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The Modern Way of Training Situation Awareness: Virtual Reality for Firefighters

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Table of Contents

Abstract

Topic and Research question- Firefighters training usually takes a great amount of time to equip the firefighters with the skills needed. Thus, the firefighters' department hope to find another effective way to train their firefighters. The current study aims at investigating the effectiveness of virtual reality in the context of firefighters training. The main research question is '*Can training with virtual reality increase firefighters' situational awareness when coping with traffic accidents?'* The research question was answered using two predictors, 'number of observed scenarios' and 'number of action scenarios' as independent variables and three levels of situational awareness as dependent variables. Two moderators 'Technology Acceptance' and 'years of experience' are included to investigate whether the growth rate of Situation Awareness can be explained by personal characteristics. **Method -** The research design includes both a quantitative design and a qualitative design. Ten firefighters from the region of Twente airport participated in answering the questionnaires while three participants from the same group participated in a semi-structured interview. The questionnaire data was analyzed using SPSS and tested by linear regression. The interview was collected at the firehouse where the interviewees worked. The data was analyzed using the thematic network analysis. **Results and Conclusion-** The results show that observation in VR training has a positive influence on firefighters' SA growth while being in action has partial positive influence on firefighters' SA growth. The study contributes to further understanding of VR training effectiveness. Meanwhile, a positive view toward VR training is provided to the firefighter department.

Keywords: virtual reality, firefighters training, Situational Awareness, Technology Acceptance, professional experience

The Modern Way of Training Situation Awareness: Virtual Reality for Firefighters

When it comes to fire accidents, the fewer casualties, the better. Fire accidents can be quite dangerous for closed places with little ventilation and proper evacuation routes (Cha, Han, Lee, & Choi, 2012). Firefighters training always aims to equip firefighters with the ability to make the optimal choices for the most urgent situations by undergoing a full-scale training. However, in order to fully equip firefighters with the knowledge of all kinds of situations, the economical expenses can be quite heavy (Cha, Han, Lee, & Choi, 2012). According to Bliss, Tidwell, and Guest (1997), traditional firefighters training may waste precious time to rescue victims by looking at the blueprint of a specific building and still fail to find the location of the strategic fixtures, for example, a gas cut-off. These difficulties are worrying the firefighters' institutions and cannot be neglected because of the high stakes fire accidents can contain. They are trying to train their firefighters with lower costs but cannot sacrifice any aspect of the training. To provide an equally effective but less expensive solution, Virtual Reality (VR) technology has been introduced to this area.

Researchers as well as practitioners have recognized the need for an alternative training method and have tried to investigate how VR can improve the traditional firefighters training and minimize the casualties by creating virtual scenarios related to firefighters training (Bliss, Tidwell, & Guest, 1997; Cha et al., 2012; Querrec & Chevaillier, 2001). By using VR, the training scenarios can provide virtual experiences to observe how firefighters respond to a car on fire, or wounded passengers, which stand as valuable data to predict the outcome of an actual traffic accident (Cha et al., 2012). Moreover, it is possible to rebuild and repeat the accidents. This can already be the first step to reducing the heavy expenses that traditional trainings may impose. As such, the aim of this study is to gain insights into whether virtual reality has a positive influence on firefighters training outcomes.

In this study, the training scenarios covered were mostly car accidents that can happen in real-life. These training scenarios were mainly about vehicle collisions. In these scenarios, firefighters learn to take on the role of officer-in-charge and divide tasks to their teammates. They also need to familiarize themselves with the procedure when a car accident happens. These skills not only require multiple practice sessions to develop, but also require firefighters to pay close attention to what is happening in each virtual incident. Situation Awareness can help a person be aware of the things happening around them as well as retrieving the correct information from an incident.

Theoretical Framework

Virtual reality

Virtual reality (VR) is an emerging technology that offers rich sensory perception under a virtual scenario (Burdea & Coiffet, 2017). It is also defined as a way for people to visualize and interact with computers that allows them to feel more deeply involved in the virtual scenarios (Schultheis & Rizzo, 2001). Some technologies share similarities with VR technology, for instance, 3D computer simulation (Carrozzino & Bergamasco, 2010). The characteristics of VR are similar to those in a video game or the 3D reconstruction of a building (Bruno, Bruno, De Sensi, Luchi, Mancuso, & Muzzupappa, 2010). These technologies all feature a virtual representation of subjects or objects. VR technology aims at reinforcing such an effect further.

There are two main important qualities when it comes to designing VR technology. The first one is the level of immersion, and the other one is the level of interaction (Carrozzino & Bergamasco, 2010). The first important quality is psychological immersion. The term ‘immersion’ is defined in a dictionary as ‘dipping something or someone into a liquid’. To transfer this meaning to the context of VR technology, psychological immersion represents that someone has deep mental involvement in the virtual scenarios presented in front of them. VR technology is expected to have a high level of technological immersion because it has three dimensions rather than two (Schultheis & Rizzo, 2001). It is crucial for VR to provide a large virtual space because it can have a high level of immersion (Mirhosseini, Sun, Gurijala, Laha, & Kaufman, 2014). There are different factors that might influence the level of psychological immersion one can experience. For example, larger screens can provide players with a greater sense of presence and heavier mood change than those with smaller screens while playing video games (Hou, Nam, Peng, & Lee, 2012). This study was in line with why VR simulation was changed to projection display on blank spaces or walls instead of screens in later development. (Stone, 2001).

The other important quality of VR technology is the interaction between the technology itself and the users. When people use technology, it is often that they interact with it. If the design of technology fails to include this quality, the technology will likely be considered difficult to use. For example, if the technology does not give response when users click on the wrong button, it can be hard for them to know what goes wrong during the process. Furthermore, low usability can lead to negative emotional experiences, which also influence the user’s perception of the technology (Thüring & Mahlke, 2007). For example, technology such as web-based systems support reciprocal communication with the learners, which allows the learners to gain control over their learning process by actively knowing if they understand everything before moving on to the next step (Liaw & Huang, 2002). This can provide learners with the opportunity to develop their own way of learning that may result in better learning outcomes. In addition, using tablets to learn mathematics has proven to be effective if interaction such as timely feedback was included during the learning process (Galligan, Hobohm, Loch, 2012). These studies showed that it is crucial for technology to be interactive with its learners. Hence, it is beneficial to facilitate and exploit its merits in the development of technologies. It is also important to note that the more interaction between humans and technology, the higher level of acceptance for VR (Shin, 2007).

VR Learning Effects

With the growing interest in VR technology, the question of whether it is effective for improving job performance has become a popular topic. Some researchers focused on exploring the effectiveness of VR in the context of medical training or students' learning (Aggarwal, Ward, Balasundaram, Sains, Athanasiou, & Darzi, 2007; Merchant, Goetz, Cifuentes, Keeney-Kennicutt, & Davis, 2014; Schultheis & Rizzo, 2001; Van der Meijden & Schijven, 2009). The learning effects are reported to be positive for both technical skills and non-technical skills. For example, Aggarwal et al. (2007) studied the effectiveness of VR simulation in surgical training. Their study provided evidence for the effectiveness of VR as a training method: the trainees who trained with VR performed better in dexterity, a technical skill, during surgery than those who did not. Trained surgeons need to obtain the technical skills which involve specific surgical knowledge to perform successful surgeries after their training. This study supported that VR training can improve technical skills. Besides medical training, VR simulation has also been reported to be effective for other types of job training. In manufacturing, VR simulation can increase worker safety and decrease the time needed to accomplish job goals (Mujber, Szecsi, & Hashmi, 2004). In this context, VR can also train the workers on the manufacturing lines to obtain technical skills, which they need to use for machining, assembly, and inspection.

Additionally, VR technology can allow the users to engage in active learning because they can choose which subject interests them the most (Mantovani, Castelnuovo, Gaggioli, & Riva, 2003).

Apart from training hard skills, VR can also train people's non-technical skills, including communication skills or problem-solving skills. In VR scenarios, people can be trained to communicate with other people in a fast and unmistakable manner under disastrous situations (Haferkamp, Kraemer, Linehan, & Schembri, 2011). Thus, VR training is not just a tool for training technical skills but also the non-technical ones. With SA being a non-technical skill, it is hypothesized that VR can train SA too. From these studies, VR technology seems to provide a promising path for the future development of training programs.

As VR technology may become a new tool for training programs, it is expected that users will encounter difficulties when using it for the first time. In most training sessions, trainees are trained in groups. The benefits of training in groups is that people can observe others. Observing others is considered a way of learning because it invites people to evaluate the information spilled in advance (Delong & Deyoung, 2007). The role of observation often allows learners to compare their understanding and ideas with others (Okita & Schwartz, 2006). In training settings, trainees usually take turns to be the observers and the participants. Therefore, being observers gives them the chance to learn from others' mistakes or places the participants have overlooked. Thus, it is likely that VR training can benefit from learning in groups by using the concept 'learning-by-observing'.

Situation Awareness

The earliest concept of Situation Awareness (SA) was brought in during the stage of World War I. It was connected to the importance of gaining awareness of the enemy before the enemy develops similar awareness (Gilson, 1995). However, SA did not receive much attention either in the technical or academic field until the 1980s. But ever since then, SA has become a hot topic and has been widely used in training settings such as aviation pilot training (Endsley 2000).

SA is generally defined as a person being aware of the things that happen around him or her (Endsley, 1999). To further elaborate on that concept, Endsley (1995) created a model that broke down the concept of SA into three sublevels: perceiving the elements in the environment, understanding the current situation, and predicting the future status (Endsley, 1995; Stanton, Chambers, & Piggott, 2001).

The three-level model provided by Endsley (1995) is arranged in a hierarchical order, meaning that in order to evolve into the next level, the previous level must be developed. The first level is the perception level. This is considered the lowest level of SA because it requires one to have the ability to perceive the elements in the environment (Stanton, Chambers, & Piggott, 2001). Since this is a perception level, no interpretation of the collected data is involved (Stanton, Chambers, & Piggott, 2001). An example of this level is that a pilot is aware of the flying altitude of the plane.

The second level is comprehension. This is a level in which one needs to start interpreting and integrating the data they gathered from level one. The ability to comprehend the information becomes crucial because it helps create a mental picture of what is going on. For example, a firefighter can recognize that gas leaks can cause great danger to the people around the area. During this stage, people learn to detect patterns and relate these patterns to specific scenarios so that the information they gather from level 1 can be integrated into more meaningful data. In psychological terms, schemas mean the ‘matching behavior’. Schemas allow people to focus and can help direct their attention to the appropriate information (Endlsey, 1996). Schemas are described as a pattern of thoughts or behavior that one organizes based on their previous experiences or information (Mcvee, Dunsmore, & Gavelek, 2005). Once schemas are formed, it is expected that people can recognize patterns faster under similar scenarios because the connection is already formed. For example, the firefighters can quickly connect severe car accidents with the possibility of fire explosions because of the leaking gas. Furthermore, if activated properly from long-term memory, schemas can be used to aid performance in domain-specific tasks (Endsley, 1995). Nevertheless, it is possible that people are tricked by the bias they come to develop during this process. This is called the false habitual schemas (Endsley, 1995). Schemas can inhibit processing irrelevant objects, but it can also blind people from seeing things from a new angle. That being said, the merits of schemas cannot be overlooked. Having appropriate schemas can speed up the information process, which is considered crucial to forming meaningful understanding of the relevant objects. SA level 2 aims at achieving this process and is the steppingstone to the third level.

The third level is the projection on the future. This is the highest level in the model because it consists of the ability to foresee future status (Stanton, Chambers, & Piggott, 2001). The accuracy of the prediction is highly dependent on the completeness of the collected data from level one and level two (Stanton, Chambers, & Piggott, 2001). For example, a fireman can see that there is a car accident and that there are wounded subjects, which is the observation from SA level 1. Then, he understands that the wounded subjects need to be treated because heavy bleeding can put the subject's life in danger, which is the comprehension from SA level 2. Finally, the firefighters decide to call the ambulance because he knows his patient might die if he does not do anything, which is the projection from SA level 3.

The application of SA

SA is so important because it can help cope with complex situations. Quite a few studies have investigated the benefits SA can bring to professional training. Companion (1989) emphasized that SA is a skill, which includes having the ability to make sense of the surrounding environment using cognitive skills such as perception or attention. This statement corresponds to the first level of SA, which emphasizes the significant role of perception in early SA development. In another study done by Endsley (1999), she pointed out that SA is important to aviation training because pilots need to make the optimal decisions under complex situations. Besides, trained pilots not only need to know how to operate the aircraft but also need to understand the up-to-date data fast to make proper decisions. This reflects on both the second and third level of SA (Endsley, 1999). Therefore, including SA in aviation training has been viewed as a crucial application to successful pilot performance. Another complex job training, police officers training programs, provided supporting evidence that people who trained using SA showed a lower level of mental workload compared to those who did not (Saus, Johnsen, Eid, Riisem, Andersen, and Thaye, 2006). Lower mental workload can lead to lower mental stress, which may increase job performance. Additionally, SA is also important in prehospital emergency care. Medical staff need to have the ability to obtain the correct and critical information to prevent job failures (Norri et al., 2015). Based on these facts, it is evident that SA is both a concept and a skill that can strengthen one's ability to handle matters, especially the complex ones.

To learn how to develop the three levels of SA fully, many practice sessions are required since SA is not a skill that one can pick up in a day. VR can be very useful in that sense. One of the benefits of training with VR is that it is a cost-effective method when it comes to repeating training (Cha, Han, Lee, & Choi, 2012). Unlike traditional methods, VR can rebuild and repeat the scenarios as many times as needed. This can shorten the amount of time needed to train SA. Apart from that, VR can create various virtual scenarios that can either focus on training a specific level of SA or a combination of it. Consequently, it is hypothesized that VR is expected to be a good tool to help people learn to develop SA by creating customized scenarios that fit the need.

The benefits of training SA have been widely mentioned in previous studies. These benefits include better job performance and lower mental effort. However, few studies have investigated how SA can benefit firefighters training. The reason why SA is so relevant for the firefighters is that their job is complex. Not only do they need to receive proper procedure training, but they also need to make optimal choices under limited time. They need to minimize the casualties (Bliss, Tidwell, & Guest, 1997; Cha et al., 2012). The level of job complexity of firefighters can resemble that of the pilots. Both jobs require them to cope with complicated situations. Since Endsley (1999) claimed that pilot training could benefit from training with SA because of its high level of job complexity, firefighters' training should be no different. Having SA can assist the firefighters in decision making when they need to process large volumes of information. Furthermore, each level of SA plays a significant role in firefighters' training programs. Firefighters first start with learning how to recognize relevant hazards and eventually possessing the ability to predict the future correctly. Thus, including SA in the firefighters training programs can help them perform their job better. Considering that SA is crucial to firefighters' training, this study aims at examining the effectiveness of firefighters' simulation training with the construct of SA.

Individual Differences in SA Development

Although SA is often used in training settings, it is worth noting that there are factors that can influence forming SA (Endsley, 2000). A model provided by Endsley (2000) mentioned these factors. She reported that individual differences, for instance, personal experiences and innate abilities such as fast learning or high level of sensitivity, can generate various outcomes though given the same input data. Other external or internal factors can also jeopardize the development of SA during the training process (Perry, Sheik-Nainar, Segall, Ma, & Kaber, 2007). External factors such as noise or temperature can create stress, which can be distracting factors (Perry et al (2007); internal factors such as fear or self-esteem can have a negative impact on developing SA. Dealing with internal factors can be difficult because they mostly come from a rather personal aspect. Personal factors such as previous experiences and individual abilities can already create a different level of comprehension of the same information, which can generate different objectives and expectations on the subjects they observe (Lee, Suh, & Whang, 2003). To summarize, it should be remarked that the outcome of SA development might differ because of the personal factors.

SA development represents the process of which one learns to observe, comprehend, and project future status based on the relevant subjects. Studies pointed out that previous experiences can show significant differences in acquiring SA during trainings. For instance, pilots who had previous flight experiences acquired SA skills better during the training compared to those who did not (Waag & Houck, 1994). Similarly, experienced learners are likely to have better SA and thus make less mistakes compared to novice counterparts under conversational distractions (Kass, Cole, & Stanny, 2007). Studies have also stated that previous job-related experiences have a positive influence on job motivation and job performance (Klassen, & Chiu, 2010; Li, &

Zhang, 2000). Experience can help a person form schema, which are useful for developing SA. With these studies demonstrating the positive influence of job experience on SA development, it is worth investigating if such influence will also reflect on the SA growth rate. In the context of firefighters training, the ones with more experience in firefighting may acquire SA faster. Thus, it is relevant to find out whether 'years of experience' can also make these firefighters output a steeper learning curve in SA development during the training process.

Another factor that may influence the effect of VR training on SA is 'Technology Acceptance'. While studies provided evidence for the learning effectiveness of VR technology, others provided insight into how human perception, for example, motivation can influence the acceptance of VR technology (Shin, 2017). The definition of TA is mostly known through the UTAUT (Unified Theory of Acceptance and Use of Technology) model. It is known for identifying the four determinants of TA. The four determinants are performance expectancy, effort expectancy, social influence, and facilitating conditions (Venkatesh, Morris, Davis & Davis, 2003) (see Figure 1.).Performance expectancy is defined as people believe using the technology can help them in their job performance. This factor can influence TA because people tend to use technology when they can perceive its usefulness or their personal gains. Effort expectancy is defined as the level of ease of use of technology. This factor can influence TA because technologies that are too complicated can lower users' motivation in the beginning of the learning process. People tend to give up easily when they fail to see immediate progress. Social influence is defined as the degree to which a person perceives that their important others believe they should use the technology. This factor can influence TA because people tend to be persuaded by the ones they trust. If their important others hold positive attitudes toward the new technologies, it is likely that they will think alike. Facilitating conditions are defined as people believing that an organization or a technical infrastructure can support them in using the technology. This factor can influence TA because people need to be technically supported to use the technology. A higher level of TA was reported to have a positive effect on both user's learnability and the perception toward the usability of VR (Shin, 2017). Since the current study includes training with VR technology, it is likely that TA can also influence the growth rate of SA development.

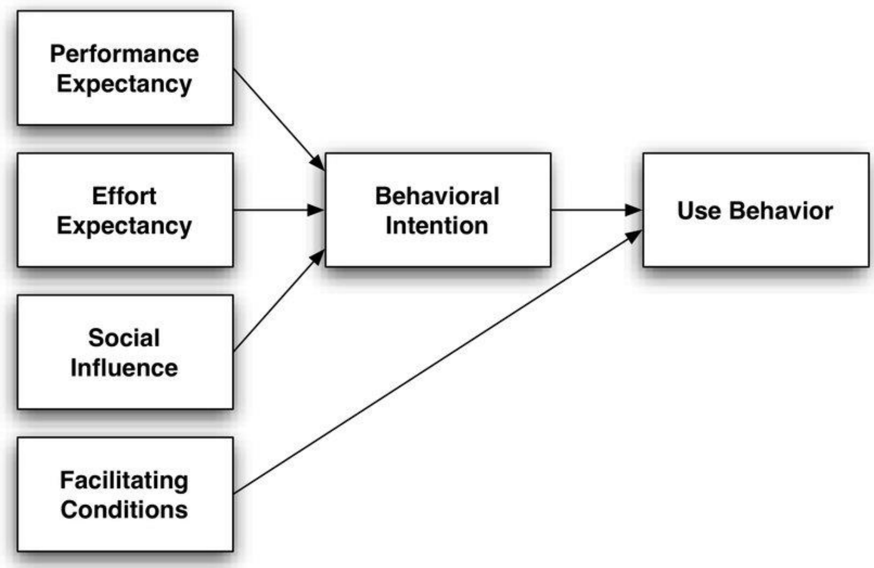

Figure 1. The UTAUT model without the four moderators (gender, age, experience, and voluntariness of use)

Many studies have provided information on the application of the UTAUT model. For instance, a study found that people show low intention of using internet banking because it is difficult to learn (Sok Foon & Chan Yin Fah, 2011). Because the performance expectancy is too high, a negative attitude is likely to form. Another study reported that the four determinants from the UTAUT model successfully predicted the students' acceptance of using tablets in educational settings (El-Gayar, & Moran, 2006). Two factors in the UTAUT model, perceived usefulness and perceived ease of use are known to affect the learners' satisfaction in e-learning (Lim, Lee,

& Nam, 2007). Furthermore, it was reported that the easier it is to use the e-learning environment, the better the learning performance (Sun, Tsai, Finger, Chen, & Yeh, 2008).

Consequently, the UTAUT model is selected as a guideline to design the TA questionnaire in this study. However, Venkatesh et al. (2003) reported that behavioral intentions, which represents the facilitating conditions moderator, is fully mediated by effort expectancy. Thus, facilitating conditions is not included in the questionnaire.

To conclude, individual factors such as ‘years of experience’ may influence the growth rate of SA. Meanwhile, TA may influence the training effects of VR technology and can also influence the growth rate of SA. Therefore, these factors are chosen as moderators in this study to present a clearer view of the training effects.

The research can contribute both in research and in practice. For the research part, the current study is expected to contribute to the field of technology, specifically in the field of virtual reality development because the research aims at investigating the effectiveness of VR. Apart from that, this study can provide empirical data to assist and support further research on understanding the effectiveness of VR. For the practice part, since the target group of this study is the firefighter department from the region of Twente airport, it is expected that the results will be able to provide the firefighter department with the necessary information to consider alternative methods when training their firefighters. If the effectiveness of VR is proven through this research, it is possible that firefighters training can cost less. Furthermore, if a positive outcome can be reported after the firefighter department from the region of Twente airport has applied such technology to their training program, it can be a great opportunity for the technology to spread nationwide and worldwide.

Research question and hypotheses

The current study first focuses on investigating the effectiveness of firefighters training with virtual reality. The training effects are measured using the construct of Situation Awareness divided into three levels. The first level of SA is to recognize relevant objects. The second level of SA is to make proper interpretation of the information gathered from level one. The third level of SA is to have the ability to predict the future based on the information collected and interpreted from level one and level two. Therefore, the first research question is: *Can training with virtual reality increase firefighters' training effects in the context of Situation Awareness when coping with traffic accidents?* Secondly, this study focuses on the moderating effects of the two moderators in this study: 'years of experience' and 'Technology Acceptance'. Therefore, the second research question is: *Do years of experience and Technology Acceptance have moderating effects on VR training effectiveness?*

The following hypotheses guide this study.

Hypothesis 1: Training with virtual reality has a positive effect on aspiring officers-in-charge's number of perceived key objects (SA level 1).

Hypothesis 2: Training with virtual reality has a positive effect on aspiring officers-in-charge's understanding of the situations (SA level 2).

Hypothesis 3: Training with virtual reality has a positive effect on aspiring officers-in-charge's prediction of the near future (SA level 3).

Hypothesis 4: The more years of experience a fireman has, the higher the growth rate one will have on perceiving the key objects.

Hypothesis 5: The more years of experience a fireman has, the higher the growth rate one will have on understanding the meaning of the key objects.

Hypothesis 6: The more years of experience a fireman has, the higher the growth rate one will have on predicting the near future.

Hypothesis 7: The higher the Technology Acceptance, the higher the growth rate one will have on perceiving the key objects

Hypothesis 8: The higher the Technology Acceptance, the higher the growth rate one will have on understanding the meaning of the key objects.

Hypothesis 9: The higher the Technology Acceptance, the higher the growth rate one will have on predicting the near future.

The aim of the interviews is to gain insight into an overall perception of how the interviewees perceive the X-VR training. During the interview, the interviewees will be asked to give inputs regarding the process of the training and to express their likes and dislikes about the training. They will also be guided to discuss whether they think the training is effective or not. It is expected that the interviewees think the training is effective, but the limitations of the technology still remain.

Method

Research design

The research design of this study was a mixed methods design which included a quantitative design and a qualitative design. The quantitative design was conducted using questionnaires. It was a quasi-experiment study which aimed at investigating the SA growth rate of the firefighters. The qualitative design was conducted using interviews, which aimed at gathering individual perspectives of the X-VR training. The study had two purposes. First, the study focused on investigating whether participants showed growth in Situation Awareness during simulation training, which allowed the researchers to gain insight into whether such training was effective or not. Therefore, three levels of Situation Awareness were measured using ‘aspiring officers-in-charge’s number of perceived key objects’, ‘aspiring officers-in-charge’s understanding of the key objects’, and ‘aspiring officers-in-charge’s prediction of the near future’ as dependent variables. Two predictors ‘number of observed scenarios’ and ‘number of action scenarios’ were used as independent variables, which represented the amount of X-VR training each participant had received. “Years of experience’ and ‘Technology Acceptance’ were selected as the moderators.

Participants

There were 10 people from the region of Twente airport who participated in the study. The overall response rate for the quantitative design was 83%. They were selected based on the participation of the existing simulation training class from the firefighter department training program for the role ‘officer-in-charge’. All of them were male, aged between 18 and 50 years old. Two trainers participated as informants. The first trainer had approximately five years of experience with VR training. The other trainer has two to three sessions of VR training prior to the X-VR training sessions. Both trainers had a great amount of experience as firefighters. The 3 participants for the interviews were collected from the existing participants from the quantitative group. The overall response rate for the qualitative design was 30%.

Instruments

X-VR. X-VR is the virtual reality tool which was used in the experiments and was a tool that allowed users to control the virtual scenarios with a joystick at hand. The virtual scenarios designed were made for the training program named ‘bevelvoerder’, which meant commander training in English translation. The scenarios were projected on a white wall in front. All directions (straight, left, right, back) and head-turning could be controlled using the joystick. The joystick also had buttons on the front to zoom-in or zoom-out. All scenarios practiced in the training sessions were vehicle accidents. Each scenario started with a film clip. The film clip was a pre-recorded footage which was used to visualize how the fire truck arrived at the scene of the accident. The fire truck siren was included in the film clip to bring in the real-life feeling. After that, the collision of the cars, trucks or vans were presented in the scenarios. There were injured drivers and passengers. The scenarios took place in diverse locations. Each scenario lasted for around 45 minutes, including the film clip in the beginning. Additionally, there was a trainer manual which was provided to the trainers to check which information was made available for the trainees to ask for each scenario. During the training, the virtual scenarios were controlled by another person in the VR room. This person could insert live changes to the scenarios, for example, the arrival of the ambulances or the police. This person would also respond as the driver of the fire truck during the film clip. The number of observed scenarios and action scenarios were provided by the organizer of the training. Each scenario had one person in action, while the others were registered as observers. They responded as a team of firefighters.

Situation Awareness questionnaire. A questionnaire consisting of nine questions was used to assess the level of Situation Awareness of each participant after each training session ended, and it was filled out by the trainer. The questions were divided into three parts according to the three levels of Situation Awareness (see Appendix B). Each part consisted of 3 questions. Each question was answered using the Likert-scale with 1 as strongly disagree to 7 as strongly agree. The first part was focused on whether the participant could perceive the relevant objects, hazards, and location which needed to be recognized by the participants, for example, ‘The trainee could accurately perceive relevant information such as location, status, and hazardous objects in the selected scenario(s)”. The second part was focused on whether the participant understood the meaning of the recognized objects, hazards, and location from the first part; for example, ‘The trainee had the ability to make an integrated analysis based on the information perceived from the selected scenario(s)’, for example, ‘The trainee could make a realistic assessment of when and how hazards will become immediate threats’. The third part was focused on whether the participant could project the future based on the subjects they perceived and the understanding of the subjects; for example, ‘The trainee can make a realistic assessment of when and how hazards will become immediate threats.’

The questions were designed based on the soft-copy booklet provided by the firefighter department. In the booklet, information on how the trainer would mark the performance of each participant after a scenario was included. From the information, the researchers combined the professional knowledge provided in the booklet and their own understanding of Situation Awareness from literature such as Endsley (2000) to generate the optimal questions for the study. Additionally, the questions were formulated broadly on purpose so they could apply to all scenarios. For the detailed content of the questionnaire, please see Appendix B.

Years of Experience. A single question in the background questionnaire was used to collect the data of a firefighter's years of experience. Seven options were provided. The years can range from 0 to more than 20 years. For the detailed content of the background questionnaire, please see Appendix A.

Technology Acceptance. Nine questions were used to measure TA. The aim of the questions was to evaluate the level of TA for each participant. Three constructs were taken from the model and were incorporated into the sub-questions, namely performance expectancy, effort expectancy, and social influence. Performance expectancy was measured with three questions, for example, ‘I think VR technology is useful for my job.’. Effort expectancy was measured with three questions, for example, ‘I think VR technology is easy to use.’. Social influence was measured with three questions, for example, ‘I think VR technology is necessary because my colleagues said so.’ (See Appendix A). All questions were answered using the 7-point Likert scale with 1 as strongly disagree to 7 as strongly agree. The questions designed in the questionnaire were adapted from Madigan, Louw, Dziennus, Graindorge, Ortega, Graindorge, & Merat (2016) and the UTAUT model.

Interview questions. The questions aimed at gaining knowledge of the participants' perception of the X-VR training process and their perception toward the technology. The interview questions were generated based on the researcher's knowledge on learning effectiveness and SA. There were six open-ended questions. Three main concepts, the usefulness, the practicality, and the training process, were investigated based on the questions. Follow up questions could be asked if needed. For detailed content of the questions, please see Appendix C.

Procedure

The research method of this study has been approved by the Ethical Committee of the University of Twente. The location of the data collection took place in the firefighter department from the region of Twente airport. In the training room, the joystick was placed on a table. The table was placed in front of the walls, of which the virtual projection would appear. There was another table for the observers to stand or sit around and take notes. The trainers sat behind the computers to monitor the whole training process. There were four training sessions in total. One session took place per week. Each of it lasted around 3.5 hours.

The researchers arrived before the start of each training session. Upon arrival, they explained why they were present and what they would do during the session. Before the first session began, two questionnaires and the active informed consent forms were handed out to the participants (trainers and trainees). The first questionnaire was the background questionnaire. This questionnaire was used to collect the background information of each participant. The second questionnaire was used to assess the trainee's level of Situation Awareness, which was filled out by the trainer after the scenario ended. Participants were asked to sign after reading the informed consent form. The participants had the chance to ask questions about any aspect of the study. All experiments were carried out in the same manner and took place with the presence of the researchers. All participation of the experiments was voluntary.

In each training session, two virtual scenarios were practiced. All virtual scenarios were already selected by the trainer from the firefighter department before the training sessions began. For each training session, 10 trainees attended. Most trainees remained the same throughout the four training sessions. They were divided into two groups for training purposes. One group for 6 people and the other one for 4 people. However, there was no difference between the groups in terms of training methods or procedures.

In each group, one person would take control of the joystick while the others stand behind him to observe. The observers were allowed to take notes. They could also interact with the trainer and the person in action by giving feedback or providing reminding comments. During the simulation training, each participant freely controlled how they wanted to explore the scenario. They also needed to follow the training procedure set by the firefighter department. The training was divided into two parts for each scenario. The first part contained a ride scene that lasted for exactly 6 minutes. During this time, the trainee needed to select and filter information and communicate with the rest of his team, the observers, who were standing or sitting behind him. The trainee also needed to communicate with his trainer. The communication between the trainers and the trainees resembled that of the radio communication.

After the first part ended, the trainer, the trainee, and the observers evaluated the performance. During this evaluation, the trainer asked the trainees if there were any information they forgot to discuss during the film clip. After that, they moved on to the second part.

The second part of the scenario was the scene where an accident took place. In this part, the trainee had to give commands, think aloud, say the subjects or objects he saw, the actions he planned to do, and communicate with his commanders and his team. When the incident master signal was given, the second part would end. Then, the trainer would give the trainer his feedback on what would be a good performance for each scenario. The observers also provided feedback and discussed what would happen if the scenario was real-life. Each scenario was carried out in the same manner. 15 scenarios in total were practiced throughout the training sessions. Each session contained four scenarios except for the third one. The third training contained three scenarios.

After four training sessions were finished, three interviews were done to collect qualitative data. Since the interviews were an additional request to the participants, another informed consent form was given out to the three participants who agreed to do the interview. The additional data collection was also approved by the Ethical Committee of the University of Twente. The interviews were scheduled based on the available time slots of the participants. The location of the interview was at the firehouse in which each participant worked as a firefighter. Each interview took around 15 minutes. Each interview was done individually to avoid answers being influenced by other participants. The interview was audio recorded. During the interview, the interviewer made encouraging remarks to help the interviewees elaborate their answers.

Data analysis

Quantitative data

Quantitative data was collected using the SA questionnaire and the background questionnaire. The data was inserted into SPSS manually. To investigate whether the questions in the SA questionnaire addressed the relevant variables, a factor analysis was carried out (see Table 1). Based on the factor analysis results, only the questions aimed for SA level 1 were grouped into a single factor. The possible explanations for this was that SA level 2 and 3 included more diverse skills than SA level 1. It was possible that the questions in SA level 2 and 3 did test the comprehension and the projection skills. However, observation skills might still be included in those questions. Therefore, those questions might not be restricted to only comprehension or projection skills. Due to this hypothesis, SA was still investigated as three separate variables. To test the reliability, Cronbach's' ɑ was: 0.98 for the entire SA questionnaire, 0.95 for SA level 1, 0.94 for SA level 2, and 0.94 for SA level 3. The number of Cronbach's ɑ indicated that the reliability for the SA questionnaire was excellent.

SA growth was investigated based on the mark on SA questionnaire. If the mark of each SA questionnaire went up together with the number of observed and action scenarios, then there was SA growth during the training process. Then, linear regression was conducted to report the effect of X-VR training on SA growth. Each SA score was entered separately into the regression analysis. Three levels of SA and two predictors were tested separately. The predictors tested in the models would be 'number of observed scenarios' and 'number of action scenarios'. Due to time constraints, not every participant has the data for SA questionnaire in every session.

To analyze the effect of the two moderators 'Technology Acceptance' and' years of experience' on the SA growth rate, the correlation between the moderators and SA was first investigated using Spearman's rho in SPSS. Spearman's' rho was used because the data in this study violated some assumptions of the Pearson's correlation while no assumptions needed to be met when using Spearman's rho. After that, linear regression was used to further investigate the relation between the moderators and the SA growth. Variables TA, years of experience, number of observed scenarios, and number of action scenarios were first centered to reduce the changes of multicollinearity before the analysis. The interaction terms, however, were computed before the variables were centered. Each interaction term was created with one moderator (TA or years of experience) and one predictor ('number of observed scenarios' or 'number of action scenarios'). The three levels of SA were tested separately for the interaction effect. This allowed the researcher to see if the interaction effect of the particular moderator on a specific SA level was significantly stronger than the one without the interaction effect. To guarantee the questions in TA questionnaire answered the relevant variable, a factor analysis table was made (See Table 1). Based on the results, effort expectancy and social influence did not meet the expected factor loadings. Although only the questions aimed for performance expectancy met the expected loadings, other questions did successfully investigate at least one of the constructs of TA. This indicated that the questions still maintained its value based on their factor loadings on TA.

To test the reliability of TA questionnaire, Cronbach's' ɑ was: 0.86 for the entire TA questionnaire, 0.94 for performance expectancy, 0.59 for effort expectancy, and 0.36 for social influence. Due to the low reliability of effort expectancy and social influence, the idea of merging TA into one variable was supported. Merging TA into one variable reframed the focus of the value of Cronbach's ɑ to 0.86. This meets the standard view of high reliability, which is 0.70 for Cronbach's ɑ (Shelby, 2011). To further support the decision of merging TA into one variable, pre-analysis was made on the difference between analyzing the factors of TA separately and analyzing them as one single variable. The pre-analysis revealed that the results did not generate different interpretations even if factors were to be analyzed separately. This conclusion applied for both the correlation test and the moderation analysis. Thus, it was decided that TA continued to be analyzed as a single variable throughout the study.

The variable trainer who filled in the questionnaire was scrutinized in several exploratory analyses to investigate if different trainers graded the SA questionnaire differently. If so, the learning curve might yield different results. All data was analyzed anonymously.

Table 1
SA Factor Loadings Resulting from a Principal Components Using Oblique Rotation (N=10)

Item	Factor Loadings: SA level 1	SA level 2	SA level 3
The trainee can accurately perceive relevant information such as location, status, and hazardous objects in the selected scenarios	**.68**	-.15	.16
The trainee is aware of the location and status of tools that may be needed for effective execution of tasks	**.75**	-.33	-.09
The trainee is aware of the activities of people in the selected scenarios, such as first-aid helpers, victims, and bystanders	**1.07**	.14	-.01
The trainee can make an integrated analysis based on the information perceived from the selected scenario(s).	.06	**-.90**	.05
The trainee can evaluate the locations and activities of people present in light of planning and task division and assess progress	**.72**	-.19	.09
The trainee understands how and why hazards may pose a threat and is able to use the knowledge and resources while making decisions	.03	-.27	**.72**
The trainee can make a realistic assessment of when and how hazards will become immediate threats.	**.73**	-.03	.24
The trainee can make accurate predictions based on the current activities and observation of the people on the scene	.12	**-.78**	.13
The trainee can foresee the possible damage of the surrounding environment and can act accordingly	.07	.06	**.97**
Eigenvalues	7.33	.49	.37
% of explained Variance	81.49	5.48	4.16

Note. factor loadings over .40 appear in bold.

Table 2

TA Factor Loadings Resulting from a Principal components Using Oblique Rotation (N=10)

Item	Factor Loadings: Performance expectancy	Effort expectancy	Social influence
I think VR technology is useful for my job	**.87**	.05	.20
I think VR technology will become an important method of job training in the future	**.99**	-.12	.15
I think VR technology is/will be an effective and efficient technology when it comes to fulfilling my job	**1.02**	-.12	.01
I think VR technology is easy to use	**.59**	.05	-.05
It is not difficult for me to understand how to use VR technology	.17	**.61**	**.43**
I think it will not take me long to learn how to use VR technology	-.12	**.95**	.13
I think VR technology is necessary because my colleagues said so	**.67**	.31	**-.37**
The people around me think I should learn how to use VR technology	.09	**.93**	-.26
I am more likely to use VR technology if I know my friends or family are using it	.16	.06	**.94**
Eigenvalues	4.50	1.65	1.26
% of explained Variance	50.03	18.37	14.01

Note. factor loadings over .40 appear in bold.

Qualitative Data

The interview data was analyzed using the thematic network analysis approach adopted from Attride-Stirling (2001). This approach aims at understanding an issue or an idea by pinning down the topics based on the interview data in an organized manner. In this study, exploring the understanding of participants' perception of X-VR training was the issue. The Thematic network analysis could help identify the themes which the content of the interviews was centered around, and draw a conclusion based on the interpretation of the conversational texts (Attride-Stirling, 2001). The full process of the thematic network analysis included three steps: breakdown of the text, exploration of the text, and integration of the exploration. Due to the limited number of interviewees, the researcher decided to skip the coding scheme in the first step because a complete coding scheme worked better when there were more interviewees. However, the initial concept of the coding scheme was still used. The raw data such as similar answers or word choices would be marked as meaningful chunks of texts. To better analyze the content of the interviews, the conversations were recorded and transcribed (See Appendix D). The transcripts were used to compare the similarities and the differences between the answers of the interviewees. After that, abstract themes from the meaningful texts were organized and refined so that the data was reduced to a more manageable set of specific themes. This step contains careful interpretation of answers given by the interviewees. The three levels of SA and the overall attitude of X-VR training would be analyzed based on the answers generated by the six main questions in the interview. The last step was to arrange all the themes derived from the previous steps. All themes would be compared to form groups of similar themes. Eventually, this would result in a global theme, which could summarize the main inputs gathered from the interviewees.

Results

Descriptive statistics

The mean and standard deviation of Situation Awareness and Technology Acceptance were presented (see table 3). For SA, three levels were reported separately. For TA, three determinants were reported separately.

Table 3

		M	*SD*
SA	Level 1	4.65	1.27
	Level 2	4.85	1.12
	Level 3	4.68	1.18
TA	Performance	4.43	1.48
	Effort	4.43	.92
	Social Influence	3.30	.85

SA, Situation Awareness; TA, Technology Acceptance

The moderator ‘years of experience’ was an interval variable. Therefore, the mean and standard deviation were not possible to present. Among all the participants, 4 participants have 4-6 years of experience in firefighting; 2 participants have 7-10 years; 1 participant has 11-13 years; 1 participant has 14-16 years; 1 participant has more than 20 years.

Spearman’s rho correlation tests

Based on the results, there was no significant relationship found between the three levels of SA and TA (SA1, r = .26; SA2, r = .35, SA 3, r = .42). Similarly, no significant relationship between ‘years of experience’ and the 3 levels SA was found (SA1, r = .26; SA2, r = .16, SA 3, r = -.01). The correlation table was presented in Table 4.

Table 4

Spearman's rho Correlations

	SA level 1	SA level 2	SA level 3	Exp	TA
SA level 1					
SA level 2	.78*				
SA level 3	.83*	.86*			
Exp	.26	.16	-.01		
TA	.26	.35	.42	-.12	

SA, Situation Awareness; Exp, years of experience; TA, Technology Acceptance

Trainer difference

To investigate whether different trainers could make a difference in SA growth, trainer difference was analyzed as a moderator in the linear regression. The mean of the SA questionnaire was different. Trainer 1 had a lower mean while trainer 2 had a higher mean ($M1$ = 4.32, $SD1$ = 1.40; $M2$ = 5.23, $SD2$ = .49). Also, based on the results from regression analysis, significant effect was found between trainer differences on SA growth on both predictors. ('number of observed scenarios', R^2 change = .22, p = <.01; 'number of action scenarios', R^2 change = .20, p = .01).

Regression analysis

The regression analysis was used because it can identify if there is a casual relationship between the predictors and the SA scores. Three out of five assumptions for running a linear regression analysis were not met. The assumptions are normality, homoscedasticity, and codependency. The normality assumptions were not entirely met because variable SA is slightly skewed to the left while both predictors are normal or close to normal distribution. The simple linear regression test was conducted to investigate the SA growth from the first session to the last one. Two predictors, 'number of observed scenarios' and 'number of action scenarios' were tested separately. For 'number of observed scenarios', it revealed that there was a statistically significant effect found on SA growth for all levels. SA level 1, $F(1,19)$ = 13.34, p = < .01; SA level 2, $F(1,19) = 6.81$, $p = .02$; SA level 3, $F(1,19) = 11.80$, $p = < .01$. Investigation of the parameters showed that 'number of observed scenarios' had a significant effect on SA growth on all levels. For 'number of action scenarios', it revealed that there was a statistically significant effect found only on SA level 1, $F(1,19) = 8.76$, $p = < .01$ and level 3, $F(1,19) = 5.00$, $p = .04$, but not SA level 2, $F(1,19) = 2.38$, $p = .14$. The results indicated that the SA growth increased if one observed more scenarios. On the other hand, high number of action scenarios partially led to higher SA growth rate.

Table 5 *Standardized Estimates Resulting from the Linear Regression Analysis with SA as Dependent Variable*

	SA level	B	β	*p*	*R*	R^2 change
Observed	Level 1	.64	.33	< .01*	.64	.41
	Level 2	.52	.23	.02*	.52	.26
	Level 3	.62	.29	< .01*	.62	.38
Action	Level 1	.56	.83	< .01*	.56	.38
	Level 2	.33	.43	.14	.33	.11
	Level 3	.46	.62	.04*	.46	.21

*$p < .05$

Observed, number of observed scenarios; Action, number of action scenarios

Moderation Analysis

Moderation models were built to investigate the interaction effect between the SA training progress and the moderator variables TA and 'years of experience'. The results showed that TA has partial interaction effect between VR training and SA growth rate with the predictor, 'number of observed scenarios'. Such interaction effect was only found on SA level 2 (R^2 *c*hange = .14, p =. 02). There was no interaction effect found on SA level 1 (R^2 *c*hange = .06, $p = .10$) or level 3 (R^2 *c*hange = .06, $p = .13$). The same results were found for the predictor, 'number of action scenarios'. The interaction effect was only found on SA level 2 (R^2 *c*hange = .19, $p = .01$). There was no interaction effect found on SA level 1 (R^2 *c*hange = .05, $p = .17$) or level 3 (R^2

*c*hange =. 09, *p* = .09). To conclude, both predictors indicated that TA does not fully moderate VR training and SA growth rate.

The results for moderator 'years of experience' showed no interaction effect between VR training and the SA growth rate. The results applied for both predictors, which were 'number of observed scenarios' and 'number of action scenarios'. The results are presented below (See Table 6).

Table 6

Regression moderation models of study variables

	SA level	B	β	*p*	R^2	R^2 change
Exp		-.02	-.01	.90		
O	Level 1	.79	.47	<.01*		
Exp*O		-.54	-.05	.36	.80	.02
Exp		-.10	-.06	.62		
O	Level 2	.73	.38	<.01*		
Exp*O		-.55	-.04	.42	.72	.02
Exp		-.27	-.18	.12		
O	Level 3	.80	.44	<.01*		
Exp*O		-.64	-.05	.29	.79	.03
Exp		.13	.10	.49		
A	Level 1	.63	1.00	.03*		
Exp*A		.04	.01	.96	.65	<.01
Exp		.06	.04	.18		
A	Level 2	.43	.60	<.01*		
Exp*A		.03	<.01*	.96	.44	<.01
Exp		-.10	-.07	.64		
A	Level 3	.51	.76	.03*		
Exp*A		.06	.02	.94	.51	<.01
TA		.12	.16	.47		
O	Level 1	.75	.45	<.01*		
TA*O		-1.45	-.18	<.10	.84	.06
TA		.29	.35	.12		
O	Level 2	.60	.31	<.01*		
TA*O		-2.18	-.24	.02*	.84	.14
TA		.23	.30	.20		
O	Level 3	.65	.36	<.01*		
TA*O		-1.43	-.17	.13	.80	.06
TA		.41	.57	.02*		
A	Level 1	.67	1.06	<.01*		
TA*A		-1.00	-.40	.17	.79	.05
TA		.52	.63	.01*		
A	Level 2	.46	.65	.02*		
TA*A		-1.92	-.67	.01*	.80	.19
TA		.48	.48	.02*		
A	Level 3	.53	.53	.01*		
TA*A		-1.33	-1.33	.09	.76	.09

*$p < .05$

TA, Technology Acceptance; O, number of observed scenarios; A, number of action scenarios; Exp, years of experience

Interview analysis

The inputs from the participants confirmed the initial hypothesis of their perception toward the X-VR training. The overall perception of the XVR training was good. Interviewees reported that XVR was not hard to use and was very useful for training specific skills, which were the procedures when car accidents happened. The following quotes provided the evidence for the perceived ease of use of the X-VR training.

Interviewee 1:

> At first, the exercises were very difficult, also from my experience because you really have to know how it works. In the first exercises, it played a role for me because you really focus on the stick because you have to handle it. But the last exercises, I didn't even [notice] the things are there. (Interviewee 1, 2020)

Interviewee 2:

> At first, it's difficult. It's an extra obstacle. In the procedure, when you repeat it, it gets easier. (Interviewee 2, 2020)

Interviewee 3:

> ...the first time is not easy because it's new and you are very busy with the joystick. But after two, three times, it gets there automatically and then you can use your mind for other things that are within the simulation. (Interviewee 3, 2020)

The following quotes provided evidence for the perceived usefulness of the X-VR training.

Interviewee 1:

> I learned different things starting with I think that's for myself, the most important thing is you get structure with the incident. Second, to observe things in the screen and in the system which can help you with solving the problem. And the first thing is

> that you learn to manage the incident. And the system, in that case, is very useful because the system brings you some structure. (Interviewee 1. 2020)
>
> And the system, in my opinion, is the first step. So when we have achieved that, we get the structure of the incident, and we make the next step to […] dealing with other people…(Interviewee 1, 2020)

Interviewee 2:

> To set priorities to the setting, for that, it’s good. Yeah, prioritizing and procedure, that’s the most important I think....partly I think it helps. (Interviewee 2, 2020)
>
> I think...XVR is the future. It’s unstoppable. (Interviewee 2, 2020)

Interviewee 3:

> ...we are practicing the procedures. And that’s a skill that we are developing. It’s getting better and better…(Interviewee 3, 2020)
>
> What did I learn? Hmm, like I said, the procedures. You know them in theory but now you have do it...hmmm...you can learn them from paper, but now it takes time for someone to do the job. So you have to wait and think again ‘Oh wait, what is the next step in the procedure. Oh, that’s that.' So we learned that. Yeah and thinking the incident before you arrive. ‘What kind of scenarios can you expect?’ And that’s also a learning point. (Interviewee 3, 2020)

Apart from that, they gave credits to the merits of X-VR. Two interviewees mentioned that training with X-VR saved time, and it gave them chances to think in a more organized way. Therefore, they considered X-VR as an effective tool to train skills.

Interviewee 2:

> I write things down so I have a structure and the procedure...it's got a standard in my head…(Interviewee 2, 2020)

Interviewee 3:

> I like it because they can do everything within the small amount of time. Normally, when we go practice in the real world, you can...it's a lot of work to put the vehicles. ...everyone participates, and we can learn within one evening, you can do four incidents. Well, normally, you do one incident and it takes about one and a half hour to two hours. So your learning curve is much better. Interviewee 3, 2020)

However, all interviewees agreed that X-VR was not realistic enough as the system did not include any human factors that could interfere with the training process. They mentioned that this was a major limitation they saw from the X-VR. Phrases such as 'not practical enough', 'X-VR stays the same', 'not realistic', 'X-VR is limited', or 'missing the dynamics' were mentioned by the interviewees. For example, people with bumpy personalities in an incident could influence the rescuing process of the injured people. But this quality could not be represented in the X-VR scenarios. Also, there were few obstacles to communications and therefore was too ideal compared to real case incidents.

The following quotes provided evidence for such views.

Interviewee 1:

> The dislike of the system is it's, sometimes, I miss the dynamics. ...in real incident, when people achieve task, they get back to you and say 'I have completed the task. What's the next task?" And here is, I give them a task, they do it, and they walk back... in real incident, when they get on scene, they will come to you, and they will ask what to do. (Interviewee 1, 2020)

Interviewee 2:

> I think in reality, when you train in reality, it's better. There are much more obstacles ... In real-world, sometimes things go wrong. So when you are the leader of that incident. You have to participate on that so that's not the XVR. Everything stays the same. (Interviewee 2, 2020)
>
> No, I think it's not practical enough. So in the real world, when you free a victim out of the car, you have to watch what your men are doing. So that's...not you don't have to when you say 'remove the door', there's one way to remove the door and you don't have to look at it if it's good or not. (Interviewee 2, 2020)
>
> I think, personality of people affects most of the incidents. And you can't let it see on VR. So when someone is tired, that goes...the quality of the incident goes down. So you have to [anticipate] on that. And [in] VR, it's [fixed], it's always the same. (Interviewee 2, 2020)

Interviewee 3:

> I find it difficult that the last time we trained, there was some glass on the ground but I didn't see it because we are focused on the 'Okay, did the individual in the video was doing some kind of things?" And normally, you would see real glass on the ground and you can act on it. But that's difficult in reality. (Interviewee 3, 2020)

Additional remarks about X-VR training were that the trainers in the training sessions were helpful because they urged the trainees to think critically. Trainers stood as a necessary component to effective training in procedures and standards.

Interviewee 1:

> [The trainer is] trying to make you think about things. Ask you questions so you get to start asking questions for yourself. And you get to some point saying ‘Oh, I didn’t think about that.’ So it makes it stronger for the exercise after that. (Interviewee 1, 2020)
>
> ...you can learn from other people because they do things which is useful for your own exercises. And also learn things and get feedback from it…(Interviewee 1, 2020_

Interviewee 3:

> ...you have a lot on your mind when you do it. So the trainer gets you back on track. (Interviewee 3, 2020)

Another common remark made by the interviewees was that observations played an important role in their learning process. They all benefited from observing others because they could learn from others’ mistakes. Plus, they had more time to think about what they would do if they were the people dealing with the situations. They considered observations as a very helpful approach to learn and to improve their performances.

Interviewee 3:

> It’s (observing others) very useful for your own mindset. When you are behind a person and you are doing the training of the simulation, you have more rest and more time to think about a step ahead of something. So we’ll say ‘Oh, you forgot that’ or’ You have to do that step.’ So it’s helpful to look at others and how do they do it. And you can learn for yourself. (Interviewee 3, 2020)

Based on the inputs from the three interviewees, it could be concluded that X-VR training did manage to train the skill intended, which was remembering the standard procedures of the incidents. Although some aspects in the training were too ideal, the training was reported to be useful and time-efficient. Moreover, the training itself was carried out in an effective manner due to the existence of the trainers and the opportunity to observe others during the training process.

Discussion

The aim of the current study is to investigate whether VR technology has a positive effect on learning curves. The first research question was whether VR training can increase the firefighters' learning effects when coping with traffic accidents using the construct of Situation Awareness. The second research question was whether TA and 'years of experience' in firefighting have moderating effects in VR training effectiveness. The findings reported that training with VR does have a positive influence on SA growth. However, neither TA nor 'years of experience' have a moderating effect on SA growth.

The learning effects of VR training

First, it was hypothesized that training with VR has a positive effect on firefighters' SA growth. The findings partially confirmed such an effect. Based on the results generated from the predictor 'number of observed scenarios', all three levels of SA showed improvement throughout the four training sessions. This finding not only is in line with the previous literature about the effectiveness of VR technology, but also supported that VR can be a valuable tool for training skills. VR has been claimed to be an effective training method to medical training programs (Aggarwal et al., 2007). This study expanded the field to firefighters training, which can stand as another reason for VR technology to continue its development. Plus, such positive results can be seen as an added value for the VR technology itself. However, based on the results generated from the predictor 'number of action scenarios', only SA level 1 and SA level 3 showed improvements throughout the four training sessions. A possible reason for non-significance for

SA level 2 may be because of the small power in this study. Based on the raw data, most participants did show improvements in SA level 2; however, this was not shown on average. It is expected that the improvements of SA level 2 can be seen on average if the sample size were to be bigger. Another possible explanation can be that observation can in fact induce better learning outcomes. This idea can be supported because observational learning allows people to focus on the learning tasks fully (Braaksma, Rijlaarsdam, & Van den Bergh, 2002). Performing the tasks actively did benefit the learning process; however, observational learning can avoid dividing learners' attention since no physical actions need to be made during the learning process (Braaksma, Rijlaarsdam, & Van den Bergh, 2002). Therefore, it is possible that not all participants benefited from taking control in the scenarios because they could not dedicate their full attention to remembering the procedures or understanding the scenarios.

In the meantime, it is wise to further emphasize the merits of observations during the training process. As claimed by previous studies, observing is a way of learning (Okita & Schwartz, 2006). Observing others gives observers the chance to spot others' mistakes and learn from them (Delong & Deyoung, 2007). This process can help people to perform better when they need to demonstrate what they have learned. Furthermore, seeing others perform can increase ones' confidence in decision making when the people in action respond the same (Lamberton, Naylor, & Haws, 2013). Similarly, it can also encourage the observers to think critically when the people in action respond otherwise.

Apart from that, with the results reflecting on SA growth rate, it can be concluded that VR technology is suitable for training non-technical skills. SA is a skill that requires one to observe, comprehend, and project based on the subjects one is surrounded by (Endsley, 1999). As the average mark of SA questionnaire goes up throughout the training sessions, it can be interpreted as the participants were making progress in the process of familiarizing themselves with standardized procedures for firefighting. VR technology is commonly used for training technical skills, such as surgeon skills or pilot skills (Aggarwal et al., 2007; Endsley, 1999). This study provides supporting evidence that VR technology can also be used to train non-technical skills besides communication skills or problem-solving skills (Haferkampet al., 2011). The findings suggest that SA can be improved by using VR as a training method. Also, this points out that VR technology is not restricted to a certain type of skills but can adapt to a wider range of training purposes as long as the learning goal is set clearly.

Second, it was hypothesized that ‘years of experience’ would have a moderating effect on SA growth. This hypothesis was not confirmed. Therefore, the hypotheses that ‘years of experience’ have a positive effect on SA growth were not confirmed. This finding is inconsistent with the previous studies. There is a possible reason to explain why ‘years of experience’ did not yield the moderating effects as expected. All the trainees need to have the same level of skills and knowledge to be able to join the training. This indicates that even though the years of experience indeed is different for each participant, the actual amount of experiences accumulated over the years may be the same. Therefore, ‘years of experience’ may not adequately represent the actual experiences. This makes it hard to induce any moderation effect because in fact there may be no difference in the participants’ experiences. This explanation can be supported by a previous study on pilot training. In the study, the experience level among the trained pilots were different not only on numbers but also in reality (Waag & Houck, 1994). There were trained pilots that had previous flight experiences while some others did not. It is obvious that the population of their study did not share the same level of skills or knowledge, which is not the case of the current study.

Third, it was hypothesized that TA has a moderating effect on SA growth. The findings did not confirm all hypotheses. Based on the results, TA has moderating effects on SA level 2, but not on SA level 1 or level 3. There are two possible reasons to explain the unexpected findings. First of all, the impact of TA has been reported to only influence the learners in an early stage of technology adoption (Davis, Bagozzi, and Warshaw, 1989). However, this was not the relevant stage for the sample of the current study. According to one of the interviewees, he mentioned that he has already undergone VR or similar training before participating in the X-VR training (personal communication, 2020). His statement indicated the X-VR training was not the early stage of VR technology adoption in the firefighter department. It is also not the early stage of individual adaptation to the technology. Because of that, it may be possible that the effect of TA has subsided and could not have a significant impact on SA growth. Secondly, the X-VR training sessions were mandatory for these trainees to fulfill their job. This can greatly reduce the effect of TA (Tarhini, Hassouna, Avvasi, and Orozco, 2015). For those who must learn to use the technology has an external pressure that pushes them to use the technology. On the other hand, people who are encouraged to use technology have the freedom to learn it as a bonus skill. The participants in this study needed to accomplish the X-VR training goals so that they can finish part of their training as a firefighter. Even though their TA may vary from individual to individual, their final goal for this training is to pass the exam. Therefore, it is likely that the participants with lower level of TA recognized that learning to use X-VR was as request for them. This situation is very different from the previous studies that investigated whether TA can be an influencing factor to learning performance. For example, a study reported that there was a positive effect between TA or other factors such as learners' satisfaction and e-learning continuance intention (Roca, Chiu, and Martínez, 2006). However, while their study successfully claimed that TA showed positive effect on the learners' intention to use e-learning, they did not continue their study by investigating if the participants in fact continued to use the e-learning tool. Based on this fact, it is obvious that this is not a mandatory skill which needs to be learned by the participants. Thus, their motivation is relatively weak and cannot resemble that of the current study's.

The input given by the interviewees also contributed to the analyses of the training's effectiveness. VR training was an effective way to train firefighters even though there were limitations such as unrealistic aspects of the scenarios. Interviewees claimed that X-VR has helped them to learn to keep the structures and procedures of the incidents in mind. Furthermore, they stated that they have acquired SA skills for all three levels. During the training, they have learned to set priorities, which helped them to observe relevant subjects, understand the meaning of them, and make better decisions. Besides that, they claimed that X-VR was a tool which was easy to learn. This indicated that X-VR has high usability and is more likely to receive positive emotional experiences (Thüring & Mahlke, 2007). Additionally, the trainers provided timely feedback for the trainees during the training process. Feedback is considered an effective interaction during the learning process (Galligan, Hobohm, Loch, 2012). These merits strengthened the training effectiveness and increased the amount of interaction between people and the technology. It is thus concluded that VR training has successfully covered all levels of SA (observation, comprehension, and projection) and have improved the firefighters' performance as an individual. Nevertheless, it should be noted that the current X-VR training may not have reached the advanced stage where human factors can be implemented. The interviewees believed that VR training could not replace the traditional training at the moment as the technology could not create scenarios that closely resemble the real ones. That being said, VR technology is still an effective tool to use for learning a specific skill. Without the human factors, the current X-VR used by the trainees can help them stay focused on the assigned tasks.

Theoretical and practical implications

This study contributes to the understanding of VR training effectiveness and supported that SA is a valuable concept for evaluating training effectiveness. Previous studies did include SA in other context of training (Endsley, 1995; Norri et al., 2015, Saus et al., 2006). However, those studies did not combine firefighters training with VR using the construct of SA. This study successfully filled the gap. Fulfilling this gap is important because SA is an important concept and has been used in complex training settings. This study not only showed that VR technology is effective for training settings, but also demonstrated that it can train non-technical skills such as Situation Awareness. While previous literature focused on the importance of including SA in complex training settings, this study provided further insights into the connection between VR technology and SA. First, this study showed that SA can be trained using VR technology. Second, SA can be used to assess VR training effectiveness. Apart from that, there is little research on how firefighters training can benefit from including SA. This study showed that SA is crucial for firefighters' job content.

With other studies reporting positive learning effects on VR technology, this study continued to provide positive evidence to support the field of VR technology and uphold the promising path of VR development. This can encourage other researchers who are interested in the field of VR to dig deeper into the potential of VR. In addition, this study reported consistent findings to the understanding of the effect of TA. The results supported that TA may only pose an impact on learning performance in the early stage of technology adoption. In an early study, researchers who were investigating people's acceptance of computer technology mentioned that the influence of TA may subside as time goes by (Davis, Bagozzi, and Warshaw, 1989). This brings new insights to the existing UTAUT model by Venkatesh et al. (2003) because they did not include timing as an influencing factor to the level of TA.

Apart from contributing to the scientific field, this study also profited the firefighters department in understanding their training effectiveness. This study answered their main concern about X-VR technology by stating that the technology indeed can become one of their training tools. The positive results can give the firefighters department confidence to promote X-VR training to other regions of firefighters department in the Netherlands. Moreover, the inputs collected from the interviewees during the interviews were valuable as they claimed that the limitations of the X-VR did not jeopardize their learning process. This gives the firefighter department another reason to adopt this technology nationwide. Additionally, this study showed to practitioners that there is a possibility of benefiting from the VR technology by merging it together with the traditional training methods. Other kinds of training methods, such as virtual learning environment or computer-based training, have been claimed to be as effective as traditional training methods (Aggarwal et al., 2007; Williams & Zahed, 1996). While traditional methods tend to cost more time, it may be good to consider using VR training methods to achieve the same learning effects. This way, organizations can grow in a more cost-effective fashion. VR technology can also stretch its usability even more in the job-related training settings such as risk management training, which may increase work proficiency in organizations.

Limitations

When considering the generalizability of this study, several limitations should be mentioned. First, the power of this study was very small because the training sessions were not initiated by the researchers. Thus, the researchers could not request more participants. Although there were other groups of trainees that were to receive the same X-VR training in the later time period, the timing remains uncertain. Due to time constraints, the sample size remains as little as 10 people for the quantitative data. These limitations also applied to the qualitative data collected using interviews. Due to the limited time that each participant can have apart from their work, it was not possible for the researcher to request them all for an interview. Small number of interviewees might not be able to represent the view of all the participants. It is possible that other participants think differently in terms of training effectiveness. However, despite the small sample size, the study still maintained its value because there was an improvement in the participants' learning curve. Besides, one of the goals of this study is to specifically respond to the firefighter department if X-VR training can be a useful method in the future. The study did manage to do so. Furthermore, the interviews allowed the researcher to closely analyze the opinions from some of the participants. Having both quantitative data and qualitative data allowed the researcher to reach a more comprehensive conclusion regarding VR effectiveness.

Second, three out of five assumptions for running a linear regression analysis were not met. Those assumptions are normality, homoscedasticity, and codependency assumptions. This can be explained because SA is a variable used to assess if the participants showed learning improvement. Since the results did demonstrate a learning effect, the numbers distributed in the SA questionnaire quickly gathered around the higher side of the scale. Also, based on the similarities of the scenarios used in all training sessions, it was expected that the SA score would go up for every participant. This resulted in the non-normal distribution of the SA data. Another assumption not met was the homoscedasticity. The scatter plot showed that the participants who had fewer data in predictors variables had a wider range of residuals while the ones with more data in predictors variables had a smaller range. This can be explained because if more SA data could be compared per individual, the residuals between each set of questionnaires could be reduced. Similar logic applies to the participants with little SA data. Therefore, the residual differences existed out of the different amount of SA data for every participant. Lastly, the assumption of independency of scores was not met as each SA questionnaire was entered into the analysis as an independent observation while in fact, the same person often filled out the questionnaire more than once. This was done to increase the low power of the analysis. This decision made SA scores dependent on the individual. The lack of independency could influence the correctness of the results that linear regression yielded because error terms may correlate higher when scores are of the same participant. The results of the current study should therefore be interpreted with some caution.

Future research

The current study focused on the scope of firefighters training, especially in the area of commander training. It would be relevant to see if VR training can also report positive learning effects in other types of roles as firefighters. This could expand the knowledge of whether VR technology can be promoted to a wider range of job content. Also, including different types of roles of firefighters may be able to truthfully represent the moderating effect of experiences. Different types of roles as firefighters may involve more skills to be trained. For instance, spatial information learning skills can be strengthened by repeatedly exploring different virtual environments (Stanton et al., 1998).

Secondly, as many studies have demonstrated positive learning effects on VR training, it is crucial to investigate further whether the knowledge can be successfully transferred to the intended situations. In the medical field, it has been confirmed that the skills which surgeons learned from a VR environment have helped them to perform better in real-life surgical settings as they successfully transferred the knowledge learned (Cooper et al., 2016). It is stated that augmented cues such as change of color, vibration and audio feedback in a VR training setting can best influence the learning transfer effect (Cooper et al., 2016). It is thus recommended that researchers direct their future studies to understand to what extent the acquired knowledge can be transferred and what factors can positively influence the knowledge transferring effect.

Thirdly, it is suggested that researchers set their goal on knowing what specific skills can be fully trained by VR technology. For instance, when learning spatial information, little learning difference was found between people trained with virtual reality and people who trained in real life scenarios (Romano & Brna, 2001). This indicated that their learning effects are equivalent regardless of the training methods. It is good to know that VR training is effective, but it is even more important to know under what circumstances can VR technology be used as a replacement. As such, it is recommended that researchers direct themselves to that direction. Eventually, people may have a shot of unveiling the possibilities that VR technology can bring to various fields.

Conclusion

In conclusion, this study aimed to obtain a better understanding of whether training using VR technology can be effective in the context of firefighters training. The study used Situation Awareness as the central concept to evaluate the training effectiveness. Positive results were found, and this continued to support further development of VR technology. Additionally, this study analyzed the impact of TA and ‘years of experience’ as moderators. No significant moderating effect was found. It was hypothesized that mandatory training lowered the impact of TA, and that the number of years of experience did not matter as long as the participants had the same level of skills or professional knowledge. Apart from that, this study also provided valuable inputs given by three firefighters in their interviews. They not only acknowledged the positive impact of VR training on their role as a commander, but also responded truthfully to the practical limitations of VR technology has at this stage. Based on these interpretations, it can be concluded that VR technology remains in its early stage of adoption and many improvements still need to be made. However, the benefits that VR technology can bring to society cannot be overlooked. The potential of the possible future training tool, Virtual reality, may just be on the rise.

References

Aggarwal, R., Ward, J., Balasundaram, I., Sains, P., Athanasiou, T., & Darzi, A. (2007). Proving the effectiveness of virtual reality simulation for training in laparoscopic surgery. *Annals of Surgery*, *246*(5), 771-779. doi:10.1097/sla.0b013e3180f61b09

Attride-Stirling, J. (2001). Thematic networks: an analytic tool for qualitative research. Qualitative Research, *1*(3), 385-405. doi:10.1177/146879410100100307

Baddeley, A. (1992). Working memory: The interface between memory and cognition. *Journal of Cognitive Neuroscience*, (3), 281-288. doi:10.1162/jocn.1992.4.3.281

Bliss, J. P., Tidwell, P. D., & Guest, M. A. (1997). The effectiveness of virtual reality for administering spatial navigation training to firefighters. *Presence: Teleoperators and Virtual Environments*, *6*(1), 73-86. doi:10.1162/pres.1997.6.1.73

Braaksma, M. A., Rijlaarsdam, G., & Van den Bergh, H. (2002). Observational learning and the effects of model-observer similarity. *Journal of Educational Psychology*, *94*(2), 405-415. doi:10.1037/0022-0663.94.2.405

Bradley, C. A., Rolka, H., Walker, D., & Loonsk, J. (2005). BioSense: implementation of a national early event detection and situational awareness system. *MMWR Morb Mortal Wkly Rep*, *54*(Suppl), 11-19. Retrieved from:
https://www.researchgate.net/profile/David_Buckeridge/publication/7585707_Implementation_of_laboratory_order_data_in_BioSense_Early_Event_Detection_and_Situation_Awareness_System/links/0a85e531f0ddacb253000000.pdf#page=13

Bruno, F., Bruno, S., De Sensi, G., Luchi, M., Mancuso, S., & Muzzupappa, M. (2010). From 3D reconstruction to virtual reality: A complete methodology for digital archaeological exhibition. *Journal of Cultural Heritage*, *11*(1), 42-49. doi:10.1016/j.culher.2009.02.006

Burdea, G. C., & Coiffet, P. (2017). *Virtual reality technology* (2nd ed.). Hoboken, NJ: John Wiley & Sons.

Carrozzino, M., & Bergamasco, M. (2010). Beyond virtual museums: Experiencing immersive virtual reality in real museums. *Journal of Cultural Heritage, 11*(4), 452-458. doi:10.1016/j.culher.2010.04.001

Cha, M., Han, S., Lee, J., & Choi, B. (2012). A virtual reality based fire training simulator integrated with fire dynamics data. *Fire Safety Journal*, *50*, 12-24. doi:10.1016/j.firesaf.2012.01.004

Companion, M. A. (1989). Situational awareness: An analysis and preliminary model of the cognitive process. *Institute for Simulation and Training. 169.* Retrieved from: https://stars.library.ucf.edu/istlibrary/169

Cooper, N., Milella, F., Cant, I., Pinto, C., White, M., & Meyer, G. (2016). Augmented Cues Facilitate Learning Transfer from Virtual to Real Environments. *2016 IEEE International Symposium on Mixed and Augmented Reality (ISMAR-Adjunct)*. doi:10.1109/ismar-adjunct.2016.0075

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User acceptance of computer technology: A comparison of two theoretical models. *Management Science*, *35*(8), 982-1003. doi:10.1287/mnsc.35.8.982

Delong, G., & Deyoung, R. (2007). Learning by observing: Information spillovers in the execution and valuation of commercial bank M&As. *The Journal of Finance*, *62*(1), 181-216. doi:10.1111/j.1540-6261.2007.01205.x

Durso, F. T., Rawson, K. A., & Girotto, S. (1999). Comprehension and situation awareness. *Handbook of Applied Cognition*, 163-193. doi:10.1002/9780470713181.ch7

Endsley, M. R. and Garland D.J (Eds.) (2000) Direct measurement of situation awareness: Validity and use of SAGAT. *Situational Awareness Analysis and Measurement*, 129-156. doi:10.4324/9781315087924-9

Endsley, M. (2009). Situation awareness in aviation systems. *Handbook of Aviation Human Factors Second Edition*, 12-1-12-22. doi:10.1201/b10401-15

Endsley, M. R. (1995). Measurement of situation awareness in dynamic systems. *Human Factors*, *37*(1), 65-84.

El-Gayar, O. F., & Moran, M. (2006). College students' acceptance of tablet PCs: An application of the UTAUT Model. Dakota State University, 820, 2845-2850.

Galligan, L., Hobohm, C., & Loch, B. (2012). Tablet technology to facilitate improved interaction and communication with students studying mathematics at a distance. *Journal of Computers in Mathematics and Science Teaching*, *31*(4), 363-385.

Gilson, R.D. (1995). Situation awareness - special issue preface. *HUMAN FACTORS, 37*(1), 3-4

Haferkamp, N., Kraemer, N. C., Linehan, C., & Schembri, M. (2011). Training disaster communication by means of serious games in virtual environments. *Entertainment Computing*, *2*(2), 81-88. doi:10.1016/j.entcom.2010.12.009

Holloway, W., & Jefferson, T. (2008). Free Association Narrative Interview. The Sage Encyclopedia of Qualitative Research Methods. doi:10.4135/9781412963909.n182

Hou, J., Nam, Y., Peng, W., & Lee, K. M. (2012). Effects of screen size, viewing angle, and players' immersion tendencies on game experience. *Computers in Human Behavior*, *28*(2), 617-623. doi:10.1016/j.chb.2011.11.007

Kass, S. J., Cole, K. S., & Stanny, C. J. (2007). Effects of distraction and experience on situation awareness and simulated driving. *Transportation Research Part F: Traffic Psychology and*

Behaviour, *10*(4), 321-329. doi:10.1016/j.trf.2006.12.002

Klassen, R. M., & Chiu, M. M. (2010). Effects on teachers' self-efficacy and job satisfaction: Teacher gender, years of experience, and job stress. *Journal of Educational Psychology*, *102*(3), 741.

Lamberton, C. P., Naylor, R. W., & Haws, K. L. (2013). Same destination, different paths: When and how does observing others' choices and reasoning alter confidence in our own choices? *Journal of Consumer Psychology*, *23*(1), 74-89. doi:10.1016/j.jcps.2012.01.002

Larssen, A. T., Robertson, T., & Edwards, J. (2007). The feel dimension of technology interaction. *Proceedings of the 1st International Conference on Tangible and Embedded Interaction - TEI '07*. doi:10.1145/1226969.1227024

Lee, M., Suh, K., & Whang, J. (2003). The impact of situation awareness information on consumer attitudes in the Internet shopping mall. *Electronic Commerce Research and Applications*, *2*(3), 254-265. doi:10.1016/s1567-4223(03)00028-0

Li, X., & Zhang, M. (2000). Effects of early field experiences on preservice teachers' efficacy beliefs--A Pilot Study. Retrieved from: https://files.eric.ed.gov/fulltext/ED444973.pdf

Liaw, S., & Huang, H. (2002). How web technology can facilitate Learning. *Information Systems Management*, *19*(1), 56-61. doi:10.1201/1078/43199.19.1.20020101/31477.8

Lim, H., Lee, S., & Nam, K. (2007). Validating E-learning factors affecting training effectiveness. *International Journal of Information Management*, *27*(1), 22-35. doi:10.1016/j.ijinfomgt.2006.08.002

Madigan, R., Louw, T., Dziennus, M., Graindorge, T., Ortega, E., Graindorge, M., & Merat, N. (2016). Acceptance of automated road transport systems (ARTS): An adaptation of the UTAUT Model. *Transportation Research Procedia*, 14, 2217-2226.

doi:10.1016/j.trpro.2016.05.237

Mantovani, F., Castelnuovo, G., Gaggioli, A., & Riva, G. (2003). Virtual reality training for health-care professionals. *Cyberpsychology & Behavior*, *6*(4), 389-395. doi:10.1089/109493103322278772

McDaniel, M. A., Schmidt, F. L., & Hunter, J. E. (1988). Job experience correlates of job performance. *Journal of Applied Psychology*, *73*(2), 327-330. doi:10.1037/0021-9010.73.2.327

McVee, M. B., Dunsmore, K., & Gavelek, J. R. (2005). Schema theory revisited. *Review of Educational Research*, *75*(4), 531-566.

Merchant, Z., Goetz, E. T., Cifuentes, L., Keeney-Kennicutt, W., & Davis, T. J. (2014). Effectiveness of virtual reality-based instruction on students' learning outcomes in K-12 and higher education: A meta-analysis. *Computers & Education*, *70*, 29-40. doi:10.1016/j.compedu.2013.07.033

Miller, A., Radcliffe, D., & Isokangas, E. (2009). A perception-influence model for the management of technology implementation in construction. *Construction Innovation*, *9*(2), 168-183

Mirhosseini, K., Sun, Q., Gurijala, K. C., Laha, B., & Kaufman, A. E. (2014). Benefits of 3D immersion for virtual colonoscopy. *2014 IEEE VIS International Workshop on 3DVis (3DVis)*. doi:10.1109/3dvis.2014.7160105.

Mujber, T., Szecsi, T., & Hashmi, M. (2004). Virtual reality applications in manufacturing process simulation. *Journal of Materials Processing Technology*, *155-156*, 1834-1838. doi:10.1016/j.jmatprotec.2004.04.401

Norri-Sederholm, T., Paakkonen, H., Kurola, J., & Saranto, K. (2015). Situational awareness and information flow in prehospital emergency medical care from the perspective of paramedic field supervisors: a scenario-based study. *Scandinavian Journal of Trauma, Resuscitation and Emergency*, *23*(1). doi:10.1186/s13049-014-0083-x

O'Brien, K. S., & O'Hare, D. (2007). Situational awareness ability and cognitive skills training in a complex real-world task. *Ergonomics*, *50*(7), 1064-1091. doi:10.1080/00140130701276640

Okita, S. Y., & Schwartz, D. L. (2006). When observation beats doing: Learning by teaching. Retrieved from: https://s3.amazonaws.com/academia.edu.documents/32559225/Okita_observation_doing.pdf?response-content-disposition=inline%3B%20filename%3DWhen_observation_beats_doing_Learning_by.pdf&X-Amz-Algorithm=AWS4-HMAC-SHA256&X-Amz-Credential=AKIAIWOWYYGZ2Y53UL3A%2F20200209%2Fus-east-1%2Fs3%2Faws4_request&X-Amz-Date=20200209T134211Z&X-Amz-Expires=3600&X-Amz-SignedHeaders=host&X-Amz-Signature=a51bc90e93c32f69ba8da4ac9d3a44f845c985d3ec2fd959c7a38da00d5f4549

Perry, C. M., Sheik-Nainar, M. A., Segall, N., Ma, R., & Kaber, D. B. (2007). Effects of physical workload on cognitive task performance and situation awareness. *Theoretical Issues in Ergonomics Science*, *9*(2), 95-113. doi:10.1080/14639220600959237

Querrec, R., & Chevaillier, P. (2001). Virtual Storytelling for Training: An Application to Fire Fighting in Industrial Environment. *Lecture Notes in Computer Science*, 201-204. doi:10.1007/3-540-45420-9_22

Ragan, E. D., Scerbo, S., Bacim, F., & Bowman, D. A. (2017). Amplified Head Rotation in

Virtual Reality and the Effects on 3D Search, Training Transfer, and Spatial Orientation. *IEEE Transactions on Visualization and Computer Graphics, 23*(8), 1880-1895. doi:10.1109/tvcg.2016.2601607

Roca, J. C., Chiu, C., & Martínez, F. J. (2006). Understanding e-learning continuance intention: An extension of the technology acceptance Model. *International Journal of Human-computer Studies, 64*(8), 683-696. doi:10.1016/j.ijhcs.2006.01.003

Romano, D. M., & Brna, P. (2001). Presence and Reflection in Training: Support for Learning to Improve Quality Decision-Making Skills under Time Limitations. *Cyber Psychology & Behavior*, *4*(2), 265-277. doi:10.1089/109493101300117947

Saus, E., Johnsen, B. H., Eid, J., Riisem, P. K., Andersen, R., & Thayer, J. F. (2006). The effect of brief situational awareness training in a police shooting simulator: An experimental study. *Military Psychology*, *18*(sup1), S3-S21. doi:10.1207/s15327876mp1803s_2

Schmidt, F. L., Hunter, J. E., & Outerbridge, A. N. (1986). Impact of job experience and ability on job knowledge, work sample performance, and supervisory ratings of job performance. *Journal of Applied Psychology*, *71*(3), 432-439. doi:10.1037//0021-9010.71.3.432

Schultheis, M. T., & Rizzo, A. A. (2001). The application of virtual reality technology in rehabilitation. Rehabilitation Psychology, *46*(3), 296-311. doi:10.1037//0090-5550.46.3.296

Shelby, L. B. (2011). Beyond Cronbach's Alpha: Considering confirmatory factor analysis and segmentation. *Human Dimensions of Wildlife*, *16*(2), 142-148. doi:10.1080/10871209.2011.537302

Shin, D. (2017). The role of affordance in the experience of virtual reality learning: Technological and affective affordances in virtual reality. Telematics Informatics, *34*(8), 1826-1836. doi:10.1016/j.tele.2017.05.013

Sohn, Y. W., & Doane, S. M. (2004). Memory processes of flight situation awareness: Interactive roles of working memory capacity, Long-term working memory, and expertise. *Huamn Factors: The Journal of the Human Factors and Ergonomics Society*, *46*(3), 461-475. doi:10.1518/hfes.46.3.461.50392

Sok Foon, Y., & Chan Yin Fah, B. (2011). Internet banking adoption in kuala lumpur: An application of UTAUT model. *International Journal of Business and Management*, *6*(4). doi:10.5539/ijbm.v6n4p161

Stanton, N., Chambers, P., & Piggott, J. (2001). Situational awareness and safety. *Safety Science*, *39*(3), 189-204. doi:10.1016/s0925-7535(01)00010-8

Stone, R. J. (2001). Haptic feedback: a brief history from telepresence to virtual reality. *Haptic Human-computer Interaction*, 1-16. doi:10.1007/3-540-44589-7_1

Sun, P., Tsai, R. J., Finger, G., Chen, Y., & Yeh, D. (2008). What drives a successful e-Learning? An empirical investigation of the critical factors influencing learner satisfaction. *Computers & Education*, *50*(4), 1183-1202. doi:10.1016/j.compedu.2006.11.007

Swan, K. (2002). Building learning communities in online courses: the importance of interaction. *Education, Communication & Information*, *2*(1), 23-49. doi:10.1080/1463631022000005016

Tarhini, A., Hassouna, M., Abbasi, M. S., & Orozco, J. (2015). Towards the acceptance of RSS to support learning: An empirical study to validate the technology acceptance model in lebanon. *Electronic Journal of E-learning*, *13*(1), 30-41.

Thüring, M., & Mahlke, S. (2007). Usability, aesthetics and emotions in human–technology interaction. *International Journal Psychology*, *42*(4), 253-264.

doi:10.1080/00207590701396674

Van der Meijden, O. A., & Schijven, M. P. (2009). The value of haptic feedback in conventional and robot-assisted minimal invasive surgery and virtual reality training: a current review. *Surgical Endoscopy, 23*(6), 1180-1190. doi:10.1007/s00464-008-0298-x

Venkatesh, Morris, Davis, & Davis. (2003). User acceptance of information technology: Toward a unified view. *Mis Quarterly*, *27*(3), 425. doi:10.2307/30036540

Vernon, T., & Peckham, D. (2002). The benefits of 3D modelling and animation in medical teaching. *Journal of Audiovisual Media in Medicine*, *25*(4), 142-148. doi:10.1080/0140511021000051117

Waag, W. L., & Houck, M. R. (1994). Tools for assessing situational awareness in an operational fighter environment. *Aviation, Space, and Environmental Medicine, 65*(5), A13–A19 . Retrieved from https://psycnet.apa.org/record/1994-35735-001

Walker, G. H., Stanton, N. A., Kazi, T. A., Salmon, P. M., & Jenkins, D. P. (2009). Does advanced driver training improve situational awareness? *Applied Ergonomics, 40*(4), 678-687. doi:10.1016/j.apergo.2008.06.002

Williams, T. C., & Zahed, H. (1996). Computer-based training versus traditional lecture: Effect on learning and retention. *Journal of Business and Psychology*, *11*(2), 297-310. doi:10.1007/bf02193865

Appendix A.
Background questionnaire

Background Questionnaire

1. Name: ________________
2. Age:
   - ☐ 18-30 years old
   - ☐ 31-40 years old
   - ☐ 41-50 years old
   - ☐ 51-60 years old
3. Gender:
   - ☐ Male
   - ☐ Female
4. Numbers of years of experience in firefighting:
   - ☐ 0-3 years
   - ☐ 4-6 years
   - ☐ 7-10 years
   - ☐ 11-13 years
   - ☐ 14-16 years
   - ☐ 17-20 years
   - ☐ More than 20 years
5. How many times have you used Virtual Reality related technology? (on and off duty)
   - ☐ 0 times
   - ☐ 1-3 times
   - ☐ 4-6 times
   - ☐ 7-10 times
   - ☐ More than 10 times
6. Please answer the following questions by ticking one box below each question. (1=strongly disagree, 7= strongly agree)

   a.) I think VR technology is easy to use.

1	2	3	4	5	6	7
☐	☐	☐	☐	☐	☐	☐

b.) I think VR technology is useful for my job.

1	2	3	4	5	6	7
☐	☐	☐	☐	☐	☐	☐

c.) It is not difficult for me to understand how to use VR technology.

1	2	3	4	5	6	7
☐	☐	☐	☐	☐	☐	☐

d.) I think VR technology is necessary because my colleagues said so.

1	2	3	4	5	6	7
☐	☐	☐	☐	☐	☐	☐

e.) I think VR technology will become an important method of job training in the future.

1	2	3	4	5	6	7
☐	☐	☐	☐	☐	☐	☐

f.) I think VR technology is/will be an effective and efficient technology when it comes to fulfilling my job.

1	2	3	4	5	6	7
☐	☐	☐	☐	☐	☐	☐

g.) The people around me think I should learn how to use VR technology.

1	2	3	4	5	6	7
☐	☐	☐	☐	☐	☐	☐

h.) I think it will not take me long to learn how to use VR technology.

1	2	3	4	5	6	7
☐	☐	☐	☐	☐	☐	☐

i.) I am more likely to use VR technology if I know my friends or family are using it.

1	2	3	4	5	6	7
☐	☐	☐	☐	☐	☐	☐

Appendix B

Situation Awareness questionnaire

Questionnaire for Situation Awareness (fill out by trainer)

	Strongly disagree	disagree	Somewhat disagree	neutral	Somewhat agree	agree	Strongly agree
1. The trainee can accurately perceive relevant information such as location, status, and hazardous objects in the selected scenario(s).	1	2	3	4	5	6	7
2. The trainee is aware of the location and status of tools that may be needed for effective execution of tasks.	1	2	3	4	5	6	7
3. The trainee is aware of the activities of people in the selected scenarios, such as first-aid helpers, victims, and bystanders.	1	2	3	4	5	6	7
4. The trainee can make an integrated analysis based on the information perceived from the selected scenario(s).	1	2	3	4	5	6	7

5. The trainee can evaluate the locations and activities of people present in light of planning and task division and assess progress.	1	2	3	4	5	6	7
6. The trainee understands how and why hazards may pose a threat and is able to use the knowledge and resources while making decisions.	1	2	3	4	5	6	7
7. The trainee can make a realistic assessment of when and how hazards will become immediate threats.	1	2	3	4	5	6	7
8. The trainee can make accurate predictions based on the current activities and observation of the people on the scene.	1	2	3	4	5	6	7
9. The trainee can foresee the possible damage of the surrounding environment and can act accordingly.	1	2	3	4	5	6	7

6. The trainee understands how and why hazards may pose a threat and is able to use the knowledge and resources while making decisions.	1	2	3	4	5	6	7
7. The trainee can make a realistic assessment of when and how hazards will become immediate threats.	1	2	3	4	5	6	7
8. The trainee can make accurate predictions based on the current activities and observation of the people on the scene.	1	2	3	4	5	6	7
9. The trainee can foresee the possible damage of the surrounding environment and can act accordingly.	1	2	3	4	5	6	7

Appendix C
Interview transcription

Interview 1

Interviewer: I have six questions.
Interviewee: Yes.
Interviewer: And each question you can try to answer them in 2 minutes cause we try to aim for 15 minutes. So I'm just gonna go for the first one. What skills have you learned over the training sessions?
Interviewee: With the last four sessions in the?
Interviewer: Yes
Interviewee: I think I've learned first is to get to know the system. It's a new system and you have to understand how it works. How this thing works, how the system works. And after that, we learned to participate in the virtual world, in which we have to do our exercises and our exams in the end. And that's the things I've learned in the last four sessions.
Interviewer: Okay. And uhh, during theses sessions, about the skills. Have you learned better to observe people or observe the scenarios, for example, relevant hazards that you see in the scenarios. Did you learn to get yourself more acquainted with those objects, and that you get to understand them better, and then make better decisions?
Interviewee: Yes. In the sessions, I've learned the things you've said and the scenario. For example, in which you get to know how to see things, like, you see the color green, and the first session you think 'What's that?" and after a couple of sessions, you better understand what it is, and what to do with it. And how to observe the incidents and the role in it.
Interviewer: Okay, great. And the second question is how did you achieve the learning goals? Did you use any strategies that you are aware of?
Interviewee: Yes. I have made a list for myself. How to do the scenario, for example, I start with questions for the incidents. What kind of car do we have? How many victims are there? Are they wounded? After that, I go through a couple of things in my head which I have write it down before. So I get some structure in my exercise. And stick to those structure, something that we have to take the exam. That's the thing they want to see there. It makes a little bit easier for yourself to go through these things.
Interviewer: Okay, that's great. And the third question is what do you think that makes the training useful. I'm gonna ask four subquestions, just to guide you through it. So the first one is 'what do you think'..., 'how do you think the trainer played a role?'
Interviewee: The trainer, like..
Interviewer: Yeah, the person who is uhh..
Interviewee: The leader of the..
Interviewer: Yeah
Interviewee: He played a lot of roles. For learning, he is someone who tries to, how to I say it...He's trying to make you think about things. Ask you questions so you get to start asking

questions for yourself. And you get to some point saying ‘Oh, I didn’t think about that.’ So it makes it stronger for the exercise after that.
Interviewer: And how do you think practicing with the joystick played a role?
Interviewee: At first, the exercises were very difficult, also from my experience because you really have to know how it works. So not the functions of the stick, but he how do you get into your incident, and how do you observe everything, and how do you..where do you have to look. And that’s the thing with the stick. In the first exercises, it played a role for me because you really focus on the stick because you have to handle it. But the last exercises, I didn’t even mention the things are there. You get what I mean?
Interviewer: Yes, so you start to feel more comfortable with it.
Interviewee: Yes.
Interviewer: Okay. The third one is how do you think observations..like observing others played a role?
Interviewee: Very useful because I think that you can learn from other people because they do things which is useful for your own exercises. And also learn things and get feedback from it, which you can use for yourself. So observing others was even useful as doing the exercises for myself.
Interviewer: You think it’s more useful.
Interviewee: No, not specifically more useful, but I think it’s even.
Interviewer: Even, okay. And what do you think the evaluations of these training session played a role?
Interviewer: I think the evaluation is very important in this kind of things because hmm, you doing the exercises on the best you can so you try to do the things as you know to do things. And the evaluation you get to some point which you can do better in next exercise...the things you weren’t aware of yourself. So the evaluation is in everything we do, in this organization is very useful.
Interviewer: Okay, and did you learn different things in the XVR training?
Interviewee: Uhh yes. I learned different things starting with I think that’s for myself, the most important thing is you get structure with the incident. Second, to observe things in the screen and in the system which can help you with solving the problem. And the first thing is that you learn to manage the incident. And the system, in that case, is very useful because the system brings you some structure. You don’t have to deal with human factors like someone who don’t listen and deal with things you don’t want them to do because when I say ‘get the roof off of the car’, they get the roof off. So it’s very useful for structuring the incident because they do what I tell them to do. And in real life, maybe also in your own..., people do things you don’t want them to do. So I think that’s the key from the system.
Interviewer: And what are your likes and dislikes about XVR training?
Interviewee: The like, is like I said, the structure of the incident because it is very good to practice with the structure and the things you have to do in the role you are training for. And the dislike of the system is it’s, sometimes, I miss the dynamics. It’s like, I’m doing this, and then I

walk back to the car. So in real incident, when people achieve task, they get back to you and say ‘I have completed the task. What’s the next task?” And here is, I give them a task, they do it, and they walk back. So then, ‘oh, there you are.’ I think that's the dislike of the system. You really have to be aware of the people in the system are doing. And you really have to get to them, talk to them, and in real-life...no, for example, the police, in the system, you really have to ask for the police and they get to you. But in real incident, when they get on scene, they will come to you, and they will ask what to do.
Interviewer: Okay, yeah, okay. I think that’s all the questions I have. Oh, you are pretty fast. Hmmm, okay then I’m gonna ask you something else. I asked you about if you learned different things in the XVR training and you said besides the structure is better in the system. Compared to traditional training, I suppose you have your traditional settings...uh training, right? Before becoming a fireman?
Interviewee: Yes.
Interviewer: And do you see other qualities between the XVR training and traditional trainings?
Interviewee: Uh for myself, when we really trained, like in the stage of...In the training we do right now is really important for us to get structure of the incident. So that’s, I guess is the key for using the system also for the training at all because in the further stage of our study, we will train with real people, locations. And so that’s the step you have to make to get the real firefighting. And the system, in my opinion, is the first step. So when we have achieved that, we get the structure of the incident, and we make the next step to the..doing..dealing with other people. Because in real firefighting, you deal with people. You have four people in the back that you have to coordinate and give tasks. But before that, you have to get structure for yourself because you are in front of the car, and you have to manage the incident and for that, you need structure. The structure is very good to train in the XVR training because you don’t have to deal with the human factors of the people in the back. So that fact, I think it’s a good first step to achieving your greater goal.
Interviewer: Okay, and hmm, let me think. Do you think, I don’t know if you have observed the scenario first and then participate in the scenario. If you have, do you think you perform better in those cases?
Interviewee: When I first?
Interviewer: The scenario is the same or similar, and then you observe it, and then after that, you are the one that needs to take action. Do you think you did better in those cases?
Interviewee: Yes. I was very happy to not be the first, for real, because, first it’s a new system and second it was the first training we had. We didn’t know things we learned in the weeks before. So for me, but that was my personal learning...err...way of learning. For me, it works better to observe first and then participate. So yes, for me it was a good thing that I first observe some scenarios.
Interviewer: Okay, that’s great. I think that’s all.

Interview 2

Interviewer: So I have 6 questions for you, and I'm just gonna go for the first one. What skills have you learned over the training sessions?
Interviewee: I think for the procedure, for practicing the procedure, it's good. This way to learn...so I think procedure, that's the most important thing that we learned.
Interviewee: And do you think during the training sessions you have learned to observe objects, or subjects better in the scenario so you understand what that means and make better decisions?
Interviewee: Yes, yes. To set priorities to the setting, for that, it's good. Yeah, prioritizing and procedure, that's the most important I think.
Interviewer: Okay, and hmm the second question is that how do you achieve your learning goals? Do you use any strategies that you are aware of when you are in the training sessions?
Interviewee: Yeah, so for myself, I have write things down so I have a structure and the procedure. Yeah and to practice virtual, I think, it's got a standard in my head...the procedure.
Interviewer: What do you think that makes the training useful. I'm gonna ask four sub questions to guide you through the question. So the first one is how do you think the trainer played a role?
Interviewee: It's hmm...the trainer did good. But I think normally in a real-world, you would speak to different people, so you have the feeling that every person you...how do you say that...you have to treat every person different. So you talk every time to the same person, then that's not an obstacle in the incident.
Interviewer: So you think the trainer is making this more not realistic.
Interviewee: Yeah I think so.
Interviewer: But do you think the trainer in general helps your training process?
Interviewee: Yeah yeah.
Interviewer: And how do you think practicing with the joystick played a role?
Interviewee: At first, it's difficult. It's an extra obstacle. In the procedure, when you repeat it, it gets easier.
Interviewer: And how do you think observing others played a role?
Interviewee: Yeah it's always good observing others. You learn more and you talk about it. And then you learn from each other.
Interviewer: And how do you think the evaluation in the sessions played a role?
Interviewee: You see, when you evaluate by every person the same thing came by. So when you repeat that with the group, the next time you do a session, you take that with you. I think that's good.
Interviewer: So after the evaluation, you kind of have a summarizing idea what is the best to do in each scenario.
Interviewer: Yeah, I think.
Interviewer: And the fourth question, did you learn different things in the XVR training?
Interviewee: Different things? What do you mean?
Interviewer: Compared to the traditional training you have received over the years.
Interviewee: Yeah I think in reality, when you train in reality, it's better. There are much more obstacles..what you have. So here, everything..how do you say that. In real-world, sometimes

things go wrong. So when you are the leader of that incident. You have to participate on that so that's not the XVR. Everything stays the same.

Interviewer: So what do you think...hmmm...what do you think about the qualities in the XVR compared to the traditional one? Do you think it is more useful or you actually think that it is not practically enough?

Interviewee: No, I think it's not practical enough. So in the real world, when you free a victim out of the car, you have to watch what your men are doing. So that's...not you don't have to when you say 'remove the door', there's one way to remove the door and you don't have to look at it if it's good or not.

Interviewer: Okay, and the last question is what are you likes and dislikes about XVR?

Interviewee: I think uhhh...XVR is the future. It's unstoppable, but I think practicing with real-case scenario is much better for the future of us...future leaders.

Interviewer: For leaders or for firefighters in general?

Interviewee: In general.

Interviewer: And do you think the 'not-real-enough' quality jeopardize your learning process?

Interviewee: I think, personality of people affects most of the incidents. And you can't let it see on VR. So when someone is tired, that goes...the quality of the incident goes down. So you have to participate on that. And by VR, it's qualitated, it's always the same.

Interviewer: Okay, but what do you think the XVR help you in these training sessions?

Interviewee: You can learn the procedure. So you have a standard in your mind so the basics therefore is good. But I think you want to be a good firefighter, the leader of a firefighter, you have to practice in the real-world.

Interviewer: Okay, uh we still have some minutes. So I'm gonna ask you something that I asked him (the other interviewee) as well. Hmmm...do you think observing...so, in every training session, there are two parts. And I don't know about you, but have you been in one of those cases that you observe the scenario first, and then you take part in the scenarios.

Interviewee: How do you mean?

Interviewer: Like, say, you are participating in scenario 7. Like the whole group, practicing the scenario 7, and you are the one observing first, and then after that, you are the one who needs to take control. So you have observed first, and then you take action.

Interviewee: I have.

Interviewer: Do you think that hmmm, that you learned better in those cases?

Interviewee: Yeah, I think so. When you are the first one, you start fresh. When you see someone else goes first, it freshens up your mind. And you take a lift with you in the next scenario.

Interviewer: So you think you learned better when you don't have to go first.

Interviewee: Yes.

Interviewer: Okay. And I think… And do you think training with XVR, based on the structure and the procedure and no other obstacles, it helps you to make better decisions.

Interviewee: Yeah, partly I think it helps. But I think it's not enough for the real-world.

Interviewer: Because you mentioned the personality of the people, like there are much more obstacles, more stress for example.

Interviewee: Yes.

Interviewer: Alright, I think that's all I need to ask you.

Interview 3

Interviewer: Okay so I have six questions, and I'm just gonna go for the first one. What skills have you learned over the training sessions?

Interviewee: Hmmm, well of course we are practicing the procedures. And that's a skill that we are developing. It's getting better and better. At least I think so. The training is also getting better so that's something we learned, yes.

Interviewer: Okay, and do you think that you have learned to observe for example, relevant hazards and scenarios better, and that you understand the meaning better, then you can make better decisions based on those?

Interviewee: Well, still VR. By selecting a good position, you can see more. That's also learning, but still, the real world... I find it difficult that the last time we trained, there was some glass on the ground but I didn't see it because we are focused on the 'Okay, did the individual in the video was doing some kind of things?" And normally, you would see real glass on the ground and you can act on it. But that's difficult in reality.

Interviewer: But do you think..well... you have been a professional firefighters and not a volunteer, right?

Interviewee: Yes, yes but hmmm, our training skills are not each level. It must all be the same. We are pros and we have some extra...how do you say it…

Interviewer: Practical experiences?

Interviewee: Yeah. that is but hmm...searching for the word in English...with extra tracks or that kind of things that we know of. But the volunteers don't have to know. That's a little difference but normally the basic skills are all the same. Yes.

Interviewer: Okay and do you think training with XVR helps you to observe better or you think it's actually…?

Interviewee: Yeah when we are learning it, if you hmmm...We have four practices now and every practice, I think it's getting better by observing and getting a better position within the simulation. It's getting better. Yes.

Interviewer: Okay, so the second question is how did you achieve the learning goals? Did you use any strategies that you are aware of during the trainings?

Interviewee: Well, we get some tips. The first time you are looking everywhere and you don't see anything. But like I said, if you get a good position in the simulation, and you can see more. And the first time, we were very busy with how everything works with the joystick. But the last training, it was automatically, and then we have more time to look around and better skills to observe.

Interviewer: But for yourself as a learning person, do you have any kind of learning strategies to help you understand the situation better? Or just to be on track?

Interviewee: Ahhh yes, well I don't know if it's strategies but the tips from the training before, you take it with you and you try to succeed better the next time. So hmm yeah, maybe that's the strategy. Learn from the past and take it with you. But I didn't change learning strategies in these trainings.
Interviewer: Do you have an example of the tips that you got based on the…?
Interviewee: Well, like I said, the first time we were very onto the incidents simulation within 4 or 5 meters. Then I got top from…'walk back', then when walk away and I see the second vehicle which is involved in the incident or that you have a better view of course. That kind of tips you take it with you in the next training and try to choose a position where you can see the whole incident. So yeah.
Interviewer: So the third question is what do you think that makes the training useful? I'm gonna ask you for sub questions just to guide you through the questions. So the first one is 'how do you think the trainer played a role?'
Interviewee: Hmm a very important role. Just as in the beginning, from learning the procedures. So I noticed the first time, we have learned it in theory but now you have to do it in practice. And you have a lot on your mind when you do it. So the trainer gets you back on track. 'Did you watch anything?' Then you are one step ahead. That kind of things. So yes.
Interviewer: Okay, and how do you think practicing with the joystick played a role?
Interviewee: Well like I said before, the first time is not easy because it's new and you are very busy with the joystick. But after two, three times, it gets there automatically and then you can use your mind for other things that is within the simulation. Yes.
Interviewer: And how do you observing others played a role?
Interviewee: Well it's very useful for your own mindset. When you are behind a person and you are doing the training of the simulation, you have more rest and more time to think about a step ahead of something. So we'll say 'Oh, you forgot that' or' You have to do that step.' So it's helpful to look at others and how do they do it. And you can learn for yourself. Yes.
Interviewer: Okay. The last one 'How do you think the evaluation of the sessions played a role?'
Interviewee: Well of course there's a time limit when we did the evaluation. But the main point from your practice is a good training session. And everytime that you take three or four learning points and then you take it with you the next training. So it's helpful. Yes.
Interviewer: Okay. And the fourth question is 'Did you learn different things in the XVR training?'
Interviewee: Yeah of course. What did I learn? Hmm, like I said, the procedures. You know them in theory but now you have do it...hmmm...you can learn them from paper, but now it takes time for someone to do the job. So you have to wait and think again 'Oh wait, what is the next step in the procedure. Oh, that's that.' So we learned that. Yeah and thinking the incident before you arrive. 'What kind of scenarios can you expect?' And that's also a learning point.
Interviewer: Okay, and did you think the XVR training...uhhh…what are the different qualities you spot between XVR training and the traditional training you received?

Interviewee: Well hmmm, normally you see happen within the real world. If you get someone the job to get the door out of the car, then you know...you look around and you see it happen. In the XVR training, it's within (shh) and the door is gone.
Interviewer: Yeah.
Interviewee: So I find it difficult within tasks and time. So that's the difference between the real world. On the other hand, it is about procedure. So I think it's a good tool to learn those kind of skills. Yes.
Interviewer: The fifth question is what do you like about XVR training and why? Did those qualities help you in the learning process?
Interviewee: Well I like it because they can do everything within the small amount of time. Normally, when we go practice in the real world, you can...it's a lot of work to put the vehicles. So it's a good tool to learn that. That kind of things. So that's what I like about it. And everyone can see...everyone participates, and we can learn within one evening, you can do four incidents. Well, normally, you do one incident and it takes about one and a half hour to two hours. So your learning curve is much better.
Interviewer: Than the…?
Interviewee: Traditional because...
Interviewer: Because it's too time-consuming?
Interviewee: Because it goes faster. So you can do that. But I would like to see...I already gave feedback...I would like to see on one evening...would be nice to have one chance, and then later on you can develop a little bit more and you do one night.
Interviewer: Okay, then what don't you like about the XVR training and why is that?
Interviewee: Well like I said, there's some difference between the reality and the simulation. And hmmm that's mostly about the time it takes for the person to do stuff within the simulation. And normally you have 145-degree of view and you can see 'Oh, they are busy with the stabilization of the car.' And now it is 'Yes, it's stabilized.' So well that's the only thing you have to learn. 'Oh did they do that? ''Oh you mentioned it.' And it's done. So that's the difference. Can't say I don't like it but it is difficult within your mindset that normally it takes two to five minutes to get the stabilization done and now it's within 10 seconds and it's there.
Interviewer: And do you think those qualities hurt your learning process in any ways?
Interviewee: Hmmm, no not really. I think it's okay if you…
Interviewer: Get used to it.
Interviewee: Get used to it, and we have done it now about three or four training sessions so we learned and you accept it. You know in reality it takes more time.
Interviewer: Okay. One additional question is that during the training 'Do you think it's better for you to observe the scenario first and then you are the person who needs to take control afterwards but it's the same scenario?' Do you think you would do better in those cases?
Interviewee: It would a nice approach but we didn't do it so difficult question. But maybe it would be nice for the first training to see, I guess for the scenario and whether we have to think

about like a group process. But of course we have to do that as an individual. So but maybe the first two times, it would be nice to do it like a group process.
Interviewer: And I was planning to ask, that was a good answer but I was gonna ask something else. During the training, so let's say that you can your group are training scenario 7 and then one of your group members needs to go up there and do the scenario first but you are the one behind the table observing. And then you are the person that needs to go up there and do the scenario.
Interviewee: Do the same scenario?
Interviewer: Yes do you think it's better for you? Do you prefer that kind of learning?
Interviewee: Then you have the point in saying like which the first person fail and you can pick it up. But hmm maybe it's better to do the same scenario. It would be a nice approach but I didn't do it so. Maybe you can learn more if you do it like that. You forgot something and then I pick it up. Then you...maybe it's better for the learning skills but I don't have the experience so...difficult. But I think it could work. Yes, I am also...we have the dive team over here, and I'm also the dive leader. If there's an incident, and we did the XVR before, so I have some experience with XVR before this training. But hmm we did that with someone that does the scenario and then a week later on, another did but he's already know the scenario with a little difference. But you can see 'Hey, they pick it up last week.' Then we learn something and then we do it with better the next time. So that would be nice. Yes.
Interviewer: But you didn't do that in the training?
Interviewee: Yeah, I did in the training but this is, how do I say it…(Dutch word), and we have now obstacle to learn that. Before we did dive team, and the dive leader always have to do the XVR exam. So that's a different skill but it's the same scenario, same thing. And the funny thing about that is Arnhem, the city Arnhem, they went over here with the scenario, but they have real scenes but it was built as a scenario in XVR. So it was the real case and then build it in XVR and then they tested it within the dive leader from Arnhem, from the dive team. It's very funny that the different approach everybody does. But afterwards, we also did the same scenario, we did saw some things, some actions, and afterwards they say 'But is this a real scenario?' We said 'Well, it could be a real scenario but this and that…well it really happened.' And then you see the real movie, someone filmed it. So they have the real movie so it was very nice learning process. And then they of course told us how the real scenario went.
Interviewer: Okay great. And during the XVR training, have you never been the person to observe first and then participate in the scenario second?
Interviewee: Yeah yeah we did. But it is always a different scenario.
Interviewer: Ah okay, so you never…but it's similar. Most of the scenarios are about car accidents.
Interviewee: Yeah yeah of course. The basic is the same. So you learn from your colleagues.
Interviewer: Okay great.
Interviewee: But of course it's always a little bit different so you have to ask about the differences.

Interviewer: And do you think as a professional firefighters, this XVR training helps you make better decisions as a firefighter?
Interviewee: Of course, of course yes. I think, like I said, I think it's really good for procedure training.
Interviewer: Okay.
Interviewee: I did the exam for the dive leader and one of the scenarios is that there is fast running water. And there was a...how do you say it...baseball cap from the victim, the wounded. But they couldn't let it pass by so it stays on the spot, so I thought, on the exam, 'Oh there's no running water. It's standing still.' And then you have another approach like you would do is rest the running water. I failed because the dive didn't have enough car to do that procedure so but yeah. That's the difference between the reality. You see the water and you feel it, and so well I think that's still always a discussion in the XVR. But the procedure...uhh...step by step, it's great.
Interviewer: Hmmm, I think that's all the questions I can ask you.
Interviewee: Yes, nice.