Developing a Crisis Management Exercise Training in Industrial Environment: From Needs Analysis to Exercise Facilitation

Pierrick Duhamel[a]*, Sylvain Brohez[a], Christian Delvosalle[a], Agnès Van Daele[b], Sylvie Vandestrate[b],

[a]University of Mons, Faculty of Engineering, Rue de l'Epargne, 36, 7000 Mons, Belgium.
[b]University of Mons, Faculty of Psychology and Education Sciences, Place du Parc, 18, 7000 Mons, Belgium.
pierrick.duhamel@umons.ac.be

Crisis and emergency management in hazardous industries rely on a particular organization which modifies the companies' normal operating mode. This kind of organization requires, from both operatives and decision-makers, specific knowledge that cannot be acquired through theoretical course or real-life practice only. Simulation exercises can be a training solution to allow the practice of crisis management. Besides, developing and implementing such exercises, adapted for agents and their needs, is time and resource consuming, especially when the system where they operate is complex. There is a need to simplify the development and exploitation of these simulations to make them more affordable. A solution is to develop them according to both rigorous and flexible methodology allowing cost-effectiveness.

Between the ends of 2015 and 2017, the Expert'Crise project, an European funded training project on emergency and crisis management in industrial environment, organized seven crisis exercises mainly in hazardous chemical companies, classified as "SEVESO". This recurrent exercise development process leads us to build a design methodology based on our own experience with industrial and existing methodology. During exercises proposed to industrial partners, trainees play their own role in their usual working place. Only some emergency functions are simulated and, for instance, physical intervention with firefighter's tool are rarely set up. Therefore, these exercises can be defined as functional crisis management learning role-playing game. Because some part of the emergency organization are not simulated, arrangements must be made to isolate trainees from real environment and establish exercise framework in which participant can interact with each other and with the facilitation interface.

This paper deals with the design methodology used to set up emergency and crisis exercises in industrial environment and its experience feedback.

1. Introduction

Despite the progress of major accident prevention since the 1970's and accident such as those of Flixborough or Seveso, there are still industrial disasters. Proof, if needed, that prevention alone is not enough and safety of worker and neighbouring population needs emergency management when a disaster occurs. Yet emergency and crisis management requires, from both operatives and decision-makers, specific competences that cannot be acquired through theoretical course or real-life practice only (Lagadec, 2001). They need therefore be trained through practical exercises adapted to their environment, working habits, education, and professional needs (Wybo, 2008). Moreover, European regulation 2012/18/EU requires hazardous companies to test their emergency planning every three years, for instance with exercises.

Nevertheless, developing such exercises is a complex and time-consuming task that requires dedicated skills (Limousin, 2017). This kind of training already exists, outsourced by industrial companies to consulting firms, which have no real interest in publishing on the topic. Therefore, because organizing exercises in industrial plant is complicated, expensive, and comes with uncertain outcomes, companies often exceed regulatory deadlines (European Commission's Joint Research Centre and the Dutch Ministry of Social Affairs and

Employment, 2008). To respect these deadlines and ensure a control over the emergency management, SHE managers need a methodology to easily set up internal exercises matching with their goals.

Launched in 2015 and funded by the European Social Fund, the Expert'Crise project develops emergency and crisis management trainings for hazardous industries and critical infrastructures. These trainings are based on a pedagogy combining theoretical courses and immersive practical exercises. During such exercises, trainees play their own role in their usual working place. Hence, arrangements must be made (Duhamel et al., 2017) to isolate trainees from real environment and establish exercise scenario and diegesis (Morten, 2003). Through learning from trainings, and the literature from different fields such as pedagogy, dramaturgy, game design, and crisis management, a design methodology for crisis management Learning Role-Playing Game (Mariais, Michau and Pernin, 2012) scenario was developed.

2. Context of the development of the design methodology

Eight Walloon SEVESO companies have participated to one of the six exercises organized between 2015 and 2017. Eight other exercises are currently under preparation for 2018. Companies, their environment and the type of exercises (Tena-Cholet et al., 2016) vary from an exercise to another and cover a wide scope of situations.

Exercises are held on industrial sites and use rooms, tools and communication devices available to operatives and decision-makers both in their work-life and during emergency. This configuration allows immersive situation for trainees without destabilizing them (Cook, 2015). In addition, it provides an emergency system test for companies in accordance to European regulations. Exercises are mainly functional, focused on decision-maker functions (Lagadec, 1995). The operational part is often simulated through the control of information flow entering the crisis room. Therefore, these trainings target members of the crisis management and key persons in the warning chain.

Exercises rely on material arrangement and human organization. Human organization refers to facilitators regulating the exercise (Fréalle N. and Tena-Chollet F., 2017) near trainees (or at distance) and observers consigning what happened during the event. Experimental device is composed of cameras, microphones, projectors and speaker that allow immersing trainees in the diegesis and, on the other hand, capturing multimedia flows which are lived-streamed to distant facilitators to help them adjusting the scenario and saved to complete observers' notes for later analysis. This human and material organization is sized during the preparation of the exercise based on the analysis of the emergency system and needs of the company.

The framework of the training offered remained the same throughout the project: one to six theoretical course modules, briefing of some or all the trainees, simulation, "hot" debriefing right after the simulation, analyse of the simulation and "cold" debriefing. Nevertheless, inside this framework, each step have evolved thanks to the learning from training taking into account previous mistakes, bias, limits and suggestions of improvement into account.

This internal continuous improvement is based on a first debriefing some days after the exercise where facilitators and observers share, on an informal basis, the good and bad points of the exercise and suggest how exercises could be improved for the next time. This debriefing usually follows the pooling of notes and commentaries needed for the study of the exercise. Then, during the analysis and the writing of the report, difficulties experimented by the company are identified and a special attention is given for those induced by exercises bias. In this way, the company is not blamed for simulation limits and failures.

Independently of continuous improvement, time and project constraints reduce exercises preparation time. Indeed, six exercises were organized between 2016 and 2017 but three of them were organized in the last three-month period of 2017 and at least eight exercises are expected in 2018. This exercise rhythm is possible thanks to the rationalization of exercise production with a flexible methodology that allowed to propose an adapted exercise to each industrial.

3. Methodology: : from needs analysis to exercise facilitation

As (serious) games, Learning Role-Playing Games need rules, medium, context and players (Klabbers, 2003). Rules and medium are defined by the category of game but context and players vary depending on the company. Therefore, before considering developing a scenario for the exercise, these two elements must be properly defined with the company and will allow to build the proper diegesis – i.e. what is true in the context of the simulation – for the exercise.

The methodology is split in two parts. The first one analyzes needs (and wishes), and emergency system of the company to propose a pedagogical and organizational framework for the exercise. The second part designs exercise content inside the previously defined framework.

These two parts are not isolated from each other, and the development may step from one to the other depending on the progress of the pedagogical engineering and the reactivity of industrial contact person. In addition, the methodology is iterative, so each step is looped several times, especially the first one. This way, it ensures a good understanding of the expectation of industrials and their needs. It leads to a seven steps methodology close to existing methodology (Alberta Emergency Management Agency, 2012) mostly dedicated to public organization.
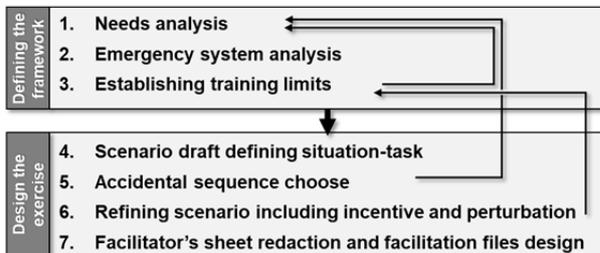

Figure 1: Structure of the emergency exercise design methodology

3.1 The framework: from needs statement to exercise proposal

After the prospection phase, the presentation of the project and the agreement of the company to participate to the training, a meeting is scheduled to deal with needs and expectations of the firm.

This **first** meeting may vary significantly depending of some parameters: contact persons, their implication, motivation, and decision-making power (or the support of their hierarchy), the corporate culture of safety and its management at operational level, the size of the company and resources they want to commit. This meeting aims to have a first scope of the training company expects including target audience identification, resources that can be used and operational (e.g. evacuation or intervention exercise, warning chain test…) and/or global (e.g. improving reactivity, internal or external communication…) objectives. These objectives formulated by the company must be interpreted to fit emergency and crisis exercises pedagogical targets identified in literature (Lapierre, 2016). As every design process (Haik and Shahin, 2010), the needs statement step have to be carefully process because of the contact person may have training preconception which may lead directly to practical solutions not meeting company needs. Therefore, meeting have to focus on needs of the company, target audience and competences they should acquire without considering yet the scenario, and a fortiori, the accidental sequence. After this first meeting, theoretical courses can be scheduled with information needed to adapt them. During this first meeting, transfer modalities (e.g. non-disclosure agreement) of emergency document as reflex sheet, emergency plan and map are discussed. In addition, when it is possible, the safety report (European Parliament and Council, 2012), and general operating rules are requested to have a wide vision of how the company operate.

Emergency plan and organization documents analysis is the **second** step of the methodology. The purpose of this analysis – besides reviewing – is to process these documents into a mental picture of the emergency system functioning. It appears that emergency plans from European Seveso companies are similar (Duhamel et al., 2017) with separated operational on site management and strategic management in a crisis room. This last one is always handle by several persons in a dedicated room, often a meeting room. Strategic management plan describes from two to six functions, often carried out by several crisis managers. The only function founded in all plan is Site manager or On-Call executive (or other similar name). However, communication responsible and maintenance (or Area) manager are also common, respectively corresponding to communication and support functions such as described in literatures (Lagadec, 1995). The main difficulty during emergency system analysis is matching function names with actual functions. On the other hand, the operational emergency management is composed of an intervention team with a leader who coordinates his team and communicates with strategic management. This common structure is convenient and allows building mental picture from an existing framework. Nevertheless, because prescriptive plans are rarely exhaustive, a second meeting with the contact person is needed to clarify or verify some points. This meeting may be held with other persons of the companies to have a better description of their role and seize the difference between the prescriptive plan and what they would do during an emergency according to their experience, their working procedures and habits. Therefore, it is possible to have a representative picture of how the emergency system could be expected to work during an emergency. Then, needs of the companies are reassessed to ensure a good mutual understanding. Indeed, since the emergency system was analyzed, company needs are more understandable and pedagogical objectives matching with them can be proposed.

Once the company's needs and its emergency system are understood, the **third** step is about establishing borders of the sub-system tested during the exercise and figuring out how this sub-system will evolve during the simulation and especially how it will interact with the defined borders.

This step leads to defined, considering the target audience, a second category of audience: the peripheral audience. Those persons are not directly aimed by the training but they play an important role in emergency plan and are direct interlocutors to target audience and have to participate, if possible, to the simulation. Nevertheless, because they are not directly targeted, facilitators mentor them by telling them how to interact with the target audience. Therefore, they can be seen as an input/output interface for facilitation. In the same way, indirect interlocutors such as Medias, political stakeholders, administrative authorities and emergency services are identified according to company's needs and facilitators simulate them during the exercise through phone, mail or other means (Fréalle N. and Tena-Chollet F., 2017). To this end, a sheet showing exercise's phone numbers and corresponding stakeholders is displayed in rooms where target audience is expected to be. Presentation and explanations related to this sheet as well as other immersive device and interfaces should be explained to trainees before the simulation or, if it is not possible, during the exercise by facilitators.

Figure2a: System borders, audiences and other organizations simulation

Figure 2b: Audience, simulation device and information flow

Once all trainees are identified, areas where they are supposed to be during the simulation must be considered. The crisis room, the disaster area, the guard post and the control room, if any, are usually the main relevant areas for exercises. Nevertheless, according to the operation of the company and its wishes, area may be added or removed. In this last situation, a specific interface has to be set up according to the target of the exercises. It can be a reduced model simulating on-the-ground operations, leaded interviews with intervention leader or sub-crisis unit managed by a facilitator. These simulations aim to give to the target audience an immersive experience including the correct information flow and interactions with stakeholder.

The last border, which should be defined, is the duration of the exercise. They usually last between one and three hours for logistic reasons but longer exercise could be planned.

Therefore, once interfaces between trainees, environment and facilitators are defined, context and players are set and the LRPG is operable. Then, an exercise draft can be submitted and the scenario development initiated.

3.2 The scenario: how to develop a simulation meeting company needs?

Once the framework is defined, scenario can be developed, it is the **fourth** step. A scenario explains the diegesis of the exercise and develops the sequence of input to the target audience, which should lead it to pedagogical targets (Limousin et al., 2016). A scenario have no need to be too developed because the more details it will have, the more rigid it will be and the less freedom trainees will have. Based on objectives expressed by the company, knowledge and competences (Winterton, Delamare-Le Diest and Stringfellow, 2006) are selected from an existing list (Lapierre, 2016). At this point, situations staging competences are considered. The relevance and the ease to stage of each situations are then evaluated to choose the more adapted situation for the exercise. This first association between knowledge and situation are proto-"situation-task" (Tena-Chollet, 2012). A situation-task is the central part of these exercises and aims to "force" trainees to do an action (the task) under special circumstances (the situation) through serious game interface and using its specific gameplay. The task is a mean to involve trainees in a reasoning process harnessing knowledge targeted (Pastré, Mayen and Vergnaud, 2006). Once all knowledge, skills, and competences that will be aimed by the exercise are identified, they are grouped into pedagogic bloc associated with a situation eventually including information input. These pedagogical blocs are integrated in a framework of the evolution

of a crisis in industrial environment inspirited by the hero's journey (Campbell, 1949) in the same way as in game design or scriptwriting methodologies (Schell, 2008). Based on the length of the exercise, arrangement of each pedagogical blocs in this framework gives a first view of how the exercise will process. Moreover, this arrangement will influence the dynamic and the stress of the exercise in addition to encourage the resolution of some problematics before other ones (Limousin et al., 2016). Further developments of "situation-task" are not possible before defining the "plot" of exercise, i.e. the accidental sequence.

The **fifth** step consists to select, with the contact person, the most adapted accidental sequence for the exercise. The accidental sequence means the causes of the accident, the accident, dangerous phenomenon associated including domino effects, and people, environment, equipment or structure affected (B. Debray & O. Salvi, 2005). Accidental sequence should lead to "situation-tasks" and should be justifications for inputs leading trainees to do the wanted task. As said in the first step, the contact person may be specific with the nature of accidental sequence wanted.

At the **sixth** step, based on the hero's journey chronology, exercise is divided in 15 minutes sequences assigned to one "situation-task" where input leading to the task are added. Nevertheless, the choice of relevant and efficient inputs is not easy. Indeed, they must lead to the task to do but in a realistic and non-obvious way to keep trainees focus and in a "flow" state (Schmidt, 2010). It is the reason why proto-situation task should integrate staging ideas in the very first step of scriptwriting. The situation is usually implied by dangerous phenomenon or its consequences such as a wounded person or damaged equipment, and the trainee's reasoning process can be help by incentive (e.g. municipal authority asking a press statement) but can also be slowed down by perturbations (Tena-Cholet, 2012) keeping the simulation challenging for trainees.

Once inputs are chosen, the way they will be injected into the system have to be defined. It could be through a call, a direct interaction with someone from the peripheral audience or the use of an immersing device such as a sound speaker playing firemen's siren. Direct interactions between target audience and facilitation must be carefully managed because facilitator may influence target audience and decrease relevancy of observation. Nevertheless, in some situations, it is not possible to fully separate facilitation and target audience. In that case, interactions must be limited – with only some fact presentation for instance – and taken into account into further analysis. In the end of this step, a precise timing with a 5 minutes meshing is established and inputs, recall, expected trainees' reaction and facilitators recommended reaction are specified in a table. There is no need to over saturate trainees with inputs if it is not the purpose wanted. Indeed, communication between participants dispatched inside the organization – especially from and to the peripheral audience – will be important independently of inputs. Therefore, little input can have a lot of implication and reaction from participants. This precise table is used to write the global script, which can be exposed to company's contact person for validation.

Once the global script written, comes the **seventh** and last step of the design methodology. Each input is integrated into the corresponding facilitator's sheet with details related to the medium and the context of injection. These sheets can be split in two groups: those dedicated to mentoring peripheral public and give it a consistent – but eventually partial – view of what happen and how they are supposed to react, and those dedicated to distant facilitation, simulating different stakeholders and controlling immersing devices. Facilitation sheets can also include a question/answer part to help facilitator to answer to possible questions from trainees. Nevertheless, these sheets cannot anticipate all questions and reactions of trainees and facilitators should adapt the scenario to trainees' reactions. A meeting with facilitators is usually scheduled to explain facilitation sheet and answers facilitator's questions. It is the last step before the exercise.

4. Conclusions

This methodology stays in a continuous improvement process where each step is improved during the development of new exercises. It is currently the case with the eight new training sessions that will be developed in 2018. Nevertheless, because each step is independently improved, the structure of exercise design will remain. Specific publications on design step has to come to specify how the methodology operationally works, especially on the fifth and sixth steps (Duhamel and al, 2018).

The purpose of this methodology is to design efficiently emergency and crisis exercise for chemical industries that have to organize periodically such exercises. Nevertheless, it still needs a high level of competences to choose and arrange situations-tasks and therefore SHE manager cannot used it to develop their own exercise. Simplification and user-friendly development are needed to make this methodology directly operable by final users such as SHE manager in order to allow them to set up exercise more regularly, ensuring a better control over emergency system.

444

References

Alberta Emergency Management Agency. 2012. Exercise design 100. Available on http://www.aema.alberta.ca/documents/exercisedesign100sel63227.pdf

Campbel J. 1949. The Hero with a Thousand Faces. Novato (CA), USA: New World Library.

Cook, D. 2015. Flight Operations. Available on https://www.tc.gc.ca/eng/civilaviation/publications/tp185-4-07-operations-4034.htm#instructor

Debray, B. and Salvi, O. 2005. ARAMIS Project: an integrated risk assessment methodology that answers the needs of various stakeholders. WIT Transactions on The Built Environment, 82, 265-275.

Duhamel, P., Brohez, S., Delvosalle, C., Dubois, L.-A., Van Daele, A., and Vandestrate, S. 2017. Le projet Expert'Crise ou la formation à la gestion de crise en milieu industriel par des exercices de mise en situation : premiers résultats. Récents Progrès en Génie des Procédés, 110.

Duhamel, P., Brohez, S., Delvosalle, C., Van Daele, A. and Vandestrate, S. 2018. Learning Role-Playing Game scenario design for crisis manage-ment training: From pedagogical targets to action incentives. Communication presented at the 20th Congress of the International Ergonomics Association, Florence, Italy.

European Parliament and Council. 2012. Directive 2012/18/EU of the European Parliament and of the Council of 4 July 2012 on the control of major-accident hazards involving dangerous substances, amending and subsequently repealing Council Directive 96/82/EC.

European Commission's Joint Research Centre and the Dutch Ministry of Social Affairs and Employment. 2008. Enforcement of Seveso II: An Analysis of Compliance Drivers and Barriers in Five Industrial Sectors: Key Points and Conclusions.

Fréalle, N. and Tena-Chollet, F. 2017. The key role of animation in the execution of crisis management exercise. Proceedings of the 14th ISCRAM Conference, 944 - 956.

Haik, Y. and Shahin, T. 2010. Engineering Design Process (2nd ed.). USA, Stamford : Cengage Learning.

Klabbers, J.H.G. 2003. The gaming landscape: A taxonomy for classifying games and simulations. Proceedings of the 2003 DiGRA International Conference: Level Up, 2, 54-68.

Morten, G. 2003. Interaction: The Key Element of Larp. Chapter In G. Morten, L. Thorup and M. Sander (eds.), When Larp Grows Up. Projektgruppen KP03, Frederiksberg, Denmark, 66-71.

Mariais, C., Michau, F. and Pernin, JP. 2012. A Description Grid to Support the Design of Learning Role-Play Games. Sage Publications, 43 (1), 23-33.

Lagadec, P. 1995, Cellules de crise - Les conditions d'une conduite efficace. Paris, France : les Editions d'Organisation.

Lagadec, P. 2001. Les exercices de crise: pour des ruptures créatrices. La Lettre des Cindyniques, 34, 5-9.

Lapierre, D. 2016. Methode EVADE : Une approche intégré pour l'Evaluation et l'Aide au DEbriefing. PhD thesis, Université de Nîmes, Nîmes, France.

Limousin, P., Chapurlat, V., Tixier, J., and Sauvagnargues, S. 2016. A new method and tools to scenario design for crisis management exercise. Chemical Engineering Transaction, 53, 319-324

Limousin, P. 2017. Contribution à la scénarisation pédagogique d'exercices de crise. PhD thesis, Ecole Nationale Supérieure des Mines de Saint-Etienne, Saint-Etienne, France.

Pastré P., Mayen P. and Vergnaud G. 2006. La didactique professionnelle. Revue française de pédagogie, 154, 145-198.

Schell, J. 2008. The art of game design. Burlington (MA), USA: Elsevier

Schmidt, J.A. 2010. Flow in Education. In Peterson, P., Baker E., and McGaw, B. (Eds.), International Encyclopedia of Education, 3ième ed., Elsevier Ltd, 605-611.

Tena-Chollet, F. 2012. Elaboration d'un environnement semi-virtuel de formation à la gestion stratégique de crise basé sur la simulation multi-agents. (PhD thesis, Ecole Nationale Supérieure des Mines de Saint-Etienne, France). Available on https://tel.archives-ouvertes.fr/tel-00741941v2.

Tena-Chollet, F., Tixier, J., Dandrieux, A. and Slangen, P. 2016. Training decision-makers: Existing strategies for natural and technological crisis management and specifications of an improved simulation-based tool. Safety Science, 97, 144-153.

Winterton, J., Delamare-Le Diest, F. and Stringfellow, E. 2005. Typology of knowledge, skills and competences. Luxembourg: Cedefop.

Wybo, JL. 2008. The role of simulation exercises in the assessment of robustness and resilience of private or public organizations. Chapter In Pasman, HJ, Kirillov, IA (Eds.) Resilience of cities to terrorist and other threats – learning from 9/11 and further research issues. Vol 6, Springer, Dordrecht, Netherland, 491-507.