A PC-Based Virtual Environment for Training Team Decision-making in High-Risk Situations

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ABSTRACT

Live team training of firefighters has several disadvantages. Firstly, it is costly because many team members and training staff are involved. Secondly, not all team members have the same competency level, and some individuals may just not be ready to train in a team context. Thirdly, live training in high-risk situations is difficult and dangerous. Consequently, critical situations can not be trained adequately. Following a scenario-based and a rapid prototyping approach, we are designing and developing a pc-based virtual training environment to train individual firefighters in making decisions in a team context operating in high-risk situations. This individual training program can better prepare the firefighters for live training, enhancing the effectiveness and efficiency of these team-training exercises. In this paper we describe the training-method, we outline how this is technologically implemented and discuss how we are planning to test the prototype.

Keywords

Team training, virtual environment, team decision-making, firefighters.

INTRODUCTION

Firefighters follow training programs and exercises specifically geared to their individual operational tasks and are primarily focused on the acquisition of domain and task specific knowledge and skills. In many cases, however, firefighters do not operate in isolation, but in a team with regularly changing team members. The Inspection Public Safety and Security (2004) concluded that the competency level of firefighter commanders and officers is insufficient and does not meet the demands of the operational environment. Important bottlenecks were related to the lack of structured after action reviews and evaluations, the low level of realism of training programs, and difficulties with training (team) decision-making. In regular training programs, risk-analysis and decision-making are trained using photographs displaying critical situations. The trainees can indicate the risks and why which decisions should be taken. The problem is, however, that these cases are static and do not represent the dynamic reality adequately. Getting realistic and hands-on experience in applying teamwork and decision-making competencies can be achieved by live team training. Live team training of firefighters has however several disadvantages. Firstly, it is costly because many team members and training staff are involved. Secondly, not all team members have the same competency level, and some individuals may just not be ready to train in a team context. Thirdly, live training in high-risk situations is difficult and dangerous. Consequently, critical situations can not be trained adequately. Using training simulators, like for instance the Advanced Disaster Management Simulator (http://www.nibra.nl) or Vector Command (http://www.VectorCommand.com) only tackle the last disadvantage of live training. Within the research project described in this paper we aim at developing a learning environment in which individual firefighters can be trained in making decisions in a team context operating in high-risk situations. This individual training program can better prepare the firefighters for live training, enhancing the effectiveness and efficiency of these team-training exercises.

We will first describe the systematic design and development of team training. This is followed by an explanation of two training methods that have proven effective in training team processes and decision-making. Next, we will describe the scenario-based and rapid prototyping approach followed in designing and developing the learning environment, and illustrate how the prototype looks like. Finally, we will discuss our plans with respect to further developing and testing the learning environment.

SYSTEMATIC DESIGN AND DEVELOPMENT OF TEAM TRAINING

The realization grows that just putting together a team of individual experts does not make an expert team (Salas, Cannon-Bowers and Johnston, 1997). In recent years, it has been shown that a good approach to training teams with complex training technology is linking training goals to events in training scenarios in a controlled fashion. This is called the 'event-based approach to training' (EBAT) and is depicted in Figure 1 (Johnston, Smith-Jentsch and Cannon-Bowers, 1997).

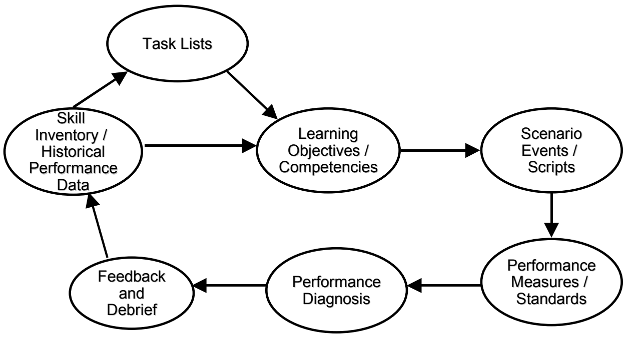

Figure 1. The EBAT framework

The EBAT framework starts at the top left hand side with the tasks to be performed by the team. The basic assumption is that training should provide opportunities for practice, enabling a team to develop critical competencies to conduct their mission, or, to manage an emergency. The team and individual behavior indicating these competencies is explicitly described in the learning objectives. Based on these learning objectives, the training scenario is developed. A training scenario consists of several events that are specifically designed to trigger the team members' behavior as described in the learning objectives. Events are critical incidents that can occur during the course of the emergency and on which the team should react. For every event, the observers know what behavior the team should demonstrate, and which prototypical mistakes could be made. This facilitates a systematic observation of the team members' behavior. Based on these measurements the training staff is able to make a valid diagnosis of the performance and to assess to what extent the learning objectives have been achieved. During the debrief, feedback is provided to the team and, together with the team, the lessons learned are formulated. The strength of EBAT is the systematic linkage among these components. Without this linkage is impossible to ensure that team members will have learned anything from the training.

TRAINING TEAM PROCESSES

During the course of training, instructional methods should be employed to ensure the team's learning (see also Van Berlo, Stroomer and Van den Bosch, 2003). Two training methods, that have proven their value for training teams and their leaders, will be described in this section: Team Dimensional Training and Critical Thinking.

Team Dimensional Training

An important distinction that resulted from research on team training is the concept of 'taskwork' and 'teamwork' skills underlying team performance (Cannon-Bowers and Salas, 1998). Taskwork consists of the position-specific requirements of the job, which are usually technical in nature (such as operating a certain workstation). Teamwork has more to do with processes that individuals use to coordinate their actions. Both taskwork and teamwork skills are important in any given team and team member (see Table 1).

Level	Content	
	Taskwork	Teamwork
Individual	1) Individual task skills (e.g. plotting of data)	2) Social and communication skills to function in a group (e.g. leadership skills)
Team	3) Team task skills (e.g. conducting an evacuation plan)	4) Social and communication skills to function as a team (e.g. supporting each other)

Table 1. A distinction of competencies with respect to training teams

Smith-Jentsch, Johnston and Payne (1998) have further delineated the skills underlying teamwork, and they identified four dimensions underlying effective teamwork: information exchange, communication, supporting behavior, and initiative/leadership. Information exchange includes seeking information from all available sources, passing information to the appropriate persons before being asked, and providing situation updates on a regular basis. Communication includes using proper phraseology, providing complete internal and external reports, avoiding excess chatter, and ensuring communications are audible. Supporting behavior includes correcting team errors, and both providing and requesting backup or assistance when needed. Finally, initiative/leadership includes providing guidance or suggestions to team members, and stating clear team and individual priorities.

These four generic teamwork skills can be regarded as key competencies of any member of an emergency management team. Learning how to work together is especially important for teams consisting of team members that frequently vary. Being a member of an emergency management team is often not a primary job; only when an emergency occurs, the team members are called together and the team is formed. In these cases, team members should possess adequate teamwork skills.

Team Dimensional Training (TDT) is a training methodology designed to aid instructors in training and evaluating teamwork skills (Smith-Jentsch, Johnston and Payne 1998). This is accomplished through a four step training cycle: briefing a team, observing a team's performance during a training exercise, diagnosing this performance, and de-briefing the team about its performance. During the briefing phase the four teamwork dimensions delineated by TDT, and behaviors associated with each, are presented to the team by the trainer. During the exercise itself, the observers gather positive and negative examples of behaviors that fall under each TDT dimension. One or two of the best examples (i.e., most relevant to the training objectives) under each dimension are summarized for debriefing. During the debriefing phase, the trainer facilitates the discussion of the team's performance, providing positive and negative examples of team behavior.

Critical Thinking

Expert decision-makers treat decision making as a problem-solving process. They use familiar elements to construct an initial interpretation of the situation. The plausibility of this interpretation is verified by explicitly challenging its critical assumptions. When faced with a complex and unfamiliar problem, experts collect and critically evaluate the available evidence, seek for consistency, and test assumptions underlying an assessment. They then try to integrate the results of the processes in a comprehensive, plausible, and consistent story explaining the actual problem situation. Experts assess the risks associated with potential courses of action by consulting their experience as well as by means of mental simulation (Zsambok and Klein, 1997). Novices, on the other hand, tend to interpret situations more superficially, and often assess the nature of a situation on isolated cues, without taking the larger pattern into account. Furthermore, they are often not explicitly aware of the assumptions they maintain, hence are less critical about them, and are more likely to 'jump to conclusions'.

The knowledge of experts and the strategies they employ when dealing with complex situations have been used to develop a new form of training in decision making and risk management: Critical Thinking (Cohen and Freeman, 1997; Van den Bosch and Van Berlo, 2002). This training method has proven to be effective for various kinds of teams. The aim of Critical Thinking training is to keep trainees from assessing situations solely on isolated events. Instead, trainees are taught how they can integrate the available information into its context, which may include elements as: the history of events leading to the current situation, the presumed goals and capacities of the enemy, potential risks associated of the environment, the opportunities of the enemy, etc. Trainees are instructed how to identify inconsistency and uncertainty, and how to adjust or refine their story by deliberate testing and evaluation. Critical Thinking training also includes a procedure for handling time constraints.

DESIGN AND DEVELOPMENT OF THE PC-BASED VIRTUAL ENVIRONMENT

We are following a scenario-based and a rapid prototyping approach while designing and developing the learning environment to train individual firefighters in making decisions in a team context operating in high-risk situations. A pc-based platform was chosen because firemen can have easy access to it (e.g. between shifts, at home via the web). A virtual environment has the advantage that the dynamics of the operational environment can be realistically simulated. Additionally, using commercial off the shelf products and re-using software developed in related projects makes this effort a relatively low-cost one.

Firemen perform many tasks. One critical task is incident management. We have further analyzed this team task into four major subtasks, namely (1) picture compilation, (2) situation assessment, (3) planning and decision-making and (4) direction and control. This analysis of the incident management task is depicted in Figure 2. Every subtask has been further analyzed into its underlying competencies and the identification of the team members' responsibilities (Van Rijk, Post and Van Verseveld, 2001), resulting in the instructional objectives.

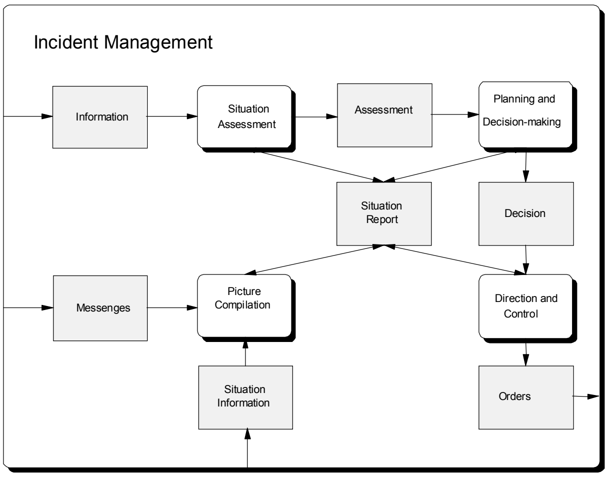

Figure 2. Incident Management Task Analysis

Together with officers of a Dutch fire-fighting brigade in The Hague, we have applied the results of this analysis in designing a scenario focusing on fighting a fire in a student apartment. Roughly, the scenario has three parts: (a) the fire alert and the transportation to the incident scene, (b) reconnaissance of the incident scene and (c) entering the building. The scenario has been designed iteratively, meaning that in several iterations the scenario was commented on and further specified. Within the context of this scenario, the specific relevant characteristics were identified of the teamwork (e.g. timely exchange of information to the right person), the team decision-making process (e.g. stating the right priorities) and the dynamic operational environment (e.g. changing color of smoke and visibility). In order to measure the trainee's performance during the training specific events were included in the scenario, like for instance incomplete information to the action center, uncertainty about the presence of people in the burning building and sudden increase of temperature. The events are combined into several scenes that constitute the scenario. After every dynamic scene, various multiple-choice questions are presented to the trainee. Answering these questions will give insight into the trainee's level of understanding with respect to the teamwork, the decision-making process and recognizing relevant situational cues. In order to improve the quality of the learning process, trainees need to reflect on their answers. An instructor who guides a discussion between various trainees (in a classroom of via the web) can support this reflection.

We used commercial off the shelf products and re-used our own software developed in related projects in order to reduce costs as much as possible. TNO has been involved in a European Commission Community Research project 'GATE' (Gamma Trial for Emergencies and Environment) aimed at producing a courseware-authoring environment for trainers in the field of emergency management, and a web-based multimedia course for firemen on dealing with hazardous materials (http://www.tno.nl/instit/fel/gate). We used the architecture of GATE for our pc-based virtual environment. An example of a screen dump is depicted in Figure 3.

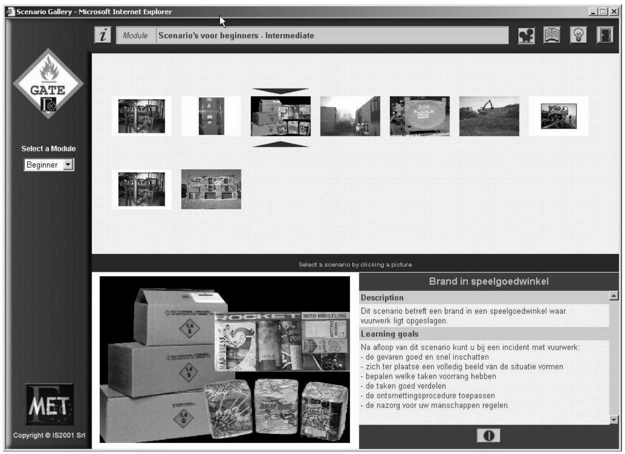

Figure 3. Screen Dump of GATE

An example of the dynamic representation of the operational environment, is the game Fire Department (also known as Emergency Fire Response) produced by Monte Cristo Games (http://www.montecristogames.com). We were not able to flexibly reuse the images, so we developed the 3D visuals for the prototype ourselves. These 3D visuals were implemented into the GATE architecture and adapted to the characteristics of the specific scenario (for an illustration, see Figure 4). The trainee can navigate through this virtual environment by means of a standard web browser, equipped with a Virtual Reality Modeling Language plugin, like the Cortona Web Client (www.parallelgraphics.com/products/cortona).

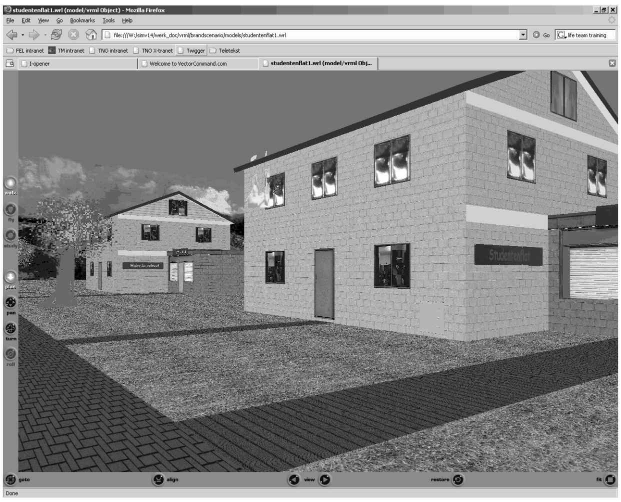

Figure 4. Screen Dump of a 3D Visual

Within the building, the operational environment is much harder to simulate realistically. Therefore we will be using digital photographs that are merged seamlessly into a realistic looking virtual environment. This environment can be flexibly enriched with specific characteristics as described in the scenario, like for instance changing color of smoke, changing visibility and construction of the building. The trainee can navigate through this virtual environment by using the arrows on the screen. An illustration of how this may be implemented is depicted in Figure 5 (http://www.barsark.com).

Figure 5. Illustration of Navigation within a Building

CONCLUSION

Teamwork and decision-making are essential to perform adequately in high-risk situations and can actually save lifes. Training these competencies means a constant balance between cost-effectiveness, safety and realism. The pc-based virtual training environment may be a piece of the solution to this problem. It offers a realistic simulation of a dynamic high-risk situation, and a safe and standardized environment in which dangerous situations can be trained. It can bridge the gap between individual training using static photographs on the one hand, and dynamic simulator-based and/or live team training on the other. This individual training program can better prepare the firefighters for team training, enhancing the effectiveness and efficiency of these costly exercises. We are planning to further develop the prototype of this learning environment and to test its effectivity in a training experiment. One group of firemen will be trained on entering a burning building using the prototype, while another group will be trained using photographs. The answers on the multiple-choice questions as well as the reflection guided by an instructor afterwards will be recorded. Both groups will than engage in a similar scenario during live training. Both the on-line communication as the after action review will be recorded. A qualitative analysis on the answers, communications and after action review will be conducted in order to test the effectivity of the training program. The following step would be to implement it in a coherent learning trajectory for firefighters.

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