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Selection of training methods in systems dedicated to detection of chemical hazards

Magdalena Dobrowolska-Opała[1,*], Grzegorz Gudzbeler[2]

[1] University of Warsaw, Krakowskie Przedmieście 26/28, Warsaw, 00-927, Poland
[2] University of Warsaw, Krakowskie Przedmieście 26/28, Warsaw, 00-927, Poland
*Corresponding author. Email address: mdopala@gmail.com

Abstract

The paper presents the process of training methods' selection in systems dedicated to detection of chemical hazards. By examining most common training methods used in detection systems, authors indicates which of them are the most relevant to hazardous chemical substance detection systems, assuming that basic efforts focus on the system as the whole (mainly on detection components) rather than the training module. Furthermore, the indicated methods are characterized in detail and combined with overall utility and economic analysis related to the dimension of the resources involved in the work on the entire project (by the example of the EU-SENSE project). In order to study the training methods and the factors influencing their choice, two research methods were used: (1) in-depth analysis of the literature on the subject of training tools in the field of crisis management and IT solutions, and (2) the case study of the EU-SENSE project (its training module).

Keywords: teaching/training methods; chemical hazards, case study, simulation, orientation, lecture

1. Introduction

Nowadays, every system, regardless of its purpose or technology, requires an introductory module that will guide end users through the specification of an entire system. Formerly a common formula was to attach technical descriptions and short user instructions. Over time, this formula had been expanding, evolving towards short training sessions explaining the basic goals and specifics of a system. Finally, training modules have become one of the elements not so much obligatory as expected (well-seen by contracting authorities), especially in areas related to ensuring safety and security, detecting threats or supporting security forces of various types and scales of operations. Systems currently perceive as a professionally prepared and useful to end users include training modules that allow their receivers to do a range of activities. The most popular are simulations of the actual operation of a system, simple or more extensive tutorials (in the form of audio, video, text documents) as well as graphic and text materials enabling a module to be used during training sessions.

Referring to the generally presented trend, the subject of this article is an indication of teaching/training methods recommended to be implemented in systems responsible for detecting chemically hazardous substances. The choice of systems associated only with chemical detection is due to three factors. The first of these is the necessity to limited the subject of the study to a specific group of security-related systems (rather than systems in general), which results from the short formula of a presentation at a conference/of a single scientific standardized paper. The second factor stems from the

need to analyze such systems that training module is not the main component of a system, but only one of many. For this reason, systems dedicated to training in making decisions, considering specific operational situations of forces and other security-related formations are not subject of this scientific reflection. As well as simulation systems develop for police or military forces. Systems dedicated to chemical detection focus on the modules responsible for detecting chemical substances and determining their composition, specifics, etc. On the one hand, developers treat a training module as a secondary aspect, not requiring the involvement of many employees and great financial resources. On the other hand training modules in this type of systems are highly useful for end users. Situations when it is necessary to use full operational version of a system during a real event are not very frequent. If such an event occurs, end users cannot afford themselves to make mistakes, especially those relating to the improper or insufficient use of a system. Thus, a training module gives end users a chance to learn how to use a system, implement it in internal procedures and use its full potential. Without such a module, relying on a technical description and an user manual, they may not adequately exploit possibilities of a system. The third factor influencing the choice of chemical detection systems is the availability of research material on the one hand and on the other with a gap in the literature connected with the selection of training methods for this type of systems. The vast part of the material for analysis comes from the currently developing chemical detection system, where the authors have the opportunity to work on the concept and implementation of the training module into the system architecture. A number of studies carried out during the project phases have served as an important research part for this article.

2. Materials and Methods

The article examines the process of training methods' selection in systems dedicated to detection of chemical hazards. By examining most common training methods used in detection systems, the following question will be answered: which training method is the most relevant to hazardous chemical substance detection systems, assuming that basic efforts focus on a system as the whole (mainly on detection components) rather than a training module. The specific questions refer to:

1) which teaching/training methods should be select to achieve basic goals of a training without losing too much time and effort, mainly dedicated to building detection components of a system, and

2) which factors should be taken into account during the process of choosing a training method (in a system design phase).

In order to answer the questions, there were used two major research strategies: (1) in-depth analysis of the literature on the subject of training tools in the field of crisis management and IT solutions, and (2) the case study of the EU-SENSE project (more precisely – its training module). Data have been collected from source literature, published reports and data obtained from the EU-SENSE project (those classified as a public).

3. Results and Discussion

In source literature, in various types of training materials and academic studies, there are widely described catalogues of teaching/training methods. Some of them have their sources in methods used by the ancients, while some are the result of constant change and adaptation to the requirements of modern digital reality. The key is therefore to find methods that, regardless of their background (introduction time or intensity of development), can be adapted to detection systems, especially chemical ones. As the result of analysis of a number of teaching/training methods and the use of several assessment factors (such as: scientific and teaching grounds, the possibility of developing and expanding a method, flexibility - especially in the context of IT requirements), four methods have been selected, i.e. the orientation, the classical lecture, the case study and the simulation. The indicated methods after appropriate transformations can be incorporated into systems dedicated for chemical detection. That has been proven through their detailed characteristics combined with overall development and economic analysis related to the dimension of the resources involved in the work on the entire project (by the example of the EU-SENSE project).

Among the four methods mentioned above, the orientation is the first to be analyzed. This method is one of the most popular, mainly because of its association with the basic introduction to a workplace or to an operating system, procedures, etc. Its basic advantages are: transparency, simplicity in the development and in making it available to an employee/end user. This formula does not require extensive personal involvement during the development as well as during a training. However, the orientation does not bring any added value, it is closer to a simple introduction to a topic/a workplace than effective training that allows to get to know and understand characteristics of a system and its utility. The challenge in introducing the indicated training method is adapting it to the specifics of a given workplace/ system. An orientation that will be boring, incomprehensible, overloaded with content or not adapted to an end user needs (in case of a system) may lead to discouragement and, over time, to resignation from using of a system. To avoid such an undesirable effect, a training in the form of the orientation should be strictly profiled to needs of an end user. According to generally available recommendations, it is advisable to find answers to key questions such as:

- what things do an end user need to know

about a system environment that would make he/she more comfortable and confident?

- what key functionalities and procedures must an end users be aware on the first use of a system to avoid mistakes during next uses?
- what special abilities, experience or knowledge should be gained by an end user at the very beginning?
- what positive experience can be provided for an end user that could be discussed with colleagues at the end of the first use of a system? (Brown, 2020)

To summarize, the orientation is useful training method at the first stage of implementation works, when features of a training module included in a system are precisely defined.

The second method is the classical lecture which presents information in a verbal method or, what it is more and more popular, via online presentation and more complex webinars. The lecture involves the dissemination of training material by a trainer to a group of trainees, at the same time assuming a high degree of passivity of listeners with the extensive involvement of a lecturer (Ostrowski Martin, Kolomitro & Lam, 2013). Moreover, in most cases trainings conducted solely with the use of a classic lecture focus on routine procedures, predictable for the average user. Which additionally deepens the passivity of listeners and significantly affects their activity and creativity in the use of available tools (including IT systems) in the future. In this meaning, the advantages of the lecture are weakened, especially in relation to dealing with extreme situations, such as leak of hazardous chemicals, when reflective analysis and creative response are required (Ford, Schmidt, 2000).

Summing up the lecture's advantages and disadvantages, it is crucial to emphasise that this popular universities teaching method (classical lecture) can be considered archaic in the context of a training module assigned to a modern system based on IT solutions. However, due to its high flexibility, it can be adjusted to attractive and permanent element integrated into materials made available as part of a training module. In the form of a video recording, it can be used for an internal training, repeated many times depending on needs of a buyer/an end user of a detection system.

The third training method – the case study – does not come from strictly businesses practices (like in the case of the orientation), but it is often used by scientists from all disciplines. The scientific case study has become more and more popular also in the training and development field. In academia, students and scientists study individual cases and try to refer them to a scientific frame (theoretical and/or methodological) and finally analyze them, understand and solve a problem connected with it (Easton 2010). Similarly, this approach helps to introduce an employee to his/her workplace or to teach him/her how to use an operating system by giving examples of practical case reports, probable situations that require the use of a given software, etc. Working on simulated or real-life situations from the past helps learners to use a system, tools, procedures etc. in the proper way. By analyzing problems/cases presented during a training, they are encouraged to think independently and analytically. The method is perfectly suited for situations where learners have prerequisite knowledge but could benefit from the applied nature of a training, especially that one which is connected with safety and security issues (Ostrowski Martin, Kolomitro & Lam, 2013). Additionally, during solving the case study there is also time for open discussion with a group when a trainer has possibility to give supplementary explanations. The great advantage of the case study method is the practical learning experience instead of collecting abstract knowledge that may be difficult to apply to practical situations. (Avery, Crowe, Cresswell, Huby, Robertson & Sheikh, 2011). The disadvantages of the indicated method are due to its high cost consumption. The full use of the case study takes into account a trainer's involvement and interaction with learners that generates high costs. Furthermore, it is increased by the necessity of making technical adaptations to a training module and of including several cases (studies) with their justification. It is also challenging to fully understand the idea behind the case study. The trainer is here not only supposed to present the problem and support the trainees in solving it, but also to point ways to alternative solutions and develop skills in solving efficiently and independently similar problems in the future and using the available tools/procedures (Ostrowski Martin, Kolomitro & Lam, 2013).

The last training method is an extensive category called simulations. Here, there are included games and traditional simulations based on operating IT systems and natural phenomena, that emulate real-life scenarios. Technical achievements allow to attract learners' interest and teach them how to solve problems and make decisions supporting themselves by dedicated systems and procedures in a safe environment without risky and dangerous implications. The simulation of real factors and action backgrounds open learners mind to seek new solutions or ideas connected with practiced topic. A high level of reality is conducive to implement the role playing or the case study method, and thus increases the commitment to training and helps to remember it for a longer time. (Di Loreto, Divitini Mora, 2012). However, the awareness of learners that they are dealing only with the simulation of a system remains a significant challenge. No real consequences for mistakes may result in not fully engagement in a training, thus producing inaccurate results. Moreover, development and then functioning of a simulation module can be very expensive and required constant updates and maintenance (Gray, 2002). Another

challenge is the proper development of simulation exercises - they should address to cognitive skills, which are crucial in response to emergency situations. The purpose and scope of these exercises may include: supporting training methods, practice opportunities in new, dynamically changing situations, evaluation of available procedures, identifying critical decisions, improving coordination and making decisions under time pressure and demanding circumstances as well as testing plans in the light of new threats (Passos, Nazir, Mol, Carvalho).

4. Conclusions

Summarizing the training methods described above, it should be emphasized that there were selected in the frame of achieving basic goals of a training without losing too much time and effort, mainly dedicated to building chemical detection components of a system. All methods offer possibilities of conducting trainings using only one of them or getting benefits from implementing them all and creating more advanced and complex training. The orientation, the classical lecture, the case study and the simulation are strongly grounded theoretically and methodologically, and are constantly practiced among different recipients groups such as: students, scientists, professional trainers and business coaches. Furthermore, over the recent years, mentioned methods are being enriched with further tools and implementation programs. They are improved and disseminated in both local and international projects. Their educational dimension is also evaluated and tested in various environments and systems - scientific literature is extensive here. Similarly, guides and manuals for trainers who are the key factor in every kind of training.

In the case of the EU-SENSE (European Sensor System for CBRN Applications) – the EU research and innovation project which is dedicated to the development of a novel network of chemical sensors (https://eu-sense.eu/) – there was made the decision to use almost all the methods indicated above: the orientation, the case study and the simulation. The classical lecture was omitted because of its academic character as well as time-consuming process of the trainer preparation. In this context, more crucial importance was attributed to the orientation – the method which will be mainly used to prepare the end user handbook/manual. The case study was included in the scenario introductions and correlated to pre-defined version of them which then will be performed in the simulation. The learners (mainly end users such as fire fighters and police officers) will be able to see the simulation of chemical agents dispersion and to cope with crisis situations presented by using the case study methodology. The simulation of real factors will promote here seeking new solutions connected with using the EU-SENSE system and as the result, increasing the recipients' commitment to the training and also helping them to remember it for a longer time (Dobrowolska-Opała, Gudzbeler, Misiuk, 2019).

In conclusion, basic goals of a training in chemical detection systems without losing too much time and effort (mainly dedicated to building detection components of a system) can be achieved through applying flexible (especially in the context of IT requirements) methods such as: the orientation, the classical lecture, the case study and the simulation. Furthermore, they can be combined with each other and create one well-build training/teaching course or even more complex training session. Moreover, referring to the practical (the EU-SENSE project) and theoretical approaches and researches (carried out among adults learners and university students – shortly described in the frame of the article), the following main factors should be taken into account during the process of choosing a training method (in a system design phase): awareness of training needs, identification of purposes, relevant content, active demonstration, opportunities for practice, regular feedback during training and post-training environment (Bullock, 2013). With regard to the selection of training methods, the indicated factors were also considered during designing a training module for the EU-SENSE system. In simple terms, their verification was as follows:

- awareness of training needs → mainly carried out by meetings with end users, experts and familiarization with the possibilities of the IT system and its architecture.
- identification of purposes → setting training goals based on expert meetings, interviews with end users and scientific studies on the objectives and tasks of training modules in the field of crisis management.
- relevant content → content adapted to the needs of end users recruited from the area of crisis response, i.e. in particular police officers and firefighters. In the analyzed project, the training content was prepared in the frame of following methods: the orientation, the case study and the simulation. This factor was of greatest importance in relation to the introductory method, in this case to the orientation.
- active demonstration → it is provided by the simulation of the functioning of the EU-SENSE system in operational mode. Moreover, the training module has built-in scenarios that based on the case study methodology.
- opportunities for practice → the system user can modify the settings of the sensors and read their data that change depending on the weather, type of chemical substance, type of sensor. In addition to the simulation, a case analysis based on the scenarios built into the module is provided. Thus, it becomes possible to place an event in the frame of procedures, other variables or even the human factor

modifying the operational situation (in the extended version of the training session).

- regular feedback during training and post-training environment → is given by a trainer, who knows the analyzed case (scenario) and explains on an ongoing basis both the situational factors (known from the introduction to the scenario and according to its plan) and the consequences of the actions taken by learners. Additional support related to the post-training environment will be provided in the end user handbook/manual, where the data will be updated depending on the software version and by maintaining online technical support.

Summarizing the above, the training methods used in the frame of EU-SENSE training module development fully implement factors proposed by Bullock. Furthermore, they are relatively cheap to develop, and their implementation into a system does not require extensive involvement of programmers or major changes in a system architecture.

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