The Role of Virtual Simulation in Incident Commander Education – A field study

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Abstract

The use of Virtual Simulation (VS) for emergency management and Incident Commander (IC) training and assessment has spread during the last decade. In VS, ICs act in computer-simulated 3D incident scenarios, e.g. fire incidents, road traffic collisions etc. Even though VS provides several benefits, there is a history of hesitation to implement and apply it in emergency education. This paper presents the results of a field study performed during the VS training in four classes of IC-students (90 students). The research focus was on the IC students` attitudes and experiences of VS training. Data were collected through observations and post-training questionnaires. The results show that students are predominantly positive towards virtual simulation. 72% of the IC-students state that they experienced presence to the same extent as in live simulation settings, where they experience high presence. Earlier, photorealism was considered to be necessary to provide virtual learning places with high experiences. According to this study, this is not equally important on a general base. The results argue for the benefits of using VS in IC training, even if there are challenges with the implementation. Furthermore, it contributes to a better understanding of user experiences and realism in VS training compared to live simulation.

Introduction

Incident commanders (IC) are expected to take charge in response to any incident, e.g. fire, road traffic accident, train crash or drowning accident etc. The IC on the first level is often the first officer on the scene, and is responsible for the first assessment of the incident, initial actions, and to provide a correct and informative report by radio to higher officers or command central (see Background for further description). In time-critical life-threatening situations, the ICs command skills are crucial. To be well prepared is equally important for all ICs, regardless if they represent a large or a small rescue service, or if they are employed as a full- or a part-time IC[1]. Besides experiences from real life, ICs train in classrooms, live simulation (LS) training environments, and by using Virtual Simulation (VS). The most common training and examination method is LS, performed in a training field, using real fire, buildings, vehicles, etc. which by instructors is considered the most realistic setting.

VS has gained increased acceptance during the last years as a method allowing practice-based decision-making-training. Today VS is used in several operational contexts, i.e. aviation, military, industry, health care, and more recently in emergency management. Among added values, e.g. reduced cost, safe training, accessible and adjustable training (Hsu et al., 2013, Hammar Wijkmark and Heldal, 2020, Engelbrecht et al., 2019), one would like to stress the possibility to provide realistic and dynamic scenarios (Riedl et al., 2008, Heldal, 2016) in which the event can develop and possible consequences of the actions are visualized. VS can also enable training scenarios that are

[1] *Part-time firefighters have a regular job with an agreement to as a firefighter on call regularly, e.g. every six weeks. 68% of the Swedish rescue service personnel are part time employed and the training course is 3+ 3weeks provided by MSB.* https://ida.msb.se/ida2#page=ceb98e10-811a-4f82-80b8-1e8f2c7391ca

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not possible in LS training, e.g. large train crashes, or fire in a shopping mall. VS also makes remote training possible.

Crucial elements for introducing VS training in education is the confidence and trust in the training from instructors and management. This prerequisite needs to be materialized in rules and policies, allowing changes in the involved organization (Heldal et al., 2018). Confidence upon the effectiveness of the training and achieving a more profound understanding of possible variation in effectiveness among participants may only be possible through expert evaluation of the students against established performance criteria from the training providers. Based on the training objective, the instructors optimize the training setting, as to the choice of realistic scenarios, which unfold in environments (LS or VS) that enhance the students` learning outcome (Hammar Wijkmark and Heldal, 2020).

More evidence is needed to illustrate the effects of VS in comparison with LS training (Heldal and Wijkmark, 2017) to contribute to understand the added values of VSs (Cohen et al., 2013, Alklind Taylor, 2014) and to understand the importance of handling physical realism and habits for designing virtual learning places (Frank, 2014) that allow subjects to experience e.g. right and wrong actions (Chittaro et al., 2014). This paper investigates the experience of presence and realism of 90 Swedish IC level 1 students, i.e. 35% of those trained and graduated in 2019. They were using VS for training in the IC curriculum (CIC, 2018) at MSB[2] during January-September 2019. All had previously been exposed to LS training. Data were collected via post-VS-exposure questionnaires. The focus was on investigating the student's familiarity with VS training, their experienced presence, and attitudes towards using VS training. The main questions were:

- Did the students experience presence during the VS training, comparable with training in LS?
- To what extent was the used VS considered as realistic enough to support users` experiences and performance?

The answers to these questions can influence further development and use of VS, and inform research in VS training on aspects regarding realism of representations and the IC students` experiences.

Background

This section includes theoretical and practical background for understanding this field study. Due to the applied character of this research, both are needed.

Fire and Rescue Services

Fire and rescue services (FRS) in most countries are organized with full-time personnel/professionals in cities and large towns, and part-time personnel in rural areas. In Norway, the organization of FRSs is regulated. A town exceeding 20,000 inhabitants has around-the-clock manned fire stations. Towns of 8,000 to 20,000 inhabitants have fire stations manned during the working hours (08:00 – 16:00) and rely on part-time personnel otherwise. Smaller villages have part-time FRS. In Norway 72% of the 12,500 operative FRS personnel (firefighter and officers) are part-time employed.

In Sweden, the FRS is the responsibility of the municipality and should be organized risk-based. In practice, this organization is very similar to Norway, i.e. full-time FRSs in larger cities and part-time FRSs in the countryside. A typical unit is organized as one

[2] MSB stands for The Swedish Civil Contingencies Agency, the responsible agency for educating and competence development for rescue and fire services in Sweden.

firetruck (and one water truck), four firefighters and one team leader, who usually is the IC level 1, i.e. the first level command.

Incident commander training education

In the MSB IC Level 1 curriculum (CIC, 2018), the required behavior during training and examination of ICs is delineated in the so-called "7-steps-model" (Mattsson and Erikson, 2017) applied during all incident handling in Sweden. Necessary competence (expressed through observable behavior) specifically for IC level 1, is described. Underlying literature, on necessary behaviors and actions for fire ground ICs can be found in Fern (2008) using Cognitive Task Analysis (CTA) (Zachary et al., 1998) or other qualitative research methods (Bearman and Bremner, 2013, Butler et al., 2020).

Decision making literature has offered much attention to the role of IC. Naturalistic Decision Making (Klein, 2008) and it`s subgenre Recognition Primed Decision (Klein, 1997), suggest that ICs make rapid (and usually correct) decisions by activating a mental database, constructed through previous experience. Education and training of ICs aim at creating experiences through simulation, to build-up and/or extend their mental database. This is often conducted using practice-based training in as-realistic-as-possible situations, often at physical, live simulation (LS) training settings.

LS on a physical training ground is traditionally seen upon, especially from the instructors (Hammar Wijkmark and Heldal, 2018), as the only practice-based method that could resemble real incidents. However, LS is resource-demanding and leaves a lot to the students` imagination. Fire and rescue training fields provide concrete and steel buildings built to withstand fire and water several times every day. According to the scenario requirements, the buildings represent apartment blocks, ships, and industries, while they do not resemble any real-life buildings. Besides that, the IC can lean back with arms crossed. The buildings will not burn down. Fire and smoke are limited and controlled, e.g. regulated amounts and types of fuel (wood or propane/butan gas), which limit the fire and smoke production, i.e. amount, color, and behaviour.

Despite the shortcomings, all interactions in LS occur among real people in the physical world.

Incident command training using virtual simulation

Several European countries have introduced VS in the training and/or assessment of ICs; UK (Butler et al., 2020, Lamb et al., 2014), Estonia (Polikarpus et al., 2019), Portugal (Reis and Neves, 2019), and Sweden (Heldal et al., 2016) at the fire academies or rescue services. A few fire brigades, mainly in the US, have in cooperation with academics, explored simulation training for IC decision making. The PhD thesis of Fire Chief K.A. Hall (2010) explored the effect of computer-based simulation training on fire ground incident commander decision making. Improved performance was revealed compared with a control group, tested in the digital media. A follow-up PhD thesis of S. Gillespie (2013) explored the transferability of knowledge from the digital to the physical realm. Questionnaires and interviews suggested that the commanders experienced enhanced confidence on scene after digital training sessions.

Earlier, there was a common assumption that experiencing a high presence in a VS would result in better performance (Youngblut, 2003). Though the literature is not conclusive on whether there is a causal relationship between presence and positive training transfer (to real-life performance), it is believed that a sufficient level of fidelity is required for effective training (Salas et al., 1998, Stevens and Kincaid, 2015). Software for training IC is less mature than other training concepts, for example in navigation and aviation. Simulation developers need to find out what variables contribute to presence and how these can be tuned to influence learning and performance. Thus, further research

is necessary to achieve an effective level of fidelity in IC training. The experience of presence in a virtual environment is affected by two types of realism; *social realism* (reflects events as they would occur in real life) and *perceptual realism* (objects and people look and sound like in real life). In IC training and examination, it is essential that the instructor is able to observe the student acting as the IC in an incident scenario, that is, the student *is the IC in the incident*, contrasted to playing along in an exercise. It is, therefore, crucial that the IC experiences presence in the situation, i.e. adequate social and perceptual realism as he/she should experience in a corresponding incident at work.

Influences for evaluations

Graphical environments have achieved improved fidelity, and research on presence and collaboration in virtual worlds has made important contributions showing how VS can be applied for training. VS is, to some extent, present in most schools educating professionals for operational settings. To design and develop VS for training, one needs to understand how and what are the existing guidelines or lessons one can apply for *making* the places and also for *using* the VS effectively. Due to complexity influencing context, representations and involved people, a large number of questions are not answered concerning design, development and evaluations. The learning context is important and dependent on the aim of learning, e.g. if one needs to learn skills or command. The representations rely on technologies used and influence both presence and performance. The participants, e.g. learners, instructors, and responsible managers, may need different achievements in order to state VS as functional.

Even though the intention with VS is not to produce an experience as realistic as in films or fiction, the experience of presence in the environment, and knowing how to react to the events, are important. Working with the technology where the technology itself is hidden for the benefit of the application is essential for increased user engagement, motivation and enjoyment. Flach and Holden (1998) argue that ”the reality of experience is defined relative to functionality, rather than to appearances (p.94)”, meaning that the experience of ”being there” (presence) depends on the ability ”to act there”. Slater argues that the real power of VR is the illusion of “being there”, the perceptual illusion that makes you perceive and react to the situation as it were for real, even though you know it is not (Slater, 2018). Since acting and presence is important for this study, the evaluation is influenced by theories and methods from the field of “presence in virtual environments.”

A questionnaire battery defined by Slater and his colleagues (Slater et al., 1994), was complemented with questions for emergency management training inspired by Schroeder and his colleagues (Schroeder et al., 2006, Schroeder et al., 2001). The added questions were influenced by issues concerning necessary actions for learning and practice in IC training. Based on the central question regarding “What is the main value of VS, for learners and instructors?” in IC education, questions were focusing on the virtual learning place, including incidents, objects, and avatars both for teachers and students (Hammar Wijkmark and Heldal, 2020, Heldal and Wijkmark, 2017). In these situations, the IC students need to be exposed to realistic incidents, perceived as a real experience, eliciting natural perception and reaction (Kolb, 1984).

Method

The context

Environment

The IC level 1 course is six weeks, and the MSB has used VS since 2017 as a training method for two days in the second week for basic command skills training. The objectives are focused on the first phases of a response to an incident; confirm the call, drive up, arrive at the scene and give the so-called window report (WR), assess the situation, give the first orders, orient and gather information and after that provide the first report by radio (L1). These different "steps" have to be practiced to be understood and internalized. Communication, giving appropriate and clear orders, and submitting effective situational reports is essential and needs to be practiced. Information gathering and situational assessment need to be practiced, as well. In the second week of training, the objectives focus on the basics; to remember to give the reports, in the correct format, in a stressful training situation that resembles a real incident. The research was conducted at MSB College Sando, January to September 2019. Class 1 (January), Class 2 (March), Class 3 (April), and Class 4 (September) took part in the study.

Participants

Ninety IC students participated, 11 % women. The average age was 38 (25 to 54). 51% were part-time firefighters, and 49% full-time. The average number of years as firefighters in the FRS was 11, but this interval spanned from 1 to 30 years. Their experiences of fire incidents differed. Some of the part-timers had no experience of fire incidents, while others had extensive experiences, i.e. 200+ actual fires.

Regarding familiarity with computer or mobile phone games, 54% never played computer games and 46% never played mobile phone games. Only 12% stated that they played games once or several times a week. Their previous knowledge or familiarity of VS for fire and rescue service was limited. 10 mentioned experience of other digital fire related simulation software. None had prior knowledge of the software used in this study.

47% performed active training not lead by the FRS. All described this training as practical skills training, using equipment, and also studying cases and procedures.

Technology used

The VS was based in XVR On-Scene[3], a virtual simulation software tool, which provides a "library" of landscapes, vehicles, avatars, buildings, animals, etc. The scenarios were developed in accordance with the learning objectives for IC-level 1, as described by Mattson and Eriksson (2017), and the MSB IC level 1 course curriculum (CIC 2018) (i.e.the student should be able to lead the response in routine incidents -for the emergency services- and the first 15 minutes of larger non-routine incidents). The simulated incident is built in the virtual environmet. When the student (the student`s avatar) arrives to the incident site, the student makes decisions and communicates directly to avatars on the screen or by radio, as in real life. The instructors then modify the virtual environment to reflect the student`s commands, through actions implemented by firefighter avatars. Thus, the scenario is instructor controlled, giving the instructor the possibility to "effectuate" the student`s orders and act through different avatars.

Examples from two scenarios, a fire in a garage attached to a family house and a fire in an apartment, seen from the IC students' view, are shown in Figure 1, 2 and 3.

[3] XVRsim.com

The evaluation

This study is based on questionnairsers developed by Slater (Slater et al. 1994) and supplemented by Schroeder and his colleagues (Schroeder et al., 2001) with own added questions regarding the current emergency and to relate the experiences in the VS and the LS conditions. These added questions were regarding e.g. the required interaction for performing tasks in the training scenarios. The questionnaires included a part covering the background information of the participants (six questions) followed by a second part regarding VS experiences (19 questions for class 1 and 25 questions for class 2, 3, and 4). The students answered the first part before the simulation sessions and the second part after completing the training session scenarios.

Figure 1 Example of the IC students' view at a garage fire incident

Figure 2 Example of the IC students' view at a garage fire incident (close up)

The students conducted the training in groups of three. After an introduction to the VS setting and method, they could familiarize with the gamepad and how the training was performed during a test scenario. Each student performed in two scenarios and observed two other students' performances (four observation sessions). Each scenario took 15-25 minutes. After each scenario, the IC who performed the training scenarios received feedback from the instructor and fellow students.

To our knowledge, this is the only field study systematically investigating the experience of presence with regards to the photorealism of representation in VS for IC training. The questions correspond to some extent to Cohen and his colleague's (2013)

and Reis and Neves's studies (2019). However, the focus for the first one was on using VS (and multi-user, open environments) for an emergency, and for the second using the same VS software (XVR On-Scene), but for large scale simulation.

Figure 3 Example of the IC students' view in an apartment fire scenario

Results

Results from the questionnaires after training

The results summarize the answers from the 4 classes, a total of 90 students (23 students, from one class in January and 67 students, from three classes after). These classes are divided into two groups, since learning from the first-class generated additional questions in the questionnaires. The questions and answers are listed in the tables below. Table 1 presents the answers delivered in Likert scale, while Table 2 presents the answers delivered as Yes/No.

Presence

The IC students were asked to relate their presence experienced in the VS to a situation when they experienced a high presence in a previous LS training. 72% of the students stated experienced presence similar to the recalled exercise, to a high or a very high extent. Only one student stated experiencing presence to a low extent, while none "very low extent". 59% of the students indicated that they experienced presence in the virtual environment to a high or very high extent, while 9% stated this to a low extent.

Realism

The students were asked to what extent the different key information in the environment was considered to be sufficiently realistic. The questions were focusing on 1) training context and learning scenario, 2) objects in the scenario (buildings, smoke and fire, bystanders and sounds), and 3) humans (and/or avatars).

The majority of the students stated that the realism of these aspects was sufficiently realistic to a high or a very high extent. Two students stated that the realism of buildings and vehicles were realistic to a very low extent, and another on objects related to incidents, e.g. smoke and fire. This particular student was among the least experienced as a firefighter (10 years as a part-time firefighter, including only 2 real fires).

Table 1: Students` response to VS-training, Likert scale, 1 (low) to 5 (very high).

Summary (Part 1, n=90)	Percent % (Likert 4/5)	Avarage (scale 1-5)	SD
Presence			
Think of some previous training sessions when you experienced a high presence. Compared to that, to what extent did you experience presence in the simulation today?	72 %	3.90	0.83
To what extent did you feel that you were in the simulated environment?	59 %	3.63	0.86
To what extent did you feel that you were in the same environment as the persons you met (firefighters, bystanders etc.)?	68 %	3.81	0.99
How easy was it to communicate with others?	57 %	3.63	0.81
Learning objectives			
How easy was it to solve the task (handle the situation as IC)?	11 %	2.87	0.67
How easy was it to understand the training objectives?	80 %	4.16	0.73
Orientation			
How easy was it to move in the environment?	68 %	3.81	0.99
To what extent was the VS task handled as you intended?	73 %	4.01	0.91
Overall			
To what extent would you like to perform similar training again, on your own at your fire and rescue service?	100 %	4.86	0.35
To what extent would you like to perform similar training again, together with others at your fire and rescue service?	99 %	4.83	0.46
To what extent would you like to perform similar training again, on your own in your spare time?	80 %	4.28	0.95
To what extent would you like to perform similar training again, together with others in your spare time?	79 %	4.26	0.93
Summary (Part 2, n=67)			
To what extent do you consider virtual simulation as a method for IC training?	87 %	4.45	0.76
Realism			
To what extent was the environment sufficiently realistic?	72 %	3.94	0.83
To what extent were buildings and vehicles sufficiently realistic?	79 %	4.12	0.86
To what extent were crowds and people sufficiently realistic?	73 %	3.96	0.82
To what extent were the sounds sufficiently realistic?	64 %	3.75	0.87
To what extent were fire and smoke sufficiently realistic?	66 %	3.75	0.84

Table 2: Students` response to questions answered with Yes / No

Did you feel like you managed the task as well as you would in real life?	57% Yes
Did you give the window report?	98% Yes
Did you give the Situation report?	99% Yes

Was there anything that hindered you from performing efficiently? What hindered you from performing the task and manage it as an IC?

30% of the students (27 students) stated that the unfamiliarity with the gamepad, how to move in the environment, was a hinder, e.g. “the joystick”, “I am not an experienced gamer”. 11% (10 students) described hinders were related to their inexperience in the IC role; “my own inexperience”, “the only hinder is myself”.

Please describe aspects that you found pleasant in the task.

The answers revealed several aspects that were found positive by the students; “all actions taken were shown in the scenario”, “educative”, “It gave the possibility to interact”, “Nice that it was to realistic”, “Great environments”, “Includes many aspects of an incident scenario”, “That I could feel so present”.

To what extent do you see that VS should be a method for training in the IC role?

87% (Class 2, 3 and 4) of the students stated that VS should be a method for IC training. None stated this to a very low extent. The answers are detailed according to age in Table 3. The assumption that older students was less positive to VS training was not confirmed.

Table 3: Students’ response to: *To what extent do you see that VS should be a method for training in the IC role? Sorted in age by decades. (n=67, class 2, class 3, class 4)*

Born in	Students	Percent % of all	Likert 4,5	Likert 3	Likert 2	Likert 1
1990s	14	21 %	12 (86%)	2	0	0
1980s	22	33 %	21 (95%)	1	0	0
1970s	27	40 %	21 (78%)	5	1	0
1960s	4	6 %	4 (100%)	0	0	0

Discussion

The variation in previous firefighter experience in the group of IC-students was considerable. It represents variation as is in the real-life, in a setting where professionals and part-time firefighters need to join the same courses to become ICs, and are assessed in the same manner. Though future incidents will not differ according to whether the IC is full-time or part-time employed, optimal training may be different for the two groups to reach the expected competency.

Some of the lowest ratings on the experienced presence and perceptual realism stem from the less experienced (years of experience in the fire service or related to the number of incidents) participants. This may imply that some degree of real-life experience may be required to benefit from the VS-training (Boe and Jensen, 2008) optimally. Alternatively, the result may indicate the need for more training to reach the level where VS-scenario training is beneficial. Hence, VS could be the way forward to provide this, also remotely, as pre-training. The same way forward may be suitable for the students who expressed that they experienced hinders related to the use of the gamepad. It is possible that more training in how to use the gamepad or replacing the gamepad with other, more intuitive, input devices would overcome these hinders and enhance presence for these students, especially since they all show a positive attitude towards further use of VS.

The acceptance of VS for training purposes (Do you see VS as a method for training ICs?) reported in the present work (87%) is somewhat lower than in Cohen et al. 2013, (95%). That study did, however, examine the feasibility of VS and its usefulness among professional medical / paramedical personnel. The study of Reis and Neves (2019), addressing VS training to increase decision-making competences in fire and rescue responders, reports 87.5% positive to the same question, which is very close to our result.

The question regarding whether the participant performed as he/she would in real life was answered positively by 57% of the IC students in the present study, but by only 43% at the research of Cohen et al. This question may also be a measure of acceptance, as well as experienced presence and realism. The fact that the incident developed dynamically, according to the orders the IC student gave (or did not give) was appreciated. This may, for some of the students, counteract the drawback of the less naturalistic of interpersonal communication between the instructor and students, and among students (Nordström-Lytz, 2013).

One of the most crucial learning objectives of IC level 1 includes communication with the higher command and Emergency Call Center, performed as in real life, by radio. During VS-training, the emergency radio channel was used for reporting to higher command, represented by the instructor. So, this part of interpersonal communication was as close to real as possible and appreciated as a training moment.

Aspects of orientation (*understanding how to use the user interface, and ability to navigate in the virtual world)* account for some difficulty among 13% of the participants (Likert score below 3). This result is comparable with Cohen and his colleagues' work (2013), studying an emergency exercise involving a major clinical incident, performed in the virtual environment. 68% of the participants in the present study stated that it was easy to move in the virtual environment. Among the questions that have a relatively low score, this aspect may be the one that is the easiest to resolve.

Aspects of perceptual realism (visual portray of the environment) were evaluated as adequate by 97% of the students. This result is higher than the one reported by Cohen and his colleagues (Cohen et al., 2013), which was 87%. The overall enjoyment and perceived usefulness expressed as free-text comments suggest that many of the participants responded positively to the VS training experience.

In a time when VS technology has rapidly developed and becomes available, the users that potentially would benefit from it have to start exploring and use it to understand their own needs and beliefs. As more users challenge traditional methods, study implementation steps and adjust the technology to their perceived needs, more knowledge in the field may be gained.

Conclusion

This study shows that VS is appreciated as a form for training ICs in Sweden (87% of the students, Likert 4 and 5) from 35% (90 students) of the IC students that graduated at MSB 2019. The acceptance was decomposed in the level of experienced presence, the aspects of realism considered to be important for this learning space, and the lack of hinders from the applied interfaces.

The majority of the students experienced presence to a high or very high extent and found necessary aspects/objects in the simulation, as it was conducted here, sufficiently realistic. All the students stated that they would like to perform VS training again, if possible, together with others. The gamepad was experienced as a hinder by several students. If the attention of the student has to be focused on technical issues to achieve orientation, the overall experience may deteriorate. Thus, the user interface has an improvement potential. The present study contributes to the discussion on how to exploit the strengths of both LS and VS to achieve more effective IC training.

REFERENCES

ALKLIND TAYLOR, A.-S. 2014. *Facilitation matters: A framework for instructor-led serious gaming.* Ph.D., University of Skövde.

BEARMAN, C. & BREMNER, P. A. 2013. A day in the life of a volunteer incident commander: errors, pressures and mitigating strategies. *Applied ergonomics,* 44**,** 488-495.

BUTLER, P. C., HONEY, R. C. & COHEN-HATTON, S. R. 2020. Development of a behavioural marker system for incident command in the UK fire and rescue service: THINCS. *Cognition, Technology & Work,* 22**,** 1-12.

CHITTARO, L., BUTTUSSI, F. & ZANGRANDO, N. Desktop virtual reality for emergency preparedness: user evaluation of an aircraft ditching experience under different fear arousal conditions. Proceedings of the 20th ACM Symposium on Virtual Reality Software and Technology, 2014. 141-150.

CIC. 2018. *Curriculum Incident Commander level 1.* [Online]. The Swedish Civil Contingencies Agency. Available: https://www.msb.se/siteassets/dokument/utbildning-och-ovning/alla-utbildningar/2018-00019-kursplan-raddningsledare-a.pdf [Accessed 2020-10-16].

COHEN, D., SEVDALIS, N., TAYLOR, D., KERR, K., HEYS, M., WILLETT, K., BATRICK, N. & DARZI, A. 2013. Emergency preparedness in the 21st century: training and preparation modules in virtual environments. *Resuscitation,* 84**,** 78-84.

ENGELBRECHT, H., LINDEMAN, R. & HOERMANN, S. 2019. A SWOT analysis of the field of virtual reality for firefighter training. *Frontiers in Robotics and AI,* 6**,** 101.

FLACH, J. M. & HOLDEN, J. G. 1998. The reality of experience: Gibson's way. *Presence,* 7**,** 90-95.

FRANK, A. 2014. *Gamer mode—identifying and managing unwanted behaviour in military educational wargaming,* Stockholm, KTH Royal Institute of Technology.

GILLESPIE, S. 2013. *Fire Ground Decision-Making: Transferring Virtual Knowledge to the Physical Environment,* Grand Canyon University.

HALL, K. A. 2010. *The effect of computer-based simulation training on fire ground incident commander decision making,* The University of Texas at Dallas.

HAMMAR WIJKMARK, C. & HELDAL, I. 2018. Training Emergency Preparedness for Meeting New Risks: Examining the Role of Virtual Simulations for Firefighter Preparedness. *27th Annual Conference of the Society for Risk Analysis Europe.* Östersund.

HAMMAR WIJKMARK, C. & HELDAL, I. 2020. Virtual and Live Simulation-Based Training for Incident Commanders. *Information Systems for Crisis Response and Management.* Blacksburg Virginia: Proc. ISCRAM.

HELDAL, I. Simulation and Serious Games in Emergency Management: Experiences from two case studies. Proc. 22nd Int. Conf. on Virtual Systems and Multimedia (VSMM) 2016 Kuala Lumpur, Maelysia. IEEE.

HELDAL, I., FOMIN, V. & WIJKMARK, C. H. Technology Adoption Failure Through the Prism of an Organizational Regulation Model. European Conference on Knowledge Management, 2018. Academic Conferences International Limited, 324-XIX.

HELDAL, I. & WIJKMARK, C. H. 2017. Simulations and Serious Games for Firefighter Training: Users' Perspective. *In:* MONTARNAL, A., LAURAS, M., HANACHI, C. & COMES, T. (eds.) *The 14th International Conference on Information Systems for Crisis Response And Management.* Albi, France.

HELDAL, I., WIJKMARK, C. H. & PARETO, L. Simulation and Serious Games for firefighter training: Challenges for effective use. Norsk konferanse for organisasjoners bruk av IT, 2016.

HSU, E. B., LI, Y., BAYRAM, J. D., LEVINSON, D., YANG, S. & MONAHAN, C. 2013. State of virtual reality based disaster preparedness and response training. *PLoS currents,* 5.

KLEIN, G. 1997. The recognition-primed decision (RPD) model: Looking back, looking forward. *Naturalistic decision making***,** 285-292.

KLEIN, G. 2008. Naturalistic decision making. *Human factors,* 50**,** 456-460.

KOLB, D. A. 1984. *Experiential Learning: Experience as the Source of Learning and Development,* Prentice Hall.

LAMB, J. K., DAVIES, J., BOWLEY, R. & WILLIAMS, J.-P. 2014. Incident command training: the introspect model. *International Journal of Emergency Services,* 3**,** 131-143.

MATTSSON, M. & ERIKSON, L. 2017. *Taktikkboken – en håndbok i systematisk ledelse av slokkeinnsatser mot bygningsbranner (The book of tactics - a handbook for systematic management of firefighting efforts against building fires),* Oslo.

NORDSTRÖM-LYTZ, R. 2013. Att möta den andra: Det pedagogiska uppdraget i ljuset av Martin Bubers dialogfilosofi.

POLIKARPUS, S., BØHM, M. & LEY, T. 2019. Training Incident Commander's Situational Awareness—A Discussion of How Simulation Software Facilitate Learning. *Digital Turn in Schools—Research, Policy, Practice.* Springer.

REIS, V. & NEVES, C. Application of virtual reality simulation in firefighter training for the development of decision-making competences. International Symposium on Computers in Education (SIIE), 2019. IEEE, 1-6.

RIEDL, M. O., STERN, A., DINI, D. & ALDERMAN, J. 2008. Dynamic experience management in virtual worlds for entertainment, education, and training. *International Transactions on Systems Science and Applications, Special Issue on Agent Based Systems for Human Learning,* 4**,** 23-42.

SALAS, E., BOWERS, C. A. & RHODENIZER, L. 1998. It is not how much you have but how you use it: Toward a rational use of simulation to support aviation training. *The international journal of aviation psychology,* 8**,** 197-208.

SCHROEDER, R., HELDAL, I. & TROMP, J. 2006. The usability of collaborative virtual environments and methods for the analysis of interaction. *Presence: teleoperators and virtual environments,* 15**,** 655-667.

SCHROEDER, R., STEED, A., AXELSSON, A.-S., HELDAL, I., ABELIN, Å., WIDESTRÖM, J., NILSSON, A. & SLATER, M. 2001. Collaborating in networked immersive spaces: as good as being there together? *Computers & Graphics,* 25**,** 781-788.

SLATER, M. 2018. Immersion and the illusion of presence in virtual reality. *British Journal of Psychology,* 109**,** 431-433.

SLATER, M., USOH, M. & STEED, A. 1994. Depth of presence in virtual environments. *Presence: Teleoperators & Virtual Environments,* 3**,** 130-144.

STEVENS, J. A. & KINCAID, J. P. 2015. The relationship between presence and performance in virtual simulation training. *Open Journal of Modelling and Simulation,* 3**,** 41.

YOUNGBLUT, C. 2003. Experience of presence in virtual environments. Defense Analyses Document D-2960.

ZACHARY, W. W., RYDER, J. M. & HICINBOTHOM, J. H. 1998. Cognitive task analysis and modeling of decision making in complex environments.