Serious Games for First Responders

REDHEAD, Andrea and DAVEY, Steffi

Chapter 9: Serious Games for First Responders

Andrea Redhead, Steffi Davey
CENTRIC, Sheffield Hallam University, UK

Abstract. *In this chapter, serious games for fire and rescue services and medical personnel are investigated. Command training and joint training are considered for the value it can provide in all first responder services learning to work together.*
Keywords: *first responders, professional training, collaborative pedagogy, virtual reality, serious games*

1 Introduction

Tasks of first responders are complex and fast-moving. Hence, first responder personnel must receive adequate training to execute their work in the often very challenging situations they face. For firefighters, tasks may reach from community service tasks such as educating the public about fire safety procedures to more traditional experiences such as fire and rescue; paramedics may have to triage victims of traffic accidents or respond to biohazards. That said, even the experiences thought of as 'traditional' for these roles are becoming more complex; for instance, due to a closer integration of services, more intense scrutiny by the public and changing technologies. The training provided while the first responder is a student and any additional training alongside their job has to ensure that they are ready for these experiences physically, mentally and academically (e.g. ensuring sufficient grounding in laws, regulations, relevant theories etc.) in order to respond successfully and flexibly across situations (Smeby, 2005).

The training first responders receive has changed considerably over the years, from the way that training is carried out to the type of content that must be taught and the pedagogical methods involved. For instance, training for firefighters and paramedics must now handle the increasing likelihood that they may be the first to respond to a terrorist incident (Carnevale, 2005). Yet, the current approaches often understate the danger of such situations due to the lack of realism in the practice simulations (Goodale, 2005). In recent years, there has therefore been a shift to including e-learning within the syllabus; either that the content of a module is delivered online or in form of virtual simulations and examinations (Williams et al., 2011).

This means that face-to-face learning as pedagogical method has been expanded, since digital technologies also allow distance learning (Holmgren, 2014). Especially, the development of technologies such as virtual reality (VR; see Chapter 2) and augmented reality (AR; see Chapter 3) in combination with that of other digital enhancements improves distance learning capabilities (Birt, Moore, & Cowling, 2017). Distance learning facilitates the inclusion of large groups of people lowering overall resource requirements and costs and removes some limitations of real-life trainings (e.g. the size of physical locations no longer limits the number of trainees that can participate within a particular training sequence). In addition, an instructor is no longer mandatory for a training to take place, as the game itself can become the tutor and inform trainees of the missions and tasks that must be accomplished.

At the same time, serious games should not be seen as a replacement for traditional trainings or instructors. Instructors retain an important role also in serious game-based trainings, e.g. by

observing the trainee within the scenario, interpreting their results and performing debrief sessions after the training, in which the trainee and the tutor discuss actions, attitudes, experiences and decisions.

Simulations (see Chapter 4) are gaining in popularity as a training tool for first responders as they allow the training of situations that may be difficult or even unethical to recreate in practice (e.g. realistic hostage taking scenarios in a civilian environment). Simulation-based serious games further facilitate training sessions across distances and in collaboration with people distributed across locations, and especially for large-scale exercises they are a cost-saving alternative. Game-based trainings further allow for built-in scorekeeping that can support a detailed and repeated review of participants' actions (McGrath & Hill, 2004).

The benefits of simulation-based serious games for first-responders have been demonstrated repeatedly. For paramedics, for instance, the ability to participate in high-fidelity medical simulations facilitates learning and has proven superior to passive learning techniques (Cook et al., 2012). The positive effects stem at least partly from the fact that serious games offer first responders a safe and controlled environment for learning (Issenberg, Mcgaghie, Petrusa, Gordon, & Scalese, 2005).

One system developed to train paramedics is *MeRiTS* (Chodos, Gutierrez, & Stroulia, 2012). *MeRiTS* uses a virtual world to deliver scenario-based pedagogy using the scenario of a car accident victim. The objective for the student is to rescue and transport the victim to the emergency room. The students are able to work in pairs to complete the scenario with one acting as the lead and the second as assistant. The game allows the instructor to watch the two students interact with the patient and with each other as well as to observe the hand-off to the emergency room. This close observation of the whole process allows to provide feedback about trainees' communication skills, decision making and the sequence of their actions. After the scenario is completed, the students have a debriefing conversation with the instructor during which they can discuss such observations as well as their own experiences within the scenario.

The same technology can be employed to train collaboration between different disciplines of first responders, aiming for a better understanding of the way various organisations operate (collaborate pedagogy). Such experiences can build a vital link between first responder services, as they help to ensure that personnel from multiple services can respond collectively in an efficient and effective way. Serious games can further be valuable to train for situations that may not occur very often. A good example is the *Realistic and Adaptive Interactive Learning System* (RAILS) that was developed to train first responders to find, identify and determine the threats posed by radioactive sources (Winso et al., 2010). Determining a radioactive source is not something that first responders will have to do often. However, when they do have to, it is important that they know how to proceed. The *RAILS* software makes it possible for trainees to experience this situation alongside an instructor. The instructor can enable or modify training content, communicate with the participant, adjust the radiation source and control game style elements like the instruments available or the time limit in which the scenario has to be completed. The trainees have a variety of systems they can manipulate within the game scenario including during tutorial style scenarios in order to understand how to use the equipment. Trainees are further able to experience base radiation dose concepts to help them understand their effects. The game also offers challenge levels with various difficulties. Upon completion of the scenarios, trainees are provided with a debrief. According to Winso et al. (2017) follow-up questions about the scenario helped to cement the learning while also providing metric

scores with respect to time taken to complete the scenario, the radiation sources identified and the dose that the trainee would have received.

For a more detailed view of serious games targeted at first responders, in the following we discuss concrete game examples in three different areas: fire and rescue, medical responders and command training.

2 Examples of First Responder Serious Game Trainings

2.1 Fire and Rescue

One of the common exercises that firefighters have to perform is entering a building and searching for victims. This involves a systematic search of the building where sight may be limited. This situation, when combined with rising heat levels, can require firefighters to crawl close to or actually on the floor. Once a victim has been located, they must be taken to a safe environment before the search can continue.

Traditionally, this type of training is performed in a building with dummies standing in for victims, which is effective but can incur considerable efforts and costs to plan and conduct. Firstly, a suitable area has to be found; for example, a hotel, factory or train all have different requirements and different costs associated with them. In addition, dummies are required that represent a wide range of victims such as different genders, a variety of sizes and ages, also considering disabilities.

Backlund et al. (2007) investigated the effectiveness of virtual environments to complement the existing training methods for fire and rescue teams. Their study presented a search and rescue scenario in a game-based manner with the aim of making learning self-motivating and allowing for training outside of working hours. In the context of this research, the *Sidh* game was created and used in experiments with firefighter students. While playing the game, the students were equipped with masks, boots and a heavy coat. In addition, they were required to carry a heavy nozzle and navigate the game by body movements. The results of the *Sidh* experiment suggests that the game encouraged learning through repetition. Even when the scenario changed slightly (for example, from a small apartment to a large office complex), the basic principles of handling the situation still apply. This allows students to learn from mistakes in previous scenes, while also exposing students to a variety of environments they are likely to encounter in their work. The *Sidh* game further promoted a low body position, which is important in search and rescue scenarios. Not only does the low body position in the game force the participants to become used to the physical demands required for the job – especially as they were performing this movement with equipment; it does also help to ensure that the students perform this crouching behaviour automatically once they are on the job.

A considerable part of training for firefighters can take place within mock training scenarios. To test for the value of virtual trainings, Tate et al. (1997) tested the benefit of a virtual environment on fire extinguishing tasks. Firefighters often have to extinguish fires within areas that they have not or only rarely encountered during training. A virtual environment gives users the chance to experience an environment that may be hard to get access to for practice runs. In their study, a group of firefighters was split into two conditions to examine whether a virtual environment could help them prepare better for the moment they have to enter an environment they may not have been exposed to before. One group trained using only traditional methods, the other trained also within the virtual environment that simulated the real-life location. Each group performed two tests: One was a

navigation task, in which the firefighters had to reach a specific location while dealing with the visibility loss that occurs due to smoke from a fire. The second task required the participants to find the fire equipment and then extinguish a fire within the real location. The time taken to reach the goal, together with the number of wrong turns, was recorded for both groups.

The findings of this study showed that the participants who used the virtual environment navigated the area quicker and made fewer wrong turns than those who had trained only by traditional means. The team that used the serious game also was faster in extinguishing the fire at the scene. This suggests that they were better prepared for the environment and the situation they were presented with. When every second is vital, being able to minimise time and possibly dangerous mistakes such as wrong turns can make a significant difference to the outcome of the task.

2.2 Medical Responders

One of the crucial techniques that paramedics need to conduct is the triage system. *Triage* is the process of assessing injuries to determine their severity. First responders also need to quickly assess, which patients need immediate attention, and which have injuries that are not critical. This allows effective deployment of supplies, for instance, during the immediate aftermath of a major incident. Although some research has been conducted into the possibility of remote triage (Acharya & Imani, 2017), triage is most commonly used by first responders in the field in response to major incidents using a methodology called the triage sieve (NARU, 2014; see Figure 1). The triage system is heavily based on the perception of the paramedic, and therefore paramedics should refresh their knowledge on regular basis. In a situation where triage is required, the paramedic must be certain about which label they apply, as an incorrect triage tag could result in loss of life.

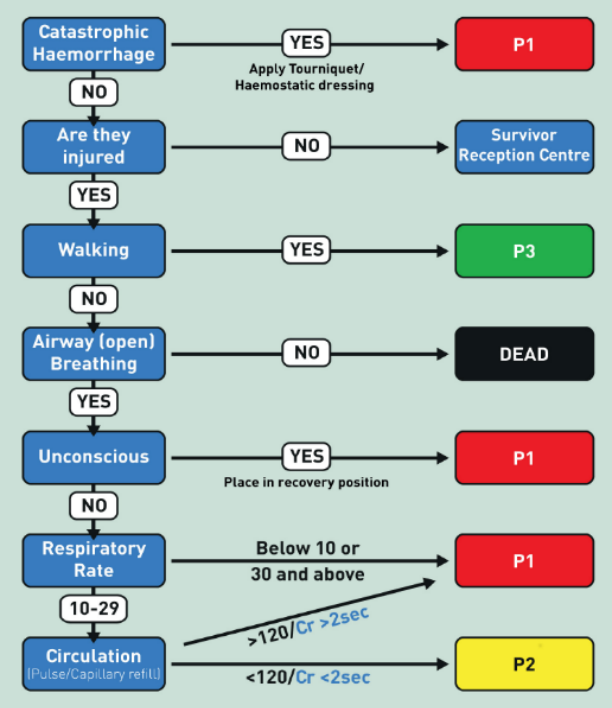

Figure 1: 2013 Triage Sieve (NARU, 2014)

The sieve process is commonly taught in practical workshops, where learners are introduced to the concept and given a short amount of time to practice, normally with mock patients like actors or mannequins within a classroom setting. Naturally this system is far removed from the situations, in

which these students will be utilising their skills and completely disregards any emotional resilience training. This leaves students vulnerable to experiences of stress, which could severely impact the students' performance during real-life events. This being said, large scale scenarios that would accurately replicate a live disaster zone are not necessarily viable due to the costs, resources and time involved.

Serious games can help bridge this gap by allowing students to play a scenario in which their knowledge of triage can be applied in a realistic setting. Students can treat virtual patients in ways that they would not be able to with live actors. This gives students a safe place to fail and learn from mistakes.

The serious game *Triage Trainer* (Knight, et al., 2010) was designed to allow students to play through a major incident and triage the casualties. The authors evaluated the effectiveness of this style of learning against a card-sorting exercise, which students traditionally received in a classroom environment. The results of the experiment concluded that the students who learned with *Triage Trainer* showed significantly higher accuracy on all casualties compared to those who practised with the card-sorting exercise. The act of learning from mistakes is well known as a tried and tested learning method (cp. Chapter 1 on learning theories), and serious games add another layer to that approach in the form of realistic scenario training.

Another study at a medical school (Vincent, Sherstyuk, Burgess, & Connolly, 2008) recruited volunteers to take part in a mass casualty triage training simulation. Participants were required to have a certain level of knowledge before they could participate and had to pass a criteria examination to ensure they met the requirements for the experiment. For each of the three scenarios that the trainee participated in, the following outcomes were measured: intervention score, performing the intervention correctly, the time taken to perform the triage and a triage score. The triage score was calculated as a combined score based on whether participants were able to correctly identify the main problem of each casualty, identify the correct intervention and whether they put the casualty into the correct triage category. Results indicated that students could learn efficiently and effectively within the virtual environment, indicated by improvements to their scores across the board.

Overall, the evidence suggests that serious games are a viable learning tool for medical responders by providing paramedics an environment in which they can fail safely. Virtual reality tools have the potential to take this sort of training even further by providing first responders with environments that are close to the ones that they may experience in the field, ensuring they are prepared for as many situations as possible.

2.3 Command Training

Although first-line staff has so far been the primary focus for serious game trainings, they are not the only ones who can benefit from serious games; staff at command centres or officers in charge of a unit can equally benefit from the training opportunities that serious games provide.

Traditionally, in command trainings table-top exercises are performed that may be augmented by educational workshops or full-scale scenario exercises. However, these types of training methods are associate with high costs. Not only do they require the hiring of facilities that can hold a sufficient number of people, they also require equipment and often the closure of locations for the

public. As communication is key within most of these exercises, people must be present at the same location.

Gamification (i.e. the process of adding game style elements; see Chapter 4) can be used to enhance command training and remove expensive restrictions, while maintaining a focus on the communication and coordination as learning outcome (Kanat, Siloju, Raghu, & Vinze, 2013). Further, online systems can significantly reduce the costs of having to hire a location big enough for all attendees and equipment, as headsets and other communication devices allow for collaboration amongst widely distributed users.

In addition to collaborative serious games exercises, serious game trainings can also take on the role of an instructor for individual users. In this case, users can practice in their own time, rather than having to schedule training sessions around the availability of rooms, equipment, instructors, etc. The systems can also provide an interpretation of results and debriefings after the completion of individual or all training scenarios. Alternatively, the in-game debrief can be combined with a feedback session with an experienced instructor giving trainees and tutors the chance to discuss results, analyse what could have been improved or done differently and why the trainee chose to make certain decisions. Upon the replay of a scenario, or if the user embarks upon a different scene, the trainee will be able to compare and contrast their results across practice sessions adding valuable personalised information about their learning process.

Examples of serious games for command trainings can be found for fire and rescue contexts in the training of Fire Company Officers, amongst others. Each company of firefighters – often consisting of four to eight people – has a Fire Company Officer (FCO) in charge, who is responsible for ensuring the safety of the unit. FCOs traditionally perform mock training scenarios to practice and prepare for their duties. Training scenarios targeted at command levels allow to play out situations that leaders might come across in their jobs and sometimes involve real fires and blazes in training buildings. However, mock scenarios are generally limited to a specific building that the firefighters and Fire Company Officers train in again and again. They may become used to the building schematic or structure, which may hinder the transfer of skills acquired in the training setting into a real-world situation.

As with the above examples for fire and rescue personnel, a serious game within a virtual environment allows FCOs to experience a variety of scenarios with less expense and without the risks involved in case of a real fire. St. Julien and Shaw (2003) created a serious game prototype in which the FCO could instruct teams of virtual firefighters to put out virtual fires. The simulation allows the FCO to watch virtual firefighters carry out the commands, while also seeing changes in the fire and smoke in response to their actions. The damage to the building and the safety of the firefighters depend on the sequence of commands chosen. In a system like this, an FCO can test a variety of situations and the effect of different approaches. This more generic setup could be combined with the knowledge FCOs possess about their officers from mock training exercises to get an idea what kind of responses by their crew may be expected and with which consequences. Virtual and mock scenarios can also be conducted in sequence, meaning that FCO could take insights from the virtual training back to the mock exercises or vice versa. A similar virtual system could be built to allow for the FCO to join colleagues in a command team or to directly collaborate with members in their unit. The benefit of such as setup would be that the entire unit can train together in a variety of situations and thus obtain a better understanding of team dynamics under near realistic

circumstances. It would also eliminate the gap for FCOs when moving from virtual actors to their own (real-life) units.

Systems for command training can of course be applied also in other contexts beyond firefighters. Law enforcement and medical personnel in leadership positions could use the same style of training with scenarios developed for their specific needs.

2.4 Virtual Reality Enhancements for Emotional Preparation

While fire and rescue and triage are skills firefighters and paramedics use once they reach the scene, the scene itself can be fraught with hazards. Often the intensity of the situation can affect first responders who are not used to the tension and sights. The training settings discussed so far are useful for learning, assessing and updating skills; however, training approaches often overlook the stress inherent in crises situations. Preparing first responders emotionally for difficult situations can improve both short-term coping as well as long-term wellbeing.

Subjecting trainees to high-stake situations without danger is only possible through staged scenarios. These staged exercises employ moulage (i.e. mock injuries for the purpose of training) to provide realistic settings. Yet, again these exercises can be expensive and time consuming, and it is often difficult to capture important elements of real crisis situations. For example, medical personnel cannot accurately treat the actors who play victims, and symptoms of these actor victims do not deteriorate over time as they would in reality. Also, it is challenging to replicate real-life consequences; e.g. although paramedics might wear the necessary protective gear, they may not obtain a full understanding of what significance a tear in their suit might have in jeopardizing their health. In virtual reality based serious games participants can experience crisis situations without harm to themselves or to others, yet in a highly realistic manner that may induce stress levels comparable to real crises.

One example is a system called *MediSim* (Stansfield, Shawver, & Sobel, 1998), which was created to provide training of emergency triage for personnel on the battlefield. It use s four sensors placed on the head, lower back and both hands of paramedics which provide input for a virtual avatar that represents the movements participants make. It further runs voice recognition software to allow the user to request vitals and issue commands. *MediSim* laid the foundation for another simulation focused on biohazards, *Bioterrorism Simulated Medical Emergency Response* (BioSimMER). *BioSimMER* (Stansfield, Shawver, Sobel, Prasad, & Tapia, 2000) gives the user a scenario in which a small airport has been taken over and hostages are involved. The background information to the scenario mentions that the insurgents claimed a biological warfare agent had been released, but that they had not given any specifics as to the nature of the chemical. The scenario further states that law enforcement officers have entered the airport and an explosion occurred. The participant enters the scene just after this point. Once the trainee enters the scene they are tasked with the triage of victims. The game allows the administration of medication, insertion of an IV and the application of dressings. As the trainees carry out their tasks, the only feedback they receive is the changing condition of the patient. This differs from a real-life exercise in which the participant would state what they intend to do, and the trainer would provide feedback instantaneously. *BioSimMER* records the trainee's actions together with the time and speed at which they were done. Taking these readings allows the participant's performance and actions to be analysed and discussed after the session and thus provides a more natural experience for the paramedic in training.

The *JUST VR* project investigated the realistic aspects of virtual reality for medical scenarios (Manganas et al., 2004). The system had two scenarios: a participant experienced either an office setting or a city park. These were both similar in nature with the main difference a higher number of virtual people in the city park. Within both scenarios, the user initially has to navigate through the virtual environment until they come across a collapsed figure, while someone nearby calls for help. The virtual person calling for help will become the participant's virtual assistant. The trainee is expected to assess the situation until the ambulance arrives, during which time the virtual assistant is asking questions about what to do. The trainee is expected to answer the questions and make correct decisions within a certain time frame, the expectation being that the sense of urgency will cause a more realistic experience. If the trainee takes too long or hesitates with their responses, the virtual assistant will perform the correct action with the potential of adding to the participant's stress. The addition of extra people in the city park scenario is intended to increase the sense of urgency and potentially create more distractions, comparable to onlookers in real-life situations. After participants completed one of the scenarios, they were asked to rate how realistic the scenario felt. The results indicate that in general users were convinced by the virtual reality scenario, and that they felt they were participating in a real setting. Another example for the use of virtual reality based serious games for emotional preparedness is the AUGGMED platform, described in Chapter 5.

Overall, findings show that virtual reality offers interesting enhancements to first responder trainings by allowing trainees to experience particular situations as if it were real – including situational factors such as time pressure, emotional impacts and the presence of by-standers.

3 Making Use of Collaborative Pedagogy

When a major incident occurs, first responders are the ones dealing with the immediate aftermath. Each profession trains to handle this, but they are often trained in isolation. In reality, a large number of first responder organisation will be at an incident at the same time and required to work together. Thus, as helpful as it is for each type of first responder to prepare for the unforeseen circumstances of major incidents, the benefits are compounded when collaborative pedagogy takes place. Yet, it is complex enough for one profession to obtain real-life training; the chances of two or more professions being available at the same time are even smaller, making collaborative pedagogy a daunting task.

With the advent of massively multiplayer online (MMO) games in the leisure games market, the learning industry has started to investigate how to employ this technology also for serious games. Massively multiplayer online games can be a viable learning tool (O'Connor & Menaker, 2008), as they can provide multiple participants with consistent training in a flexible environment, generate scenarios specific to the learning objectives and mechanics for reflection, and hence allow for specific knowledge and skills to be taught, enriched or reviewed.

Prasolova-Førland et al. (2017) created a virtual reality simulation in which emergency management personnel from various professions can train together. This *VR-Active Learning Module* (VR-ALM) represents a crisis situation in which participants are expected to make decisions, while the situation evolves and changes in real time. Options are available for a desktop display in addition to the VR headset. Four professions are represented within *VR-ALM*: local workers, firefighters, paramedics and police officers. Each profession has a specific repertoire of actions based on their real-life responsibilities; for example, a firefighter is the only one able to operate the fire hose, whereas

paramedics can perform triage and communicate with the injured. With the addition of time constraints and other changing factors, the participants are expected to make decisions similar to those in live exercises, while having the opportunity to communicate with other professions. The benefit of this setting is that participants do not need to be in the same physical location in order to train together. One of the downsides of *VR-ALM* is a certain lack of realism.

Mossel et al. (2017) showcased a simulation tool called *VROnSite*, which aims to overcome the current limitations in training; realism among them. *VROnSite* is an immersive experience that simulates decision making while also requiring physical movement. It was tested with fire brigades and paramedic units. The study illustrated that especially the quick setup of the system afforded participants the chance to obtain valuable additional command level collaborative training with minimal overhead for the participating organisations.

Allowing various first responders to train together helps to minimise the likelihood of mistakes in the field when an actual incident occurs. Technological advances allow for these training sessions to be carried out from anywhere around the world and to overcome the usual obstacles when trying to ensure a large amount of people can get to one location at the same time.

4 Conclusions

Training is slightly easier now that face-to-face learning can be enhanced and, in some cases, replaced by distance learning. Online courses and online course elements allow for first responders to train without necessarily requiring proximity to training grounds. This can cut cost, resources and time required for organisations to train new staff or to enhance their current staff's abilities. As the above discussion and examples show, serious games offer a worthwhile addition – or in some cases an alternative – to traditional training approaches.

Virtual reality based serious games allow first responders to refresh old skills and learn new ones. Virtual reality further provides a platform to train situational awareness, which helps first responders to be better prepared for decision making and collaboration in fast evolving crisis. Especially the ability to learn from a distance opens opportunities for co-training and inter-professional learning amongst different disciplines of first responders. Not only can training times be scheduled across shifts, but at any time that suits the organisations involved. First responder organisations from around the world can train and learn together, while minimising the costs and efforts this would usually entail.

Overall, serious games provide a viable platform for training and enhancing skills and emotional preparedness in first responders. The skills obtained through this style of training can dramatically alter the rate of mistakes as well as reaction times, both things that are vital in the effective handling of crises. Whether it be a firefighter learning to keep a low body posture and performing a search and rescue or a paramedic understanding how to identify a potential biohazard and triage casualties, all disciplines can utilise serious games to train and enhance their knowledge. This does not have to involve large-scale technologies, as many serious game bases trainings can be conducted in the form of table-top or computerised games. Still, as illustrated in this chapter, virtual reality can be a powerful tool to increase the fidelity of serious games trainings with positive effects on the skills and physical and mental preparedness of first responders.

References

Acharya, S., & Imani, O. V. (2017). A novel resource management approach for paramedic triage systems. *2017 IEEE International Conference on Bioinformatics and Biomedicine* (pp. 836-839). Kansas City, MO, USA: IEEE. doi:10.1109/BIBM.2017.8217763

Backlund, P., Engstrom, H., Hammar, C., Johannesson, M., & Lebram, M. (2007). Sidh - a Game Based Firefighter Training Simulation. *2007 11th International Conference Information Visualization* (pp. 899-907). Zurich, Switzerland: IEEE. doi:10.1109/IV.2007.100

Birt, J., Moore, E., & Cowling, M. A. (2017). Piloting mobile mixed reality simulation in paramedic distance education. *2017 IEEE 5th International Conference on Serious Games and Applications for Health (SeGAH).* Perth, WA, Australia: IEEE. doi:10.1109/SeGAH.2017.7939270

Carnevale, D. (2005). Video Game Helps Firefighters Train for Terrorist Attacks. *The Chronicle of Higher Education*, 30.

Chodos, D., Gutierrez, L., & Stroulia, E. (2012). Creating healthcare training simulations in virtual worlds. *2012 4th International Workshop on Software Engineering in Health Care* (pp. 58-64). Zurich, Switzerland: IEEE. doi:10.1109/SEHC.2012.6227008

Cook, D. A., Brydges, R., Hamstra, S. J., Zendejas, B., Szostek, J. H., Wang, A. T., . . . Hatala, R. (2012). Comparative effectiveness of technology-enhanced simulation versus other instructional methods: a systematic review and meta-analysis. *Simulation in Healthcare*, 208-320. doi:10.1097/SIH.0b013e3182614f95

Goodale, G. (2005, June 6). In case of emergency, play video game. *The Christian Science Monitor*, p. 11.

Holmgren, R. (2014). Firefighter training in Sweden: from face-to-face learning in training grounds to distance learning – a challenge for exercise instructors? *Technology, Pedagogy and Education*, 249-267. doi:10.1080/1475939X.2014.968197

Issenberg, S. B., Mcgaghie, W. C., Petrusa, E. R., Gordon, D. L., & Scalese, R. J. (2005). Features and uses of high-fidelity medical simulations that lead to effective learning: a BEME systematic review. *Medical teacher*, 10-28. doi:10.1080/01421590500046924

Kanat, I. E., Siloju, S., Raghu, T. S., & Vinze, A. S. (2013). Gamification of emergency response training: A public health example. *2013 IEEE International Conference on Intelligence and Security Informatics* (pp. 134-136). Seattle, WA: IEEE. doi:10.1109/ISI.2013.6578802

Knight, J. F., Carley, S., Tregunna, B., Jarvis, S., Smithies, R., de Freitas, S., . . . Mackway-Jones, K. (2010). Serious gaming technology in major incident triage training: A pragmatic controlled trial. *Resuscitation*, 1175-1179. doi:10.1016/j.resuscitation.2010.03.042

Manganas, A., Tsiknakis, M., Leisch, E., Ponder, M., Molet, T., Herbelin, B., . . . Schenone, A. (2004). The JUST VR Tool: An Innovative Approach to Training Personnel for Emergency Situations Using Virtual Reality Techniques. *The Journal on Information Technology in Healthcare*, 399-412.

McGrath, D., & Hill, D. (2004). UnrealTriage: A Game-Based Simulation for Emergency Response. *The Huntsville Simulation Conference.* Huntsville, Alabama.

Mossel, A., Froeschl, M., Schoenauer, C., Peer, A., Goellner, J., & Kaufmann, H. (2017). VROnSite: Towards immersive training of first responder squad leaders in untethered virtual reality. *2017 IEEE Virtual Reality* (pp. 357-358). Los Angeles, CA, USA: IEEE. doi:10.1109/VR.2017.7892324

NARU. (2014, February 27). *NARU input to new Triage Sieve*. Retrieved March 7, 2018, from NARU: https://naru.org.uk/naru-input-to-new-triage-sieve/

O'Connor, D. L., & Menaker, E. S. (2008). Can massively multiplayer online gaming environments support team training? *Performance Improvement Quarterly*, 23-41.

Prasolova-Førland, E., Molka-Danielsen, J., Fominykh, M., & Lamb, K. (2017). Active learning modules for multi-professional emergency management training in virtual reality. *2017 IEEE 6th International Conference on Teaching, Assessment, and Learning for Engineering* (pp. 461-468). Hong Kong, China: IEEE. doi:10.1109/TALE.2017.8252380

Smeby, L. C. (2005). Education Ii the Fire Service. *Public Management*, 34-35.

St. Julien, T., & Shaw, C. (2003). Firefighter command training virtual environment. *Proceedings of the 2003 conference on diversity in computing* (pp. 30-33). Atlanta, Georgia: ACM. doi:10.1145/948542.948549

Stansfield, S., Shawver, D., & Sobel, A. (1998). MediSim: a prototype VR system for training medical first responders. *IEEE 1998 Virtual Reality Annual International Symposium* (pp. 198-205). Atlanta, Georgia, USA: IEEE. doi:10.1109/VRAIS.1998.658490

Stansfield, S., Shawver, D., Sobel, A., Prasad, M., & Tapia, L. (2000). Design and Implementation of a Virtual Reality System and Its Application to Training Medical First Responders. *Presence: Teleoperators and Virtual Environments*, 524-556. doi:10.1162/105474600300040376

Tate, D. L., Sibert, L., & King, T. (1997). Using virtual environments to train firefighters. *IEEE Computer Graphics and Applications*, 23-29.

Vincent, D. S., Sherstyuk, A., Burgess, L., & Connolly, K. K. (2008). Teaching Mass Casualty Triage Skills Using Immersive Three-dimensional Virtual Reality. *Academic Emergency Medicine*, 1553-2712. doi:10.1111/j.1553-2712.2008.00191.x

Williams, B., Boyle, M., Molloy, A., Brightwell, R., Munro, G., Service, M., & Brown, T. (2011). Undergraduate paramedic students' attitudes to e-learning: findings from five university programs. *Research in Learning Technology*, 89-100. doi:10.1080/21567069.2011.586679

Winso, J. H., Rolando, J. B., Knight, W. H., Ackermann, E. S., Wijekumar, V. J., & Yu, H. (2010). Integration of radiation transport models in an interactive video game to train law enforcement and first responders on preventative RAD/NUC detection (PRND) methods. *IEEE Nuclear Science Symposuim & Medical Imaging Conference* (pp. 560-565). Knoxville, TN: IEEE. doi:10.1109/NSSMIC.2010.5873823