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Assessment of web-based interactive game system methodology for dissemination and diffusion to improve firefighter safety and wellness

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ABSTRACT

This paper describes research to assess the efficacy of web-based interactive game-like training in comparison to traditional classroom training for improving firefighters' knowledge, to advance the dissemination, diffusion, implementation and adoption of new information stemming from research interventions in fire-service. A web-based, interactive multimedia training tool called ALIVE (Advanced Learning in Integrated Visual Environments) was developed, that simulates the critical decision-making aspects of firefighting, and imparts knowledge and training though interactive game playing. Field experiments were conducted in three cities with career and volunteer firefighters to assess the efficacy of ALIVE and its adaptability for use in different fire-service related topics. Analyses of the results showed that knowledge transfer and retention using ALIVE was better compared to traditional classroom training in almost every case. Firefighters trained with ALIVE performed significantly better post-training and on a long-term retention test than those who were trained in a classroom. They also rated their own acquisition of knowledge higher than did those who had participated in the classroom training. These results hold true for the participant population as a whole, as well as with career and volunteer firefighters, and across participants of different levels of firefighting experience. These findings suggest that ALIVE training may be a particularly efficacious tool for use as part of firefighter training programs.

1. Introduction

Research projects conducted in the United States and around the world have made substantial progress in the development of technologies and tactics that hold the potential to improve firefighter safety and reduce injuries and fatalities among firefighters and civilians [1–5], while increasing the effectiveness of fire suppression. The practice of firefighting, however, has not kept pace, and the gap between the development of science-based interventions and their widespread implementation in the field remains large [5]. To save lives and to prevent injuries to firefighters, the fire service needs up-to-date information and knowledge about effective interventions. Additionally, during dissemination and training, the scientific language and protocols developed through relevant original research needs to be translated into everyday terms for use by firefighting practitioners, and presented in effective ways.

There are many factors that contribute to the number of on-duty deaths and injuries suffered by firefighters. Of immediate concern is the possibility that many firefighters are not aware of advancements in firefighting methods that could have changed these tragic outcomes. After new interventions have been identified and adopted by the fire service, fire officials need tools for implementing effective and continual training and knowledge diffusion within their own organizations.

The need for good training is real and growing. Fires are always dangerous and life-threatening, and this risk to people and property can be exacerbated by adverse weather conditions. Moreover, residential fires are becoming more complex to fight because of a variety of factors, including the increasing diversity of building materials, different types of construction technologies, the use of synthetic materials in furnishings, and generally high and increasing combustion loads [6–8]. These changes require firefighters to be increasingly knowledgeable and sophisticated about

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understanding the nature of the fire they face and the tactics they choose to fight it.

Systematic and controlled research in laboratory and field situations helps to provide a knowledge base that can support firefighting and lead to new tactics and strategies. Recent studies of wind-driven fires in high rise structures, for instance, have improved understanding of these difficult and dangerous fires and led to new methods and equipment for combating them [9–11]. Research in medicine and exercise physiology has postulated scientific intervention methodologies for improving firefighter health and habits, ultimately aiding in the prevention of injury [5].

For new discoveries and tools to benefit firefighting in practice, effective means of dissemination and diffusion of innovations are needed, i.e., ways to ensure that individual firefighters are aware of those new assets, and understand them sufficiently to change their behavior in the field when the need arises [12–14]. Today's fire services follow traditional paths for the dissemination and diffusion of new information to its members. This typically includes asynchronous perusal of printed or electronic materials, synchronous face-to-face or webcast attendance of lectures, or combinations thereof. In too many instances, dissemination and training is limited or may even be absent due to resource constraints or an institutional reluctance to change [13].

To address these problems, an online, web-based, interactive, scenario-based training system called ALIVE (*Advanced Learning in Integrated Visual Environments)* was developed [3]. The goal of this study is to assess and quantify the effectiveness of ALIVE, with its online access and logistical advantages, in teaching critical information to fire fighters and to systematically compare its efficacy to traditional classroom-based training methods in terms of how much information is learned and retained.

2. Previous approaches

Scientific studies that lead to the development of technical innovations often pay insufficient attention to strategies for dissemination. Such considerations are often left to the potential users of these new technologies. For fire departments this means that they must (1) have an awareness of the research; (2) understand the implications of the research for their firefighting practices; (3) find or create ways to translate it for everyday use by firefighters; and (4) direct resources to widely, rapidly and effectively disseminate these new technologies so that they are adopted in the field [13]. The spread of new technologies and knowledge is often difficult and slow, especially when it involves shifting understandings and changing paradigms. Even officially adopted new technologies are not always quickly and readily deployed to field situations (the “assimilation gap”) [15–17].

Effective training for this kind of practice requires a mix of three essential elements: didactic presentation of information, skills demonstration, and opportunity for skills mastery [13]. Traditional dissemination and training methods may not excel at all these tasks [18]. Fire Departments have made use of a variety of hands-on training systems, which are extremely valuable but entail high costs and significant risks [19]. Moreover, these controlled settings often cannot address some of the most difficult and dangerous circumstances, such as wind-driven, high-rise fires. Virtual reality systems may be able to obviate some of the scenario constraints in firefighter training [20,21], but despite the fact that the technology holds great promise, developing an effective virtual reality environment requires significant capital outlays and a great deal of time. Moreover studies have shown that at least in the case of firefighter wayfinding training, the virtual training environment was no more effective than training with maps [22].

Traditional training systems implemented in fire departments typically fail to provide substantive feedback to the trainer, department or firefighter on the effectiveness of training, particularly in terms of how much the firefighters comprehend and retain the material. Most methods have limits in terms of their likely impact (asking firefighters to simply read or watch prepared material), time commitment and infrastructure (classroom training), and cost (simulation facilities, virtual reality systems). Most fire departments in the country cannot afford the training methods discussed above, beyond dispensing materials [13]. Even if a new technology was deemed vital to all firefighters, the effort, time and cost to train the 1 million firefighters across 30,145 departments, in classes of 30, would require 100 person years to complete!

Although direct contact between teacher and student has many benefits, online training has several important potential advantages, such as lower costs, increased convenience and accessibility, low infrastructure and space requirements, and the ability to reach more people more quickly. Online training that uses programmed instruction has the additional benefit of providing immediate individualized responses and feedback to students [23–27]. In a number of studies conducted across a variety of settings, online training has been shown to be at least as effective as, or in some cases modestly better than, face-to-face courses in learning outcomes. In some cases, students preferred online education to traditional instruction, because participation may be less intimidating, and the quality and quantity of interaction may be increased in online classes [23–27].

3. ALIVE training

In 2008, researchers from the New York University Polytechnic School of Engineering (NYU-Poly) and National Institute of Standards and Technology (NIST), in collaboration with the Fire Department of New York (FDNY), conducted a study of wind-driven fire dynamics in high-rise structures. The experiment yielded new and critical information concerning fire behavior and the efficacy of certain newly developed firefighting tactics. This research changed the department's standard operating procedures (SOPs) [9–11]. The FDNY also collaborated with NYU-Poly to train its 11,000-plus firefighters. After completing this locally based project, NYU-Poly, the FDNY and NIST sought to share the results of their research with the nationwide fire service audience, in a way that could address the needs of both career service and volunteer firefighting communities – leading to the development of ALIVE.

ALIVE training uses video, images, audio and text to present realistic fire-fighting scenarios, and asks users to assess the scenarios and choose strategies and tactics to address them [28]. ALIVE incorporates basic principles of learning theory and programmed instruction to present material, and requires step-by-step responses while providing immediate feedback and reinforcement. Users progress through several topic sections devoted to various fire principles and firefighting techniques. This information is reinforced with questions regarding actual situations or simulated scenarios. In a real fire, incident commanders (ICs) make approximately 80% of their fire-ground decisions within one minute of arrival on the scene [29]. ALIVE simulates this decision-making process, providing users with multiple firefighter intervention options that alter the situation in different ways. Learners must utilize information from the training to determine the best possible method for tackling the fire situation. Every incorrect answer prompts an explanation citing the principles that make that selection inferior, and the user is given an opportunity to make another selection. This process is repeated until the optimal answer is chosen, allowing users to learn from their mistakes (see [28] for ALIVE screenshots). All responses are automatically saved to a database to track progress and performance.