

Use of a Collaborative Virtual Reality Simulation for Multi-Professional Training in Emergency Management Communications

Judith Molka-Danielsen
Molde University College
Molde, Norway
j.molka-danielsen@himolde.no

Ekaterina Prasolova-Førland
Norwegian University of Science and Technology
Trondheim, Norway
ekaterip@ntnu.no

Mikhail Fominykh
Molde University College
Molde, Norway
mikhail.fominykh@himolde.no

Katherine Lamb
Effective Command
Charlbury, United Kingdom
katherine@klambassociates.com

Abstract—Challenges of disaster and emergency situations require communication across professions and therefore that students in emergency management (EM) professions are well trained. Common training relying on lectures and desktop exercises have limitations. Live training exercises are expensive to model, risky, inflexible to adapt and difficult to replicate. These approaches often focus on mono-professional teams, and can omit crucial communications or collaboration protocols from training. New education methodologies that apply virtual reality (VR) simulations offer opportunities to support immersive training for EM multi-professional co-located teams of medics, firefighters, police, and industry at the incident site. This paper presents results of a project that has developed a model for multi-professional EM education using VR simulations. We present a VR prototype design that applies decision models Naturalistic Decision Making/Recognition Primed Decision forming the basis of the pedagogical model for multi-professional EM training. We discuss results of the trials and identify opportunities and challenges.

Keywords—virtual reality, game-based learning, emergency management, immersive learning, communication, collaboration

I. INTRODUCTION

The needs of the Disaster and Emergency Management (EM) domain that are often highlighted by national and international reports, for example, by the Centre for European Security Strategies, CESS (<http://cess-net.eu>), have pointed out that cooperation during catastrophes between regional, federal and authorities of neighboring states is generally insufficient and that the areas lacking are particularly that of anticipatory scenarios. They have identified a need for scenario-oriented training, based on simulation, experimental and life experiences. In addition, there is a growing global need for cost effective education and training in Disaster and EM [1][2]. Emergency events require that different professionals make decisions, which can make a difference in averting losses, injuries and

fatalities [3]. These decisions depend on the ability to correctly diagnose the situation and extract relevant cues from the environment [4][5].

Such knowledge-intensive skills can be trained with use of virtual reality (VR) simulations [6]. Often a required part of professional education includes practical training. However, the opportunities for in situ training are not always available or cost effective. VR solves this by allowing students to interact with realistic simulations and through such interactions give opportunity to develop competence and expertise through repeated practice.

Often first responders (fire, police, and ambulance) are required to undertake agency and multi-agency training. The common multi-agency training is usually limited to live exercises that are resource intensive, time consuming and occur infrequently. The challenge is to find a resource effective and adaptable method for short (e.g., lunchtime) multi-agency training events to develop and maintain a greater understanding of each other's practice. Our research is motivated by this need.

The research in this paper presents the results of a 2-year project (2016–2018). We have developed a new learning module for multi-disciplinary EM education that applies innovative uses of VR technologies.

Recently research has confirmed that VR simulation can present a dynamic development of a situation and as such can help the participant learner to understand their own decision making process [7][8]. In the forthcoming sections of this paper, we describe the decision-making models that form the basis of our pedagogic model. We discuss the prototype design and feedback from three trial-days of user experiences with the prototype. We conclude with identification of the learning approach opportunities and discuss the challenges of applying the Virtual Reality Active Learning Module simulation (VR simulator) for training in disaster and EM communications.

II. LITERATURE REVIEW

In the field of EM, training under critical and uncertain conditions is an essential part of the professional education. Decision making frameworks are a central part of learning as they provide a theoretical foundation on which to base learning tasks. In the literature review, we present the theories, frameworks and models that informed our VR simulator design.

A. Decision Making Models for EM

Naturalistic Decision Making (NDM) [4][9] and Recognition-Primed Decision making model (RPD) are related decision-making frameworks that may be applied as a pedagogic basis for EM training. As it emerged in 1989, the NDM framework has a primary goal to study how people actually make decisions in real-life settings, under difficult conditions, that are for example, dangerous or unstable conditions, uncertainty and limited time. The NDM framework has been extensively used in military and EM training and analysis [5][10]–[13]. Several related models co-exist within the NDM family [5]. Particularly, the RPD, has its basis in the cognitive task analyses of fire fighters [4][14]. It is the most relevant framework for the EM field. RPD describes how people make rapid decisions under critical conditions applying previous experience as a repertoire of patterns. It is important to provide realistic and properly situated cues within training sessions. As these enable building a repertoire of patterns and decision-making skills that are potentially transferable to real-life situations.

B. Virtual Reality and Game-Based Learning

Game-based learning and serious games applying VR have been used extensively in EM training [15]. The VR replicate the real-life situations in a simulated training environment and offer an immersive experience for the participant. Several have applied tactical decision games as adaptive training scenario-based technique based on NDM/RPD approach. Their approach has allowed learners to build up their repertoire of responses and contributed to their practice of decision-making [2]. This former research sets the stage for applying NDM/RPD as a theoretical basis for an active learning module that we applied in a VR prototype for EM training [16].

C. Collaborative Learning and Activity Theory

Collaborative learning represents a paradigm shift from a teacher- and lecture-centered learning, to that of students' centered exploration and creative application of the course material through social interaction and shared engagement in a common activity [17]. Collaborative and active learning approaches have been successfully used in a number of VR-based environments in a wide range of educational activities [18]–[21]. It is argued that Activity theory (AT) can help to understand the way in which work activities are cooperatively realized in order to design efficient cooperative technology. AT can serve as a theoretical lens for design of computer supported cooperative work and learning and is recommended as a methodological and analytical framework for information practices in EM [22].

AT is based on the work by Vygotsky [23], Leont'ev [24] and later Engeström [25]. In AT, the fundamental unit of analysis is human activity. That is, human activity consisting of interactions that are directed towards an object, mediated by cultural artifacts and are social within a culture [26].

In our project, the student-subjects were required to communicate and collaborate in multi-disciplinary teams to respond effectively to a simulated crisis situation. The students interact with learning materials in our VR active learning module (VR simulator) and are required to collaboratively solve problems under critical conditions in a simulated emergency setting. The VR simulator instantiated a learning design that aimed to focus on the students' exploration and application of course materials that included role cards (for the professional character roles) and the simulated crisis environment. The analysis of the Active Learning system that formed the foundation of the VR simulator prototype design is outside the scope of this paper and is presented in our former work [27].

III. METHOD OF PROTOTYPE DEVELOPMENT AND TESTING

The objectives of this project have been to develop and trial a VR simulator EM training module and to explore how it can contribute to learning communication and decision making for students specializing in EM and Health education, in a simulated crisis situation. The learning task design required participants to match theoretical concepts with their prior experiences. It was expected that the module should aid them in visualizing situations to make certain decisions in the simulated environment. We also expected students to use the VR simulator to self-assess their own performance, and also to come to a greater understanding of the complexity of the situations and of how to interact with other actors, who are likely to be professionals from different backgrounds.

A. Project Phases

The VR simulator prototype was tested with six groups of students on three day-long trials in April 2016, March 2017 and April 2018. On each of the trial-days there were two groups of students that were located in separate towns. All communications during the trials therefore took place only within the VR simulation environment. The trial-days were four hours of meeting time on each of the three trial days. These meetings enabled cooperation between higher education and work-life. In particular, students in college programs and students in specialized high school programs came in contact with EM professionals and first responder-professionals (e.g., firefighters) through their role-play exercises while using the VR simulator. The students received pre-trial lectures from experts and were able to discuss their actions of the role-play exercises following their experiences with the VR simulator with the EM experts. The pedagogic tasks assigned in the trials focused on understanding the lines of communication during response to crisis situations. More specifically, the students were given the following learning goals. These learning goals were maintained across trials.

- Understanding appropriate standard response measures and routines for each team (e.g., triage, fire extinguishing, evacuating civilians)

- Understanding the roles, responsibilities and chain of command at the incident site.
- Understanding the lines of communication in relation to Incident Commander, Alarm central, other teams and civilians/general public
- Understanding the importance of clear and efficient communication at the incident site
- Establishing good communication and briefing procedures within the team.
- Performing multidisciplinary debriefs

Activity use phases in learning trials transpired as presented in Table 1.

TABLE I. VR SIMULATOR ACTIVITY USE PHASES

| NR. | Use Phases of VR simulator |
|-----|--|
| 1 | Students have a meeting with an expert in EM training who has experience in using VR-simulation for the assessment of firefighters. The expert provides background information on the reasons for using VR for training and on how that relates to their course learning objectives. |
| 2 | Students participated in as many trials (simulation runs) as time would allow on the day in groups representing EM professions. |
| 3 | Students reflected on their experiences in the simulation. They discussed their own performance (as decisions they made in the simulator) with the teacher and the VR expert who validated the process. |

B. Prototype Development

To develop the prototype the project followed a Design Science Research (DSR) five-step process model approach that is based on [28]. The VR simulator prototype was designed and operated on a VR platform called vAcademia and went through three cycles of development. It was improved before each trial-day based on the initial interviews and later (in cycles 2 and 3) based on feedback from participants and experts. Each cycle of development had five steps: (1) problem awareness, (2) suggestion phase, (3) prototype implementation (4) evaluation of prototype, and (5) conclusion of knowledge gained.

We began with gaining awareness of the problem through our interviews with EM experts [16]. The output of this step was to improve our understanding of the communication needs of the first responders. Expert interviews served as input in each cycle of the prototype improvement of the VR simulator. In the second step, suggestion, we created an EM scenario and communication task that the participants would need to resolve. In step three, the students trialed the the prototype implementation of the VR simulator and were observed by the project team.. In the fourth step, the project team evaluated the prototype according to our problem-awareness criteria that were described in the awareness step. We would reflect on feedback from observations, group interviews and surveys. The fifth step, conclusion, was at the end of each design cycle, and was used to clarify the type of knowledge gained and to explain to what extent we thought that it was generalizable.

During the project, the focus of the prototype development shifted over the three DSR cycles from realistic representations

of tools (e.g., firefighter tools) to that of implementing a realistic cross-agency communication model. In the third trial (in cycle three), simulating cross-agency communication, based on different radios became the main feature of the prototype. This was caused by two factors. First, experts' feedback from the second trial highlighted radio communication as one of the main possible improvement directions. Second, the project exhausted resources for implementing new virtual scenarios and functionalities.

We aimed that our VR simulator would be designed based on the pedagogic active learning approach of experiential learning. Experiential learning model describes a four-step cycle an individual goes through when learning from experience [29]. The cycle starts with concrete experience, when a learner performs a certain activity. Next, it goes to observations and reflections, when the learner looks back at the experience and reflects on it. Next, the learner goes to a cognitive process of formation of abstract concepts and generalization to understand how to perform better. On the final step, the learner tests implications of concepts in new situations applying knowledge gained from the experience.

C. Trial Groups

The first trial of the VR simulator took place in April 2016 with a group of 14 high school students and their teacher. The average age of this group (excluding the teacher) was 18 years. They had no prior EM training. The students received a lecture from an EM professional (expert) on the topic of "Better Understanding of Emergency Response".

The second trial was in March 2017. The trial group had participants in three physical locations with a total of 10 participants. The evaluation group consisted of four firefighters, five medical students with acute medicine specialization, and one paramedic student. The participants playing workers were not part of the evaluation.

The third day-long trial took place in March 2018. The participants were recruited and took part in the trial from two remote locations. The first group in Molde consisted of one EM professional instructor who would take on the role of incident commander, two volunteers from higher education with no EM experience to play the role of firefighters. The second group in Trondheim consisted of ten high school students with a specialized education in ambulance training and 2 teachers in paramedics with a professional background in that field. It was much more difficult to obtain the participants for the third cycle of trials.

The descriptions of the trial participants conducted during the project are summarised in Table 2.

TABLE II. TRIAL GROUPS EXPERIENCING THE VR SIMULATOR

| Date | No of Participants | Trial Groups |
|------------|--------------------|--|
| April 2016 | 14 | 14 high school students at Molde University College as part of an EM course |
| March 2017 | 10 | 4 firefighters from Molde Fire Department, 6 Health students (doctors, paramedics) in Trondheim. |
| April 2018 | 15 | 1 EM instructor in Molde, 2 non-EM specialist university students 2 paramedic teachers, 10 high school student in Trondheim specializing in a paramedic course. |

The attitude towards integrating VR simulator into training programs was very positive among the high school faculty and students (14 + 10) in trial-days 1 and 3. At the same time, the professionals (e.g., 4 firefighters in trial-day 2 and 1 EM specialist in trial-day 3) were negative. The university medical students (6 students in trial-day 2) were neutral.

In general, the inexperienced participants (e.g., high school students) rated most positive that the VR-simulaotr was beneficial to their understanding of within-and cross-agency communication. The medical students rated this as somewhat positive. They found it particularly beneficial to interact virtually with professional firefighters in a virtual training exercise. The firefighters and EM specialist (in the March 2017 trial) considered themselves already very knowledgeable in understanding appropriate response in the situation and in cross-agency communication protocols. They therefore felt that the simulation contributed very little to their knowledge in these areas. The responses within participant groups were very similar (e.g., the firefighters had similar opinions, and the high school students had similar opinions). A presentation of the survey results from trial-day 1 and 2 are previously reported in [28]. The results of survey and interviews from trial-day 3 are presented in greater detail in this paper.

IV. DESCRIPTION OF THE USE CASE

The VR simulation implements an emergency scenario that contains several characters with different roles including an operations control manager, plant workers, firefighters, police officers, and medics. The participants can select roles and play the scenario for as many iterations as time allows and changing roles to experience different perspectives. The simulation software automatically controls some of the characters with secondary roles (injured workers). The participants of the simulation can interact with each other and with the dynamic crisis situation. It is possible to adapt the role-play settings to the learning objectives defined by the educators.

The prototype has implemented one use case of a crisis situation where the participant is expected to make decisions in the changing context or situation. The participants faced dilemmas in the VR simulation that are in line with what they would face in their normal work. For example, time constraints and other stress factors that are typical in EM situations, such as to enter a burning building or not. The environment provides realistic, dynamically changing cues that the students need to extract in order to diagnose the situation/pattern correctly. For example, the amount of smoke is increasing over time.

The actions that the decision maker takes have an impact on the simulated incident. For example, applying water from the fire hoses can extinguish fire, but delaying the rescue of the injured people worsens their conditions.

Four types of roles were implemented in the simulator. One or several players could play the role of local workers, firefighter, medic/ambulance worker, and police officer. In addition, a single person could play a local EM center operator (Fig. 1). The characters had appropriate appearance and different functions that could be carried out in the simulation. For example, the firefighter could operate the firehose, while regular workers could pick up fire extinguishers in the building. The medical professionals could perform triage, address the injured, and transport the injured.

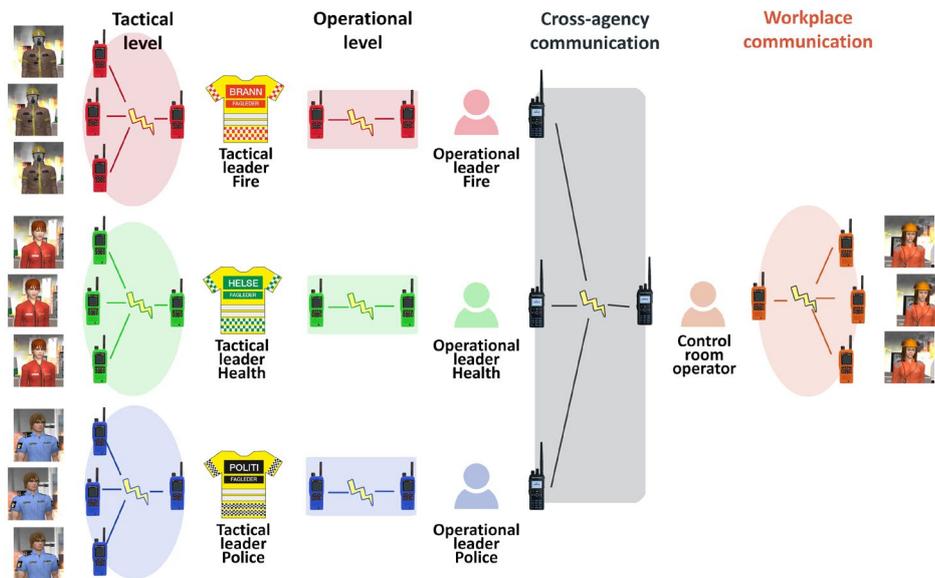


Fig. 1. Radio communications support in VR simulator

In each of the agencies (fire, health and police), we implemented three types of roles: professional team member, tactical leader and operational leader (Fig. 1). We also implemented different radios (communication devices) in the simulation depending on the role. The radios allow communication on different levels. Within each agency, there are two levels of communication: tactical (between professionals and their tactical leader) and operational (between tactical leader and operational leader). In addition, a cross-agency communication level has been implemented (between operational leaders of all three agencies and the control-room operator). The workplace communication connected all workers and the control-room operator (Fig. 1) and (Fig. 2).



Fig. 2. Desktop view of radio support

V. EVALUATION

The approach dynamic decision making in VR simulation has been validated with firefighters in the United Kingdom [7][8]. This approach has never been tried across professions, with EM professionals and medical professionals interacting in simulated environments. Through trials with students in the Molde and Trondheim that used the VR simulator, the performance and learning of the students was assessed by the teacher, external expert, and students in self-assessment. The evaluation of the VR simulator as a learning tool was based on the assessment of the learners.

A. Learner Feedback from the First and Second Trials

We summarize the findings from first and second trials, the first in April 2016, and second in March 2017.

From the first two trials, we found that the inexperienced participants (high school students) felt that the VR simulator was beneficial to their understanding of within- and cross-agency communication. In the second trial, the participants (professional firefighters and medical students) provided rather negative feedback. This was mostly due to the limited realism of the VR simulator. The attitude towards integrating VR simulator into training programs was very positive among the high school students. At the same time, the majority of the professionals and medical students were neutral or negative [30].

B. Discussion and Assessment: of the Third Day-Long Trial

The third day-long trail on March 2018 had participants acting from two locations. The first group in Molde consisted of one EM professional instructor who would take on the role of incident commander, two volunteers from higher education with no EM experience to play the role of firefighters. The second group in Trondheim consisted of nine high school students with a specialized education in ambulance training and a teacher in paramedics with a professional background in that field. It was much more difficult to obtain the participants for the third cycle of trials and there were several reasons for this. The academic EM program in Molde had not taken in a new group of students at the start of that academic year. We therefore did not have access to students specializing in EM. In addition, we received late notice that we were not able to schedule a class of high school students as we did in the prior trial.

The data at the third trial were collected after the role-playing session by using a questionnaire with both groups and a group interview (with the paramedic student group only).

The low number of participants did not allow to apply statistical analysis methods, but the survey and interview data can still provide indications of the participants impressions of the immersiveness and effectiveness of the learning module. We asked, “do you think the simulator was easy to use?” Initial feedback were that participants were rather neutral about the ease of use of the VR simulator. That is five students rated ease of use as neutral or positive, and five rated it somewhat negatively.

In the survey, we asked the questions *After trying out the simulator, do you have a better understanding of...*:

- ... *how members of your profession should act in an emergency situation?* [1(20%), 2(30%), 3(20%), 4(30%)]
- ... *EM roles and responsibilities?* [1(20%), 2(20%), 3(20%), 4(40%)]
- ... *the chain of command and communication structure in an emergency situation?* [1(10%), 2(40%), 3(10%), 4(40%)]
- ... *how team members communicate within their team in an emergency situation?* [1(10%), 2(30%), 3(10%), 4(50%)]
- ... *communication and collaboration between multi-professional teams?* [1(22%), 2(22%), 3(22%), 4(22%), 5(12%)]

When answering if their understanding of different aspects of communication in a crisis situation, the responses of student participants were from neutral to slightly positive. The feedback of the teachers and experts was from neutral to negative. The distribution of 10 responses, having the meaning: 1- not at all, 2- very little, 3- somewhat, 4- considerably, and 5- to a great extent; are indicated next to the questions above. Overall responses to these questions concerning their understanding of different aspects of communication in a crisis situation, were from neutral to slightly positive for the students. The verbal feedback of the two teachers and one expert, for

these questions, was neutral from the teachers to negative from the EM expert.

Additionally, we asked the students an open question:

Do you think EM VR simulation training should be a part of training at your school/workplace?

The responses to the question if such a training module could be a part of educational offer in EM, were mostly positive. Finally, we encouraged open comments regarding suggestions for improvements.

At the group interview, the experts provided feedback on the immersiveness and realism of the simulation in a form of a discussion with the participants. Most of the professionals highlighted the differences between the simulation and reality, that were also identified in trials 1 and 2, but not implemented due to limited resources. The teachers expressed a desire to acquire the VR simulator for their school when (and if) it is more complete and polished.

Technical challenges, such as equipment appearing to not follow the moving avatar due to system lag, and some avatars freezing-up thus not able to continue to follow the group, were discussed. We the developers understood in retrospect that the cause of the system lag and freez-ups were rooted in the fact that the underlying VR platform (vAcademia) was getting older. Since the start of the project vAcademia, selected because it is open and free for use, had not been significantly revised by its developers. It followed that vAcademia did not work as well at the end of the project on many of the PCs that had received periodic software upgrades in graphic cards and sound cards.

The students stated that the mentioned technical problems played a significant role in disrupting the immersive flow of the communication in the simulation run. While they could perceive the objective of using the prototype, these disruptions were particularly disruptive to the older participants. The high school students were somehow more accepting of what could go wrong. They also made several suggestions on improving the navigation and interface of the simulator. The teacher-participants of the high school students also mentioned that such a platform can be used to create a variety of situations and has a great potential for training. The feedback from the paramedic students reflected the feedback from the first and second trials in that they found the training with the VR simulator to be valuable for learning their roles and the requirements for decision making in light of the need for interdisciplinary communication.

Regardless of some positive feedback, the third day-long trial was the least successful in its execution, when compared to the other trials. This was due to several factors, being first the inability to cover critical roles in the role-play with participants who were experts in the role they played. Specifically, we did not have enough participants who were firefighters by profession that would greatly affect the decisions and actions of the other players in the trial. If it is to be useful to all participants, there needed to be domain knowledge represented in the specific roles.

Second, we did not have the resources to hire additional assistants to communicate with participants at the two locations

and to manage the technology locally when there were problems. The execution of the trials needed the following:

- Persons for dedicated communication between physical locations for the entire time
- Time to train people in use of the simulation before the actual trial runs
- All professional roles filled by professionals or students of that discipline

Since communication patterns, division of labour, the rules of engagement and other similar aspects in the professional community play a significant role at an incident site and consequently in EM training, it is crucial to allocate sufficient time to exploration of these aspects. With time shortage at trials, the attention shifts to procedural matters, resulting in under-prioritizing of communication training and understanding of cross-professional dynamics, which was by subject matter experts considered as the major potential strength of the simulator. Furthermore, sufficient time should be allocated to rotation of the simulation roles so that all the learners could explore the various aspects of inter-professional communication.

Moreover, the atmosphere in the learning group should be appropriate. It is required that the participants understand that they should not speak during the instruction phase or trials. During the trials, however, there was an atmosphere that it was a social gathering. Many students thought that any comments could be made at any time. The playful atmosphere may have detracted from the immersive experience of the trials. We suggest that this is not how people would behave in a traditional classroom when receiving instructions; e.g. usually few students would interrupt while a teacher is speaking. There were again limitations of the technology. For example, in the VR simulator trials, the students could only hear the experts speak and had to identify the avatar that the communication was coming from. The avatars had distinctive uniforms to match their role. However, it is still more difficult than in real-life to identify who is speaking. Finally, the non-professional students did not know how professionals should use their radio systems, that is to use them only for necessary communications. We conclude, the setting was not immersive enough to instill the expected normal behavior, especially among non-professional students.

VI. CONCLUDING REFLECTIONS

This research project contributed through the evaluation of the VR simulator prototype that can aid in further research and development of EM training programs and applications through the dissemination of the project results. This paper examined the perception of the immersiveness and effectiveness of the module for professional and non-professional students.

Major contributions of this research may be summarized as follows:

1) *VR simulator framework and methodology.* We have developed a methodology for creating active learning modules for EM training in VR that is largely described in [30]. This work is based on the literature studies, interviews with subject

matter experts and evaluations/observations during the trials. The methodology represents a combination and crystallization of different principles, recommendation and lessons learned, based primarily on the Naturalistic Decision Making framework and Activity Theory. Furthermore, the methodology is exemplified in a practical exercise for EM training and a collection of role cards for the simulator. This methodology emphasizes training of social and communication skills as a part of the EM simulation model, together with the physical and procedural aspects. The VR simulator framework and methodology can be seen as the starting point for the application and feedback of the prototype that was described in this paper.

2) *VR simulator design principles and prototype.* Based on the theoretical background and consultations with the subject matter experts, we have developed a set of requirements for a VR system for interprofessional EM training. The description of the process for obtaining these requirements also constitutes a contribution of this project. We implemented several identified requirements and trialled them in the VR simulator prototype that is presented in this paper. We learned that it was challenging to realize many desired communications requirements based on vAcademia due to underlying technical issues. The lessons learned here can provide a basis for a re-implementation in a modern gaming engine with full VR support, such as Unity 3D or Unreal.

3) *VR alone may not be the best approach to EM communications training.* We recognized that there were greater problems when students did not receive an introductory lecture from an EM professional (e.g., as in trial 3). We therefore proposed that blended approaches to training should be explored. Our research team are producing VR simulator training video based on the trials. The videos will illustrate the major principles of interprofessional communication at an incident. We hope to assess the learning with these video aids that have captured the simulated environment. Ideally, students could also use the recordings of their own actions during live VR trails as reflective tools after experiencing the VR environment.

The various groups of trial participants did not equally appreciate the VR simulator as an immersive and effective learning tool. In brief, certain aspects of the professional communities including communication patterns, division of labour, rules of engagement; play a significant role in incident site and EM training. It is crucial to allocate time and resources to implement these aspects in the tool if it is to be used meaningfully by professionals. Additionally, training for use and understanding of the simulation tool should not be underestimated. The principle lessons learned from the use of the VR simulator prototype are:

- In comparison to workplace training, in general VR simulations offer no training of physical skills and are therefore less realistic by definition. Nevertheless, the necessary degree of realism and complexity in our prototype design can be relative and depends on the target user group. We suggest that less realism can be adequate for non-professionals.
- Different user groups have different learning goals – it should be possible to adjust the simulation and exercises

to accommodate these differences. For example, high school students may not share the learning goal to understand inter-agency radio communications. However, they may be interested in knowing who enters an incident site, and their normal roles and responsibilities.

- Social and communication skills, as well as social and community aspects should be a part of the EM simulation model and the requirements specification. For example, professionals receive training in the correct protocol for radio usage. This specialist knowledge is lacking among high school students.
- There is a need for a consistent methodological approach to develop simulations and corresponding exercises adapted to different learning goals.

In our last concluding remarks, this work suggests that further research is needed to contribute to the development of technologies and methods. This includes affordable, efficient and accurate replication of situated cues, in the right context and in various combinations, simulating situations with varying degrees of uncertainty, also including the complex social interactions between different stakeholders at an incident site. This work also suggests that the VR-based approach holds promise. It supports the learner to increase his/her experience in the form of acquired “repertoire of patterns” at a much faster rate than traditional experience building in the field. In addition, the VR simulation allows for natural social interaction with other actors in multi-professional communications training as would occur at an incident site.

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