Active Learning Modules for Multi-Professional Emergency Management Training in Virtual Reality

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***Abstract*— In modern society there is interest for safer industrial workplaces and a growing need for cost effective training of personnel in emergency management work. Use of live trials as training modules to model emergency situations and prepare for crisis events can be expensive, risky, inflexible to adapt to alternate scenarios, and difficult to replicate. Therefore, virtual reality simulations for education and training offer new opportunities and are being increasingly adopted for such purposes. Quite often emergency situations involve a multi-professional team of medics, firefighters, police, and industry workers such as engineers who are working and co-located at the incident site. However, existing simulations for training typically focus on mono-professional teams, omitting the crucial communications and collaboration protocols from training modules. In this paper we discuss a project that has an objective to develop a new model for multi-professional Emergency Management education that involves use of virtual reality simulations. In particular, address the theoretical question of how combination of Activity theory and Naturalistic Decision Making/Recognition Primed Decision models can form the basis for a pedagogical model for multi-professional emergency management training. We present the design of the virtual reality simulation, learning scenarios and the results of the initial trials among various user groups. Finally, we identify the opportunities and challenges for applying virtual reality based learning environments for efficient and safe training.**

Keywords- Virtual Reality simulation, Active Learning, Emergency Management training, Naturalistic Decision Making, Recognition Primed Decision, Activity theory

I. INTRODUCTION

It is increasingly evident in recent years that training decision making skills are essential for Emergency Management (EM) training for safer workplaces, such as in offshore oil industry and nuclear plants [1]. The complex interactions and social dynamics for communications among first responders, both within single professional teams and between multi-professional teams at the incident site is an important part of the EM procedures, but are often not paid enough attention when designing EM training. Most emergency situations involve multi-professional teams working side by side at the incident site. These can include teams of first responders, such as medics, firefighters, and police, and teams of industry workers (including management and engineers). However, most live training exercises focus on mono-professional teams, omitting the crucial communications and collaboration protocols from the exercises. Also, while practical training for EM is often a required part of professional education, such as in the health and engineering professions, the opportunities for in situ workplace training are not always available or cost effective.

In recent years, more technology rich learning environments have been developed. Research shows that virtual reality (VR) technologies are increasingly applied and accepted in formal education that assesses a need for more than the classroom experience [2, 3]. Motivation for research and innovative use of VR-based EM training is founded in the challenges of running live trainings and the potential benefits of changing practices of EM education. The challenges of using live trials as training modules to model emergency situations and crisis events can: be expensive, have implementation risks (including risk of injury or death), be inflexible to adapt to alternate scenarios, and be difficult to replicate [4]. However, innovative use of VR technologies for the education and training of personnel can offer an alternative learning approach that supports the benefits obtained in live trainings and also add value by addressing the needs for modular design and training that are: adaptive, safe, flexible and reusable [5].

The research presented in this paper is based on a project funded by the Norwegian Agency for Digital Learning in Higher Education (Norgesuniversitetet). We have developed a new learning module for multi-disciplinary Emergency Management education that applies innovative uses of VR technologies. This research is motivated by evidence that VR simulations offer a cost effective and safe way for workers to experience training and that a number of challenges exist for creating such training. Also, recent research has confirmed that VR simulation that represents a dynamic development of a situation can help the participant learner to understand their own decision making process [6, 7].

The existing pedagogical approaches in EM training focus on behaviorist and cognitive aspects to such training and often neglect the social aspects. The educational objective of this project is to develop a new model for multi-professional Emergency Management education that are based on theories of Active Learning, socio-cultural theories (such as Activity theory), a decision making model and that apply innovative uses of VR technologies. This project develops an active learning module (ALM-VR) as a VR interactive simulation for EM training that can be used by professionals in multi-professional teams, such as first responder professionals and EM responsible personnel in industrial workplaces.

In this paper, we present the theoretical learning approaches that we suggest as the basis for multi-professional EM training. We outline the design of the VR simulation and learning scenarios and the results of the initial trials among various user groups. We discuss how a combination of Activity theory and a decision making model can form the basis for a pedagogical model that can be applied for multi-professional emergency management training. Finally, we identify the opportunities and challenges for applying VR-based learning environments for efficient and safe training.

II. THEORETICAL BACKGROUND

A. Naturalistic Decision Making and Recognition- Primed Decision making model

Training in decision making, under critical and uncertain conditions, is essential for EM. Naturalistic Decision Making (NDM) [8, 9] and the related Recognition-Primed Decision making model (RPD) may be applied as an overarching theoretical framework for the design of VR-based EM training. The NDM framework emerged in 1989, with the primary goal to study how people actually make decisions in real-life settings, under difficult conditions such as limited time, uncertainty and dangerous/unstable conditions. Within the NDM family several related models exist, but in particular the RPD model is based on the cognitive task analysis of firefighters [8, 10, 11] and is seen as the most relevant for the EM field. In brief, RPD describes how people make rapid decisions under critical conditions and is based on dually applied strategies of pattern matching (intuitive matching with prior similar experiences) and mental simulation (analyzing what would happen if certain decisions were made). When diagnosing the situation, the decision-maker needs to recognize the pattern based on the relevant cues from the environment and then correctly diagnosing the situation, choosing the appropriate ‘typical’ course of action [8]. Efficient decision-making can be trained by increasing the leaner’s experience base, for example, by developing training programs incorporating realistic scenarios enabling the learners to expand their repertoire of patterns [12-14].

Providing realistic and properly situated cues during training sessions is crucial for the developing of decision-making skills, building of the repertoire of patterns and transferability of the training to real-life situations. This motivates the use of VR as it can provide the immersion and realism needed to replicate real-life cues in a simulated training environment. There have been some preliminary attempts to use VR for decision-making training under NDM/RPD paradigm, with promising results [15]. The NDM/RPD approach applied in a VR training scenario can be seen as a starting point for a pedagogical model for EM training, providing the basis for the original design of the EM simulator developed in this project[16].

B. Collaborative and Active Learning and Activity Theory

Collaborative and active learning represents a pedagogic approach that can encompass many pedagogic theories. The approach focuses on "students' exploration and application of course materials" that produce "the social simulation of mutual engagement in a common endeavor" [17].

Collaborative and active learning approach has been successfully used in a number of VR-based environments in a wide range of educational activities [18, 19]. VR-based models have also been validated as models for training for real-world mass casualty incident response [20]. Complexity theories of learning and NDM/RPD decision making models can inform training activities that fall within the broad domain of collaborative and active learning approaches.

Kuutti uses work activity as a basic unit for analyzing a cooperative working situation for design purposes [21]. Bardram argues that Activity theory (AT) can help to understand the way in which work activities are cooperatively realized in order to design efficient cooperative technology [22]. AT can therefore serve as a theoretical foundation for design of computer supported cooperative work and learning. AT is also increasingly used in Human-Computer Interaction design [23]. AT is based on the work by Vygotski [24], Leont’ev [25] and later Engeström [26]. The fundamental unit of analysis is human activity, which is directed towards an object, mediated by cultural artifacts and is social within a culture [27].

The main components of the activity triangle are artifacts, object, division of labor, community, rules, and subject. Individuals and groups can be seen as “subjects” situated in communities mediated by rules of participation and division of labor [26]. Mishra et al [28] suggest using AT as a methodological and analytical framework for information practices in Emergency Management (Fig. 1). The artifacts are placed centrally since all human work is characterized by the collaborative production of artifacts; each of them is made with the purpose of mediating a certain activity. The mediating characteristics of an activity is crystallized or objectified into these artifacts [27].

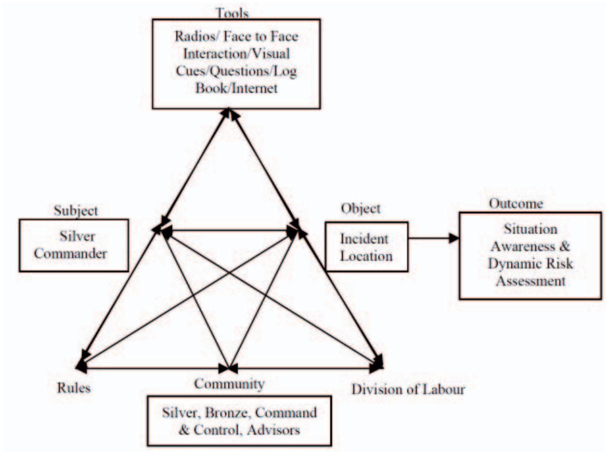

Figure 1. Activity model for commanders at an incident location [28]

Human activities have a hierarchical structure and are composed of actions that in turn are implemented through operations [23, 25]. The activity itself is oriented towards a motive, i.e. the object that the subject needs to attain (e.g. extinguishing a fire at an incident site). Actions can be defined as conscious processes that are directed at goals to fulfil the object (e.g., directing the fire extinguisher at a localized fire source). Actions are performed through operations that can be thought as routine processes providing an adjustment of an action based on the concrete context and conditions (e.g., a firefighter will automatically change his/her position in the process to avoid personal damage) [23, 25].

A human activity contains both internal and external components, with the mutual transformation processes between them (internalization and externalization) [23]. For example, the professional firefighter in the example above has in an internal script/pattern of a proper fire extinguisher procedure that he performs/externalizes while working on the fire.

III. VR Simulation for EM Training

The project created a VR simulation for EM training that is called VR-Active Learning Module (VR-ALM). The purpose of the VR-ALM design is to enable interaction of EM students in different professions, particularly of the EM continuing education program at Molde University College and with ninth term medical students at Norwegian University of Science and Technology. The modules were intended to aid in an aspect of communications training of EM and health professionals in management of crisis situations.

The simulation represents a crisis situation where the participant is expected to make decisions in the changing context or situation. In brief, the design of the VR-ALM was originally informed by theories of NDM/RPD and recommendations from experts and practitioners [16]. In particular, the following elements are implemented in the VR simulation of a crisis-scenario of an explosion in an industrial warehouse: printed signs, some firefighting and ambulance equipment with corresponding interaction mechanisms. The VR simulation was available on regular a desktop computer with an option to be an observer wearing a head-mounted display (Oculus Rift).

Four types of roles could be played in the simulation by one or several players: local workers/engineers, fire-fighter, medic/ambulance worker, and police officer. In addition, a single person could play a local EM center operator. The characters had appropriate appearance and different functions that could be carried out in the simulation. For example, the firefighter could operate the fire hose, while regular workers could pick up fire extinguishers in the building. The medical professionals could perform triage, address the injured, and transport the injured. We also implemented different radios (communication devices) in the simulation depending on the role. Each profession has its own radio. The leaders from all professions have an additional radio to communicate between each other and with the EM Center (Fig. 2, 3).

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. To go along with the functionality created for the roles in the simulation, we designed ‘role cards’ for each of the professions.

Learning with the VR-ALM is active and experiential. The participants are (1) interacting with the simulation and must make decisions as they would in live exercises and (2) they are communicating with colleagues in this activity as they would in live exercises. The limitation of the VR-ALM is that it cannot replicate the live environment to an extensive degree. However, the simulation signals and cues are such that participants could understand the crisis situation, and their tasks within that context.

Figure 2. Reviewing a training session in VR-ALM

Figure 3. Ambulance worker inventory tools

IV. Collaborative VR Trials: Results

In this section, we present the settings and results of two trials of the VR-ALM. The VR simulation had been improved between the trials based on the feedback [29].

A. Study settings

The effectiveness of the VR-ALM has been assessed by observations of the teachers, through survey feedback by students and through reflection sessions with EM training experts and professionals.

The participant interactions with the VR-ALM included the following activity phases.

1. The participants met with an expert in EM training who currently uses VR-simulation for the assessment of firefighters. They received background information on the reasons for using VR for training and on how that relates to their course's learning objectives.
2. The participants went through trials in groups and covered a variety of roles that included: firefighters, police, medics/paramedics, industrial plant engineer workers, leaders of those professional groups, and also an EM-center operator. Some participated appeared in several trials with different professional roles.
3. The participants reflected and reviewed own performance in the simulation. In a group reflection session after the trial sessions, the group discussed

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their performance with the teacher and the VR expert who gave validating feedback on the process.

B. Evaluation by high-school students

The first evaluation of the VR-ALM took place in April 2016. The evaluation group included 14 high-school students and one 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 the EM professional on the topic of "Better Understanding of Emergency Response".

The role-cards were introduced to their role for the simulation. Three runs of the simulator scenario were conducted. After the trials, the participants filled a short questionnaire, which consisted of demographic questions, five 5-point Likert-scale questions about their trial experience, and an open question on general feedback. The trial session concluded with a group interview.

C. Evaluation by professionals and master students

The second evaluation was in March 2017. The trial group had participants in three physical locations with a total of 11 participants. The evaluation group consisted of four firefighters (Fig. 4) and one EM specialist located in Molde. Simultaneously there were five medical students with acute medicine specialization and one paramedic student located in Trondheim. Several persons playing workers were located in a third location.

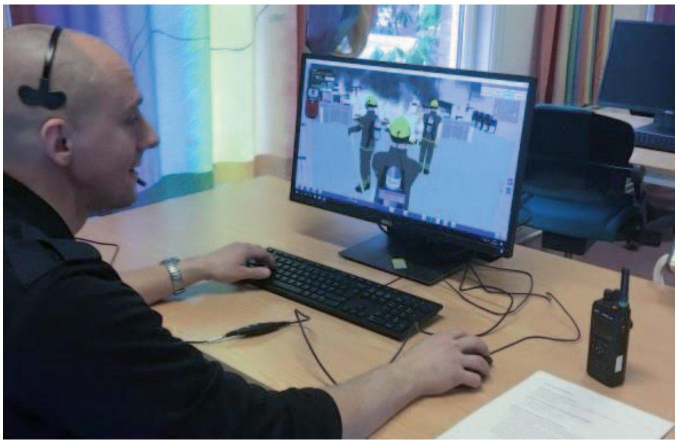

Figure 4. Professional firefighters, second trial of the VR-ALM

The procedure was the same as the March 2016 trials. The students received a lecture by an expert on communication in Emergency Response. New role cards were developed based on feedback from the prior trial. An additional radio-system was added to the VR-simulation. The revised simulation allowed for radio communication within professional groups (e.g., firefighters with their commander) and another radio for communication between team-leaders and the central EM operator. Expected lines of communication were discussed before the trial so that the professionals would be able to communicate as they would in real life.

After the trials, the participants answered a questionnaire, which contained the same five 5-point Likert-scale questions as in the first trial, an open question for general feedback, and four additional 5-point Likert-scale questions. The second trial session also concluded with group interviews: with the professional fire-fighters and with the medical students.

D. Questionnaire Results

In this paper, we present the results of the questionnaires, focusing on the questions that were asked in both trials. The questions concerned the roles of those involved in an emergency situation, team communication, realism of the simulation, and applicability for training.

The data for the emergency readiness roles shows that 12 out of 15 participants of the first trial (high school students) improved their understanding “considerably” or “to the greatest extent”. At the same time, seven out of 11 professional participants of the second trial reported “not at all” and “very little” improvement of their understanding.

From the two trials, we have found that the inexperienced participants felt that the VR-ALM simulation was beneficial to their understanding of how team members communicate both between each other (Fig. 5) and within teams (Fig. 6). In the second trial (professional firefighters and medical students), the participants responded to these questions rather negatively, due to the limited realism of the VR-ALM.

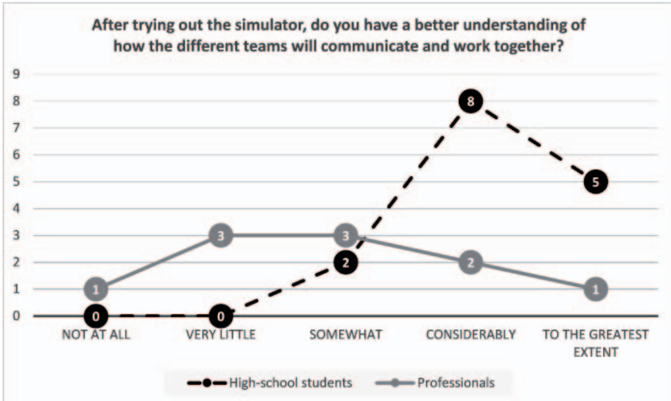

Figure 5. Understanding of communication between emergency teams

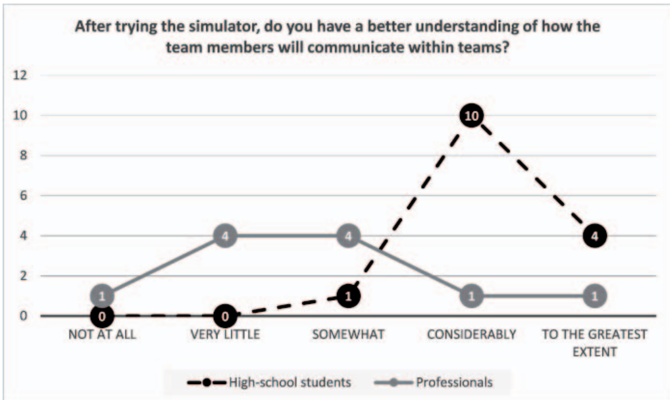

Figure 6. Understanding of team communication

The majority of the high-school student participants agreed that the VR simulation was realistic: eight participants answered “considerably” and five – “to the greatest extent”. The professionals and master students provided more balanced answers: four out of nine answered “somewhat”, two “very little” and two “considerably”. The professionals mentioned in the subsequent group interview that some elements were realistic, but having other elements (especially those related to the scenario and procedures) less realistic can diminish the usefulness for workplace training. The attitude towards integrating VR-ALM into training programs was very positive among the high-school students: six participants answered "considerably" and eight – "to the greatest extent". The majority of the professionals and medical students replied "very little" (four participants) and "somewhat" (four other participants).

E. General feedback and group interviews

The general feedback from observations and group interviews that are described in this section is a summary of the project's midway report [29, 30]. The general feedback provided in the first trial by the high-school students was mostly positive.

- *"Liked it, fun, would like to play again"*
- *"Learned about communication, how it works"*

Several students wanted the simulation to be a part of the safety course at high school and pointed other possible use in workplaces, such as construction.

The feedback given by the high-school students during the groups interview fall into the following categories:

- VR simulation improvements (6 occurrences)
- Introduction of game elements (5)
- User Interface improvements (3)
- Training session setup improvements (2)
- Emergency scenario discussion (2)
- Technical difficulties (2)

The professional firefighters were less positive to the experience then the health professionals. Their experience with frequent live events seems to diminish the value of a simulated event for training. During the trials the firefighters were called out twice to respond to calls and so the trials were interrupted until they could return. The medical students agreed that they could "absolutely" use the simulator for communication training, noting that "it is not so often we get to train with fire and police".

The participants provided feedback on *what could be done to improve the simulator, to make it more realistic*. For example, suggestions were given to (a) make the roles more precise and (b) limit the number of characters to the exact number that is common in reality.

During the group interview, the professionals provided the following feedback when discussing *how to make the virtual environment more realistic*: (a) making actions flexible, such as having more equipment and using it more freely, (b) allowing to establish a visual control of people going in and out of the emergency area, (c) providing more detailed symptom description during triage, and (d) allowing medics to work further with the injured, for example, giving oxygen, applying medications, and taking them away from the emergency scene.

While discussing *how to make the communication in the VR simulation more realistic*, the professionals mentioned that the communication must be implemented exactly as it happens in the real life, including (a) talking with or without the radio, (b) team structure and communication scheme has to be exactly as in reality, and (c) allowing a clear indication in the interface when talking with and without the radio.

When discussing the *future perspectives* at the groups' interviews, the fire-fighters reflected that VR-ALM can best be used to train communication between agencies and with other actors in crisis situations. The medical students reflected that VR-ALM can be used as part of their education at later stages of the program and for the ambulance students.

V. FRAMEWORK FOR ACTIVE LEARNING FOR MULTI-DISCIPLINARY EM TRAINING

The feedback from the trials gave information regarding the complexities of the real environment. The design team discovered that there were typically more levels of command than those that could be represented in the simulation. In particular, all levels of command among firefighters could not be represented at the trials. Regardless of who played particular roles, we also experienced technical problems with the VR-server for runs that had many simultaneous users (e.g. 15). It is difficult therefore to include the sometimes greater number of persons that are in reality involved in such incidents. So, we could not have the complete command chain represented in the simulation, as we could not support more simultaneous users.

Apart from imposing higher demands for the technical solution, the identified complexity also requires a more complex theoretical approach. While the original learning module has been designed primarily based on the NDM/RPD paradigm, there is a need to supplement this approach with socio-cultural theories such as AT. Activity theory is able to capture the complex social dynamics in situations involving large multi-professional communities and plays a prominent role in Human-Computer Interaction field [23].

Therefore, in this section we analyze the use of the active learning system and user feedbacks from the lenses of both NDM/RPD and AT, showing how these can be combined. This analysis aids the design process by helping the ALM designers to understand how the mediating technology supports the EM, engineering and medical-students, but also non-professionals, in communications training and decision-making.

As indicated in Section II.B, an activity is composed of actions and operations. For example, the overall activity of rescuing workers could be decomposed into a number of typical actions and operations in the simulator, among others 'Evacuate injured' and 'Perform triage':

TABLE I. ACTIVITY 'RESCUE OPERATION'

Action	Operation	Context/conditions/ cues	Actors
Evacuating injured	• Identify injured in the warehouse • Choose 'carry' from the inventory • Lead the injured to safety	• A worker is sitting and coughing or lying inside the building • Visible smoke and fire	Firefighters, fellow workers
Performing triage	• Choose the triage icon in the inventory • 'Click' on the patient and access the provided health information • Choose the triage color for the patient	• Patient sitting or lying • Health Information provided	Medics, paramedics, medical service leader

In Table I, we provide examples of actions and operations [31] and their corresponding contexts and cues. NDM/RPD thinking and analysis can be primarily attributed to the actions and operations level. The process of learning new patterns and recognizing patterns based on a set of cues and contexts and choosing a course of actions within the NDM/RPD thinking is paralleled by a similar internalization/externalization process in AT. For example, an experienced medic does not need to go through a checklist to perform patient examination and doing triage: it is a pattern that is already learned/internalized. This action (of performing triage) is crystallized in the associated mediating artifacts, e.g. the medical inventory (Fig. 3).

The subject/user in the VR simulation uses tools (e.g. inventory items) to react on cues and perform certain courses of action (such as evacuating the injured) to affect the subject (incident site) while receiving feedbacks on own actions (the injured are brought to safety). This corresponds to the top of the Activity triangle, (Subject-Tools-Object) i.e. the original version of AT suggested by Vygotsky [24]. The extended version suggested by Engeström [26] focuses on the collective motivated activity as the unit of analysis, with associated complex interactions not explicitly embedded into the simulation. An example is the division of labor between medics and firefighters: the former do not go inside the fire area and wait outside for patients to be brought out by the latter.

From the user feedbacks it appears that the realism, the cues/triggers and responses at the action/operation level are important. At the same time, for the communication and collaboration training we need to address the community aspects not covered by NDM/RPD. It means a combination of both theoretical approaches will provide a more accurate model for creating learning modules for EM training and providing a set of requirements for such a simulation.

To illustrate this, we suggest structuring the NDM/RPD-based requirements we earlier introduced in [16] and suggested new ones for active learning modules along the major AT components *subject, object, tools, community, division of labor and outcomes* (Fig. 1). For each component, we also provide examples of associated user feedbacks. Both professionals and non-professionals can use the resulting active learning modules as both need awareness of how a community works at an incident site. For the latter, a more simplified and less detailed description of 'rules' and 'division of labour' would be appropriate. This structure will not only define the requirements to the VR simulation itself, but also will aid the creation of scenarios. Below, we describe the main components of the Activity triangle for Active Learning Modules in VR:

Subject

- Player: commander, team member (medic, firefighter)

Elements in the simulation and requirements

- The avatars should wear profession-specific clothing, indicating their place in the chain of command
- The scenario and role cards should include a correct and comprehensive description of the roles and tasks

Examples of related user feedbacks

- "Should be able to choose avatars to walk to and communicate with"
- "Need proper avatar vests indicating different roles"

Object

- Incident site/warehouse/factory

Elements in the simulation and requirements

- The actions that the decision maker takes must also have an impact on the simulated incident
- Start conditions for the incident can be variable, for example, the number of persons injured or the starting location of the incident (fire outbreak), etc.
- Description of the incident cite and context in the role cards and exercise/scenario

Examples of related user feedbacks

- "To be realistic, after triage, people go to ambulances and get evacuated, some workers and medics will be gone, will be less people left [at the incident site]"

Tools

- Radio, avatars, inventory items (tools for triage, fire extinguishing, evacuation of injured, Fig. 3), signs, environment cues

Elements in the simulation and requirements

- Firefighting equipment, first aid equipment and other objects that are normally present in the workplace should be in the same approximate location in the virtual space
- Key equipment for different professions should be represented in the inventory (Fig. 3), serving as tools for mediating of actions. The affordances of these tools should be easy to understand
- For every player/subject, the role cards and scenario should list the available tools in the inventory and environment and possible actions/operations on them

Examples of related user feedbacks

- "Keeping focus on 'radio', highlighting whether you are talking through the radio or the person next to you"
- "Should be possible to give oxygen to the patient"

Community

- Other commanders (fire, medical, police, workers), teams members, EM center operator

Elements in the simulation and requirements

- The possibility to choose roles/team in the beginning of the roleplay
- Appropriate avatar clothing for different groups
- Modes for inter- and cross-team communication (e.g. 'radio' and on-site 'voice' communication)
- The role cards and scenario should contain the description of one's place in the community structure and associated communication modes

Examples of related user feedbacks

- "The information that the operative medical leader got from us [ambulance personnel] on the incident site should be brought further to the EM center"
- "We [medics] can hear the firefighters and the workers on the ground talking… should be able to 'zone out'"

Division of labor

- Areas of responsibility, chain of command within the same and different agencies

Elements in the simulation and requirements

- Teams arriving to different designated spots in the beginning of the simulation
- Printed signs that are normally seen in the workplace

- Signs indicating commando points for different teams, providing an indication of division of labor
- Different inventory sets for different teams
- Task description for different teams in the role cards, explicit description of responsibility areas in the exercise (e.g., medics do not go inside the fire) and the chain of command

Examples of related user feedbacks

- "Operative medical leader sits together with incident commander, medical service leader is in the filed performing triage"

Rules

- Official protocols for safety, interaction between agencies, routines for performing triage and fire extinguishing

Elements in the simulation and requirements

- The environment should provide realistic, dynamically changing cues that the learners need to extract in order to diagnose the situation/pattern correctly (based on certain rules)
- Rules and regulations are crystallized in the simulation functionalities e.g. firefighters wear masks protecting from smoke
- Diagrams and description in the exercise, scenarios and role cards reflecting the official protocols

Examples of related user feedbacks

- "At the fire scene, normally there is a control with who is going in and out"

Outcome

- Situation awareness, fire under control, triage accomplished, rescue mission successful, simulation completed, learning goals achieved

Elements in the simulation and requirements

- Players should be faced with dilemmas in the VR simulation that are in line with what they would face in their normal work. This includes time constraints and other stress factors that are typical in EM situations (and resulting in different outcomes)
- The simulation should incorporate a degree of randomness, such that the situation that unfolds (through escalations) will be different (non-constant) in successive runs of the learning module
- Possible outcomes and learning goals/roleplay goals are exemplified in the exercise/role cards

Examples of related user feedbacks

- "The training format has to be correct...The team structure and the communication channels have to be right."

VI. CONCLUDING REMARKS

The intended learning outcome for the participants of this simulation has been to increase skills and confidence in dealing with a variety of possible scenario trajectories (for professionals) and to gain awareness of multi-professional collaboration at an incident side (for non-professionals). Several learning objectives has been identified (e.g., to identify how-to quickly and effectively personnel can evacuate a building or location; performing triage). The interaction with the simulated environment takes a game-based approach, where different actions are triggered based on the participant's decisions. However, many factors need to be represented in the simulation to assure immersion and that the simulation VR training module captures the dynamic nature of a live incident. These factors also depend on who is using the simulation: professionals or students.

We have applied RPD model of decision making as a starting point and a basis for a pedagogic model in EM training. This project designed and trialed a VR simulation that tested the aspects of the NDM/RPD model for relevant cues and expectancies. In a period of two years (2016-2017) the VR-ALM simulation design in this project underwent several iterations of improvement. Several EM training experts have been consulted in the process.

Based on the project team's experience and the feedback from the users, especially the professionals, it became obvious that the complexity of EM training is higher than anticipated. Apart from decision-making training, social and community aspects need to be taken into account. Therefore, in this paper we have used AT to conduct an analysis on the active learning system. We interpreted how the various elements of the active learning system interacted to support the intended learning outcome and have gained the following insights [29]:

- In comparison to workplace training, VR simulations offer no training of physical skills and are therefore less realistic by definition.
- The necessary degree of realism and complexity is relative and depends on the target user group (e.g., less realism is 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.
- Social and communication skills, as well as social and community aspects should be a part of the EM simulation model and the requirements specification, together with the physical and procedural aspects.
- There is a need for a consistent methodological approach to develop simulations and corresponding exercises adapted to different learning goals.

Despite the identified challenges, several of the health professionals gave positive feedback on their experiences with the VR-ALM. They indicated that it was a great opportunity to be able to train with other professions such as the firefighters. Non-professionals obtained more insight from the exercise, partly because they had less previous knowledge to the field, with a steeper learning curve as a result. At the same time, it shows that even a simulation with a limited accuracy can be beneficial for certain groups of learners.

The project team suggests that there is potential for future applications of VR in EM training. The state of VR technology has reached the point when wearable and affordable devices can provide an accurate and high-fidelity replication of cues from real-life emergency situations. Future 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 holds promise not only for VR-based training but also for training that apply augmented reality (AR). AR tools (such as head mounted displays and smart glasses) and AR training components (tracked imagery within the simulation) will contribute to increase the learner's experience in the form of acquired 'repertoire of patterns' at a much faster rate than traditional experience building in the field and allow more natural social interaction with other actors at the incident site. In addition, an extensive methodological research is required for more accurate mapping of the activities and complex interactions at the field to VR/AR simulations.

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