en tilfredsstillende måte.
- Jeg har rett til å trekke deltakelsen min fra studien på ethvert tidspunkt uten å måtte oppgi en årsak.
- Jeg samtykker frivillig til å delta i denne studien.

Kontakt meg gjerne hvis du har noen spørsmål eller kommentarer. Du kan kontakte meg på sar034@uib.no eller ringe meg på 41682464.

Forskeren fyller inn:

Jeg har gitt deltakerne en skriftlig og/eller en muntlig forklaring av studien. Jeg har besvart spørsmålene til deltakerne etter beste evne. Deltakeren vil ikke bli negativt påvirket hvis deltakeren avslutter deltakelsen i løpet av denne studien.

Navn til forsker: Samuel S. Arulanandam
Forskerens autograf:

Appendix G: Sosiodemografisk spørreundersøkelse

Alder

_____

Kjønn

☐ Mann

☐ Kvinne

Annet: _____

Utdanning

Hva er din høyeste oppnådde utdanning?

☐ Fullført barneskole

☐ Fullført ungdomsskole

☐ Fullført videregående

☐ Fullført enkeltemner eller årsstudie på universitet eller høyskole

☐ Fullført Bachelor-grad

☐ Fullført Master-grad eller profesjonsstudium

☐ Annet:_____

Arbeidsstilling

☐ Fulltid

☐ Deltid

☐ Student eller under utdanning

☐ Ikke i arbeid eller studier

Arbeidserfaring

☐ Mindre enn 2 år

☐ Mindre enn 5 år

☐ 5-10 år

☐ 11-15 år

☐ 16-20 år

☐ Mer enn 20 år

1. Har du tatt kurs i hjerte-lunge-redning (HLR)? Dette inkluderer oppfriskningskurs.

☐ Ja ☐ Nei

Hvis ja, velg også hvor lenge siden du tok kurset.

☐ 0-2 måneder

☐ 3-4 måneder

☐ 5-7 måneder

☐ 8-12 måneder

☐ 1-2 år

☐ Annet:_____

2. Har du brukt hjertestarter i et HLR-kurs eller oppfriskningskurs?

☐ Ja

☐ Nei

Hvis ja, velg også hvor lenge siden du tok kurset.

☐ 0-2 måneder

☐ 3-4 måneder

☐ 5-7 måneder

☐ 8-12 måneder

☐ 1-2 år

☐ Annet:_____

3. Har du administrert HLR på noen som trengte det?

☐ Ja

☐ Nei

Hvis ja, hvor mange har du utført det på?

☐ Antall ganger utført:_____

4. Anser du det som nødvendig eller viktig å ta et HLR-kurs eller oppfriskningskurs?

Helt enig	Uenig	Delvis uenig	Nøytral	Delvis enig	Enig	Helt enig
1	2	3	4	5	6	7

Appendix H: Sociodemographic questionnaire

Age

_____

Gender

☐ Male

☐ Female

Other: _____

Education

Highest completed education?

☐ Completed elementary school

☐ Completed middle school

☐ Completed high school

☐ Completed single subjects or year-study at university or college

☐ Completed bachelor's degree Bachelor-grad

☐ Completed master's degree or professional degree/study

☐ Annet:_____

Work position

☐ Full-time

☐ Part-time

☐ Student or under education

☐ Not working or studying

Work experience

☐ Less than 2 years

☐ Less than 5 years

☐ 5-10 years

☐ 11-15 years

☐ 16-20 years

☐ More than 20 years

1. Have you taken a course in cardiopulmonary resuscitation (CPR)? This includes refresher courses.

☐ Yes ☐ No

If yes, choose also how long ago you took the course.

☐ 0-2 months

☐ 3-4 months

☐ 5-7 months
☐ 8-12 months
☐ 1-2 years
☐ Other:_____

2. Have you used a defibrillator in a CPR course or refresher course?

☐ Yes
☐ No

If yes, choose also how long ago you took the course.

☐ 0-2 months
☐ 3-4 months
☐ 5-7 months
☐ 8-12 months
☐ 1-2 years
☐ Other:_____

3. Have you ever administered CPR to someone in need?

☐ Yes
☐ No

If yes, how many people have you performed it on?

☐ Times performed:_____

4. Do you consider it necessary or important to take a CPR course or refresher course?

Helt enig	Uenig	Delvis uenig	Nøytral	Delvis enig	Enig	Helt enig
1	2	3	4	5	6	7

Appendix I: Holdning og mestringstro

Evaluer på en skala fra 1-7, hvor:
1. Helt uenig
2. Uenig
3. Delvis uenig
4. Nøytral
5. Delvis enig
6. Enig
7. Helt enig

1. Anser du deg selv som tilstrekkelig trent i å utføre HLR?

Helt enig	Uenig	Delvis uenig	Nøytral	Delvis enig	Enig	Helt enig
1	2	3	4	5	6	7

2. Anser du det som et personlig ansvarlig å kunne utføre HLR?

Helt enig	Uenig	Delvis uenig	Nøytral	Delvis enig	Enig	Helt enig
1	2	3	4	5	6	7

3. Anser du det som ansvaret til arbeidsplasser å gi deg opplæring og trening innenfor HLR og oppfriskningskurs?

Helt enig	Uenig	Delvis uenig	Nøytral	Delvis enig	Enig	Helt enig
1	2	3	4	5	6	7

4. Hvor enig er du i at bare helsepersonell bør initiere HLR?

Helt enig	Uenig	Delvis uenig	Nøytral	Delvis enig	Enig	Helt enig
1	2	3	4	5	6	7

5. Tror du at HLR kan bli utført av andre enn helsepersonell på en god og tilstrekkelig måte?

Helt enig	Uenig	Delvis uenig	Nøytral	Delvis enig	Enig	Helt enig
1	2	3	4	5	6	7

6. Folk flest er kapable til å gjennomføre HLR.

Helt enig	Uenig	Delvis uenig	Nøytral	Delvis enig	Enig	Helt enig
1	2	3	4	5	6	7

7. Hvis det oppstår en situasjon hvor HLR må utføres, har andres tilstedeværelse på-virkning på om du forsøker å utføre det?

Helt enig	Uenig	Delvis uenig	Nøytral	Delvis enig	Enig	Helt enig
1	2	3	4	5	6	7

8. Er du komfortabel med egen evne til å utføre HLR?

Helt enig	Uenig	Delvis uenig	Nøytral	Delvis enig	Enig	Helt enig
1	2	3	4	5	6	7

9. Anser du det som vanskelig å lære HLR?

Helt enig	Uenig	Delvis uenig	Nøytral	Delvis enig	Enig	Helt enig
1	2	3	4	5	6	7

10. Anser du det som vanskelige å opprettholde HLR ferdigheter?

Helt enig	Uenig	Delvis uenig	Nøytral	Delvis enig	Enig	Helt enig
1	2	3	4	5	6	7

11. Kan den nåværende måten å lære HLR på forbedres?

Helt enig	Uenig	Delvis uenig	Nøytral	Delvis enig	Enig	Helt enig
1	2	3	4	5	6	7

Appendix J: Attitude and self-efficacy questionnaire

1. Do you consider yourself to be sufficiently well-trained to perform CPR?

Helt enig	Uenig	Delvis uenig	Nøytral	Delvis enig	Enig	Helt enig
1	2	3	4	5	6	7

2. Do you consider it a personal responsibility to be able to perform CPR?

Helt enig	Uenig	Delvis uenig	Nøytral	Delvis enig	Enig	Helt enig
1	2	3	4	5	6	7

3. Do you consider it the responsibility of your workplace to provide you with courses and training for CPR and refresher courses?

Helt enig	Uenig	Delvis uenig	Nøytral	Delvis enig	Enig	Helt enig
1	2	3	4	5	6	7

4. How much do you agree that only health professionals should initiate CPR?

Helt enig	Uenig	Delvis uenig	Nøytral	Delvis enig	Enig	Helt enig
1	2	3	4	5	6	7

5. Do you think that CPR can be performed by people other than health professionals in a good and sufficient way?

Helt enig	Uenig	Delvis uenig	Nøytral	Delvis enig	Enig	Helt enig
1	2	3	4	5	6	7

6. Most people are capable of performing CPR.

Helt enig	Uenig	Delvis uenig	Nøytral	Delvis enig	Enig	Helt enig
1	2	3	4	5	6	7

7. If there arises a situation where CPR must be performed, does other people's presence influence if you try to perform it?

Helt enig	Uenig	Delvis uenig	Nøytral	Delvis enig	Enig	Helt enig
1	2	3	4	5	6	7

8. Are you comfortable with your own ability to perform CPR?

Helt enig	Uenig	Delvis uenig	Nøytral	Delvis enig	Enig	Helt enig
1	2	3	4	5	6	7

9. Do you consider it difficult to learn CPR?

Helt enig	Uenig	Delvis uenig	Nøytral	Delvis enig	Enig	Helt enig
1	2	3	4	5	6	7

10. Do you consider it difficult to maintain CPR skills?

Helt enig	Uenig	Delvis uenig	Nøytral	Delvis enig	Enig	Helt enig
1	2	3	4	5	6	7

11. Can the current way to learn CPR be improved?

Helt enig	Uenig	Delvis uenig	Nøytral	Delvis enig	Enig	Helt enig
1	2	3	4	5	6	7

Appendix K: SART questionnaire used in this study

1. I hvor stor grad opplevde du at HLR-situasjonene i videoene kunne endre seg? Var situasjonene stabil og forutsigbar (lav) eller svært ustabil og som plutselig kunne endre seg (høy)?

Lav Høy

1	2	3	4	5	6	7

2. Hvor komplekse var HLR-situasjonene i videoene som ble gjennomgått? Var de enkle og oversiktlige (lav) eller komplekse med sammenhengende komponenter (høy)?

Lav Høy

1	2	3	4	5	6	7

3. Er det mye som endrer seg i HLR-situasjonene i videoene? Er det bare noen få aspekter som endrer seg (lav) eller mange faktorer som endrer seg (høy)?

Lav Høy

1	2	3	4	5	6	7

4. Hvor aktivert eller våken ble du av HLR-situasjonene i videoene? Var du i mindre grad aktivert og årvåken (lav) eller var du våken og klar for handling (høy).

Lav Høy

1	2	3	4	5	6	7

5. Hvor konsentrert ble du av HLR-situasjonene i videoene? Fokuserte du bare på et aspekt av situasjonen (lav) eller konsentrerte du på mange aspekter (høy)?

Lav Høy

1	2	3	4	5	6	7

6. Var oppmerksomheten din delt når du opplevde HLR-situasjonene i videoene? Fokuserte du bare på et aspekt av situasjonen (lav) eller konsentrerer du på mange aspekter (høy)?

Lav Høy

1	2	3	4	5	6	7

7. Hvor mye av din mentale kapasitet måtte du bruke for å forstå HLR-situasjonene i videoene? Hadde du lav mental kapasitet til overs (lav) eller hadde du tilstrekkelig til å kunne imøtekomme flere aspekter (høy)?

Lav Høy

1	2	3	4	5	6	7

8. Hvor mye informasjon har du fått fra HLR-videoene? Har du mottatt lite (lav) eller mottatt og forstått mye kunnskap (høy)?

Lav Høy

1	2	3	4	5	6	7

9. Hvor god er informasjonen du har mottatt i HLR-videoene? Er kunnskapen som blir kommunisert unødvendig (lav) eller veldig nyttig (høy)?

Lav Høy

1	2	3	4	5	6	7

10. Hvor kjent er du med informasjonen og HLR-situasjonene som oppstod i videoene? Var dette en ny opplevelse (lav) eller har du mye relevant erfaring og kunnskap (høy)?

Lav Høy

1	2	3	4	5	6	7

Appendix L: Short interview and debriefing form used in this study

1. Hvordan opplevde du deltakelsen din i denne studien?

2. Hvordan har forståelsen din eller kompetansen din blitt påvirket av treningsopplegget du har gjennomgått?

Ekstra spørsmål til den virtuelle gruppen:

3. Synes du VR-trening har fordeler eller ulemper sammenlignet med andre måter å lære på som klasseromsundervisning og demonstrasjon?

- Jeg vil takke deg for din deltakelse.
- Hensikten med studien: I denne studien blir det forsket på virtuell trening i ferdigheter for hjerte-lunge-redning. Det blir undersøkt hvordan virtuell realitet kan brukes til å teste og trene hjerte-lunge-redning.
- Enkelte kan erfare VR-syke, som likner sjøsyke, med symptomer som generelt ubehag, kvalme, hodepine og desorientering. Forekomsten av dette er lav, men vi nevner dette for å gjøre deg oppmerksom på dette i tilfelle det inntreffer.
- Personvernsopplysninger og data blir håndtert i henhold til UiBs retningslinjer og deres internsystem for prosessering av personlig data kalt RETTE. Dette for å ivareta dine opplysninger på en forsvarlig måte og opplyse om at dette foregår konfidensielt. Hvis deltakere velger å trekke samtykket blir data som er innsamlet slettet.
- Det som ønskes å måles er systemet, og ikke individuell prestasjon. Med dette menes det at man ønsker å undersøke et fenomen og ikke individet.
- Deltakere som gjennomgikk konvensjonell trening får muligheten til å bruke VR-utstyret etter undersøkelsen.

- Har du noen andre spørsmål eller kommentarer? Hvis du har noen spørsmål ved en senere anledning er e-mailen min: sar034@uib.no og telefonnummeret 41682464.