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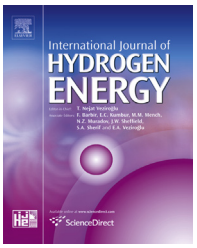

Mixed e-learning and virtual reality pedagogical approach for innovative hydrogen safety training of first responders

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ABSTRACT

Within the scope of the HyResponse project (www.hyreponse.eu) the development of a specialised training programme is currently underway. Utilizing an andragogy approach to teaching, distance learning is mixed with classroom instructors-led activities, while hands-on training on a full-scale simulator is coupled with an innovative virtual reality based experience. Although the course is dedicated mainly to first responders, provision has been made to incorporate not only simple table-top and drill exercises but also full-scale training involving all functional emergency response organisations at multi-agency cooperation level. The developed curriculum includes basics of hydrogen safety, first responders' procedures and incident management expectations.

Introduction

Fuel Cell and Hydrogen (FCH)[1] technologies and applications both in transport and energy sectors arrive to the market today. Unfortunately at the moment, European fire authorities and first responders have limited knowledge of these new technologies. Thus, an adequate training of first responders should provide them with an accurate, up-to-date knowledge of hydrogen safety basics and with essential practical skills on how to handle potential incidents/accidents within FCH systems and infrastructure; on how to protect the general public without putting lives at risk. The Coordination and Support Action project HyResponse, funded by the European Commission Fuel Cell and Hydrogen Joint Undertaking (FCH JU), aims to establish the first comprehensive training programme – European Hydrogen Safety Training Platform (EHSTP)[2] [1]. The project partners are French Academy for Fire, Rescue and Civil Protection Officers (ENSOSP), Air Liquide, Ulster University (UU), FAST/EHA (European Hydrogen Association), CCS Global group, CRIsis Simulation Engineering (CRISE) and AREVA Stockage d'Energie.

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[1] FCH – Fuel Cell and Hydrogen.
[2] EHSTP – European Hydrogen Safety Training Platform.

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The target audience of the EHSTP are first responders including fire-fighters at different levels, from field operators to high-level incident commandment, police forces, paramedics, vehicle recovery personnel, site operators, etc. The EHSTP consists of three key elements: educational training (i.e. lectures), operational exercises and innovative virtual reality (VR)[3] exercises, which reproduce in detail an entire accident scenario including either correct or incorrect intervention techniques. The educational training encompasses the basics of hydrogen safety; regulations, codes and standards (RCS)[4]; the intervention strategies and tactics relevant to first responders.

This paper describes the development of the HyResponse lectures and VR exercises through the use of innovative VR approaches combined with a comprehensive pedagogic toolbox:

- different types of VR exercising;
- face-to-face teaching and distant learning through lectures, group discussions, problem-solving tasks, seminars and independent studies;
- a physical simulator for hands-on classroom training;
- face-to-face teaching and distant learning, testing, validation and assessment tools;
- face-to-face and distant VR tools for virtual hands-on drilling and assessment, either on individual or collaborative levels.

Pedagogic scope and concepts

During the development of the HyResponse educational materials and VR exercises the pedagogic concepts of andragogy, i.e. the adult learning theory, have been taken into consideration [2]. The andragogy focuses on a self-directed learner. It requires less didactic and more hands-on approaches with real-life applications, and is based on previous and acquired experiences.

According to Knowles (1984) there are four principles applicable to an adult-centred learning:

1. Adults need to be involved in the planning and evaluation of their instruction.
2. Experience (including mistakes) provides the basis for learning activities.
3. Adults are most interested in learning subjects that have immediate relevance to their job or personal life.
4. Adult learning is problem-centered rather than content-oriented [2].

Besides, an adult learner brings into the continuing educational arena a rich array of experiences that will affect the learning styles and assimilation of knowledge. All these principles are highly relevant to the education, experience acquisition and dissemination activities of the HyResponse project.

An attainment of the first principle is an organisational matter, and the implementation of the HyResponse training sessions will require an active participation of trainees in the evaluation of all the educational materials produced in order to improve them [1]. It is expected that the HyResponse audience will understand why the programme is important to their learning and life situations. The trainees will be able to apply the knowledge they gain during the training to their own job situations and professional life, thus leading to an accomplishment of the third andragogy principle. The addressing of the above mentioned points no. 2 and 4 are the essence of this paper in particular, and are the cornerstones in the development of high quality hydrogen safety training for first responders in general.

Hydrogen risk is a technological risk; hence it calls for a deeper understanding of the main safety principles and features of FCH systems and infrastructure. Adult learners need to be convinced, and the technological elements are to be explained in detail at the audience cognitive level.

As per Knowles, 1984 [2], training objectives should be '**SMART**':

- **S**pecific: clear and easy to understand
- **M**easurable: able to be quantified
- **A**chievable: able to be attained
- **R**ealistic: true to life
- **T**ask oriented

Within the scope of the HyResponse project these objective consider:

- An evaluation of a first responder agency's current state of emergency readiness to deal with hydrogen specific behaviours during incidents/accidents.
- Knowledge gaps, weaknesses, or areas of concern that might affect the agency's performance.
- A level of first responders' knowledge and understanding of hydrogen emergency preparedness roles and responsibilities.
- An applicability of current readiness to emerging hydrogen safety problems.

With this in mind, the main objectives of the educational segment of the HyResponse programme are as follows:

- to provide first responders with the awareness and understanding of the specificities of hydrogen as an energy carrier during its production, transportation, delivery and uses;
- to familiarise first responders with the operational principles and safety aspects of a range of FCH applications including FC vehicles, refuelling stations, back-up power generation and stationary fuel cell systems for combined production of heat and power;
- to develop a critical evaluation of the safety issues associated with hydrogen physical and combustion properties;
- to achieve a systematic understanding of why the safety of hydrogen differs from that of conventional fuels;
- to provide first responders with a knowledge of potential hazards, relevant safety concepts and safety features for targeted FCH systems and infrastructure;
- to ensure that first responders are aware of typical risk scenarios for FCH systems and infrastructure;

[3] VR – Virtual Reality.
[4] RCS – Regulations, Codes and Standards.

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