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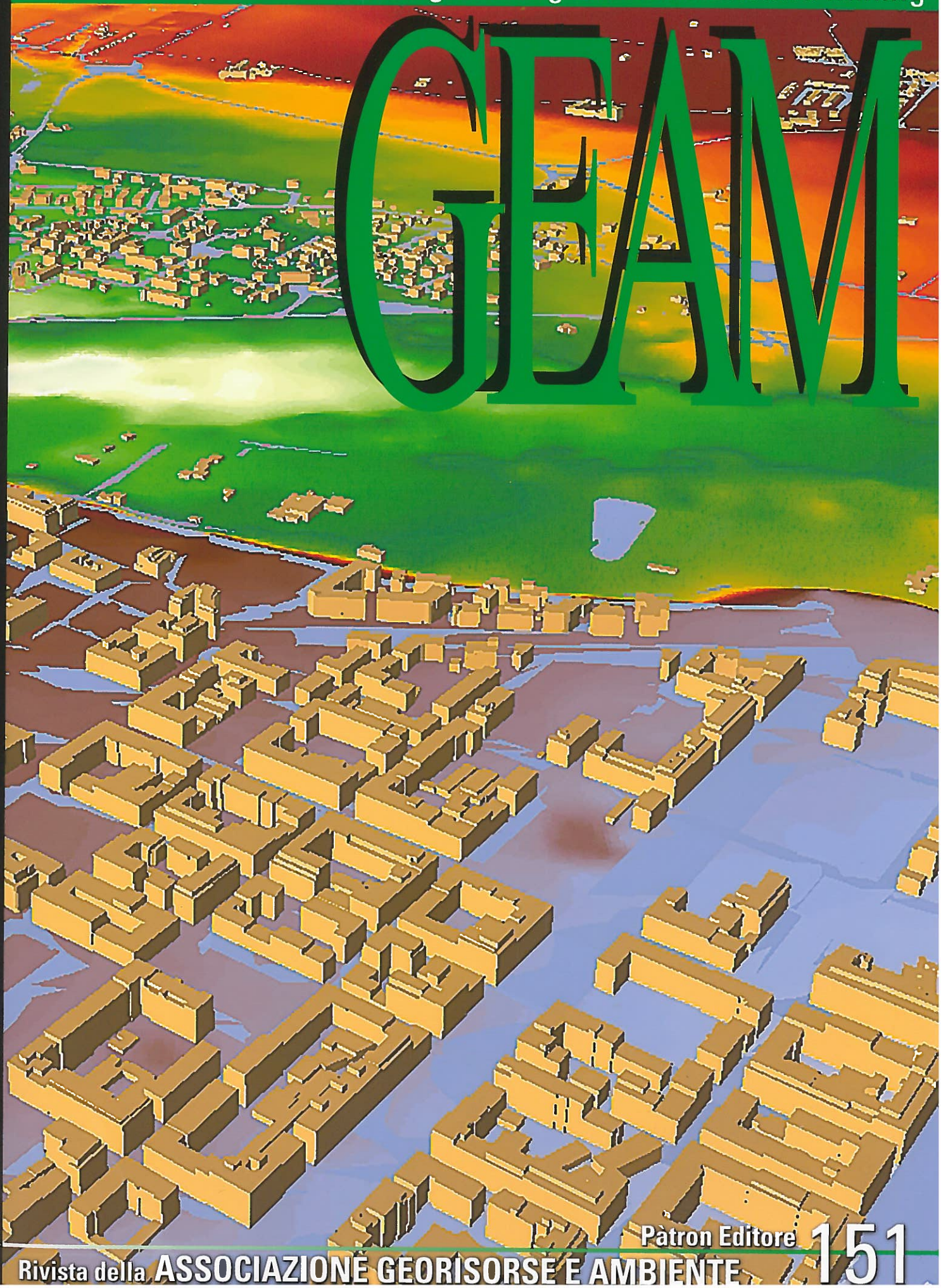

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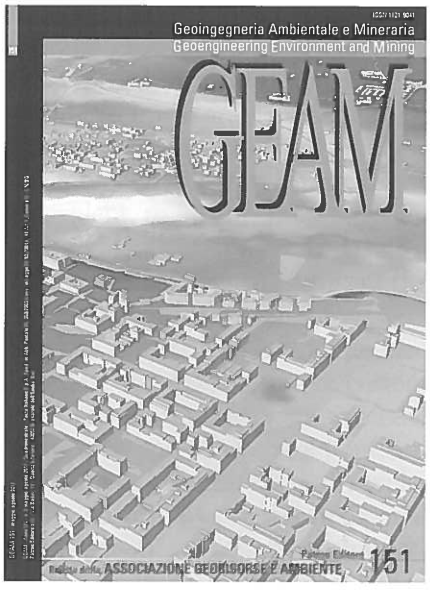

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Un esempio di modello 3D creato con software FOSS.

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The dissemination of the Culture of Safety as an essential tool for the improvement of working conditions and production efficiency: discussion on the multidisciplinary approach and main sub-topics

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This paper deals with the dissemination of the Culture of Safety, a pivotal chain link towards the improvement of the Occupational Safety and Health – OS&H conditions.
The Authors discuss the conditions affecting the work-related accidents and health impairments occurrence, together with the relationship between such criticalities and the dissemination of the Culture of Safety. The Culture of Safety still shows serious shortcomings at all levels, and in particular in situations – typically temporary or mobile construction sites and underground activities – characterized by high accident rates all over the world.
The Culture of Safety, i.e. "the enduring value and prioritization of worker and public safety by each member of each group and in every level of an organization", gained in the last decades a wide attention in the international literature as a system of organized and systematic knowledge production, i.e. a specific science, for both its importance as a basic asset for prevention, and its typical multidisciplinary characteristics.
A challenging and thorough analysis resulted in the proposal of an organic classification of the various aspects of the Culture of Safety into homogeneous sub-categories, precious as a key reading and reference for framing and analyzing in an unbiased approach the OS&H system faults in real cases.
Keywords: *Culture of Safety, System Organization, Safety in Quality Management, Promotion of best practices, Communication and Safety Management strategies.*

La disseminazione della cultura della sicurezza quale strumento essenziale per il miglioramento delle condizioni di lavoro e dell'efficienza produttiva: discussione sull'approccio miltidisciplinare ed inquadramento in sottocategorie organiche. *Nella presente nota si discutono gli aspetti di disseminazione della Cultura della Sicurezza, che costituisce certamente una delle maglie della catena su cui si fondano Sicurezza e Salute del Lavoro – OS&H. Vengono richiamati gli aspetti che incidono sullo scenario infortunistico e di malattie lavoro correlate, ed i rapporti tra tali criticità e la disseminazione della Cultura della Sicurezza, ancora oggi particolarmente carente a tutti i livelli proprio in situazioni – quali in particolare la cantieristica e le attività in sotterraneo – caratterizzate in tutto il mondo da indici infortunistici particolarmente elevati.*
Definita come "Il valore permanente e il livello di priorità da assegnare alla sicurezza dei lavoratori e dei terzi da parte di ciascun membro in ciascun gruppo a tutti i livelli di un'organizzazione", la Cultura della Sicurezza trova da tempo uno spazio decisamente ampio nella letteratura internazionale, sia per la sua ovvia importanza come strumento di prevenzione, sia in quanto scienza – intesa come sistema di produzione organizzata e sistematica di conoscenza – tipicamente multidisciplinare.
Gli Autori discutono il risultato di un rigoroso approfondimento di studio che ha reso possibile pervenire ad una classificazione organica dei vari aspetti della Cultura della Sicurezza in sottocategorie strutturate, risultato prezioso come chiave di lettura e di riferimento per l'inquadramento, ed una analisi esente da soggettività, di problematiche di sicurezza riscontrate in casi reali.
Parole chiave: *cultura della sicurezza, organizzazione di sistema, gestione della sicurezza in qualità di sistema, promozione di buone pratiche, strategie di comunicazione e di gestione della sicurezza.*

1. Foreword

According to the widespread approach also enforced by the European regulations (namely 89/391 EEC Framework Directive and daughters), Occupational Safety and Health – OS&H should be based on technical measures, organization and appropriate modus operandi. Furthermore, suggestions are available in the Safety-Quality approach standards (e.g. OHSAS 18000, ISO DIS 45001...).

This system, which constitutes the backbone of modern OS&H, in some scenarios together with further implementation of special supplementary rules (e.g. the request for development of Safety and Health plans complying with the rules in case of temporary and mobile construction sites), led substantial especially cultural gains: we have finally realized that injuries and health impairments are not a fatalistically acceptable toll associated with the work activities, but they can, and should, be avoided. A proof that this is not a goal unattainable in the real world is that in the last decade a number of important and challenging underground works hit the zero death target throughout the entire work duration, in spite of the "traditional" rate of 1 fatality / km.

However, the data available in statistical databases on work-related accidents and health impairments show still high frequency indexes, with a not encouraging trend, particularly in some NACE sectors. This is evident in the case of temporary and mobile construction sites; the scenario is even worst in under-

ground operation: ILOSTAT database highlights this criticality: the 2010 – 2015 fatality index for underground extractive activities shows values similar to the sum of the indices of all the other activity sectors, construction included.

In this scenario, it becomes important to involve people in the OS&H aspects: according to the results of an EU survey in many countries, Italy included, OS&H is considered the task of a limited number of practitioners (Maida and Patrucco, 2017). They operate in a context lacking of a widespread Culture of Safety, and not in tune with the multidisciplinary research results essential to understand in depth the specific work related Safety and Health criticalities of modern industrial and construction activities, and to identify the suitable countermeasures (Patrucco, 2014; De Cillis *et al.* 2017).

This approach results in a bureaucratic instead of substantiated Safety, a mere formality producing a *paper-based safety* pasted at the last minute to already completed projects.

The Culture of Safety should then be considered an essential tool for the effective prevention in ethically and economically sustainable production systems, able to oust the widespread incapability to act according to the OS&H spirit, logical before than regulated, and the passive approach of people involved – typically practitioners in the construction sites field – seldom contributing actively since still firmly convinced that OS&H is a part of a compartmentalized system (safety-production).

Only the full consciousness of the need of a widespread Culture of Safety may in the future contribute to the completion of the positive trend of Figure 1 (Sorlini and Patrucco, 2017), in which the various contributions of technical and social progress have already led to a substantial improvement in the *Safety performance index*, generically intended as an indicator of the safety condition in the productive performance.

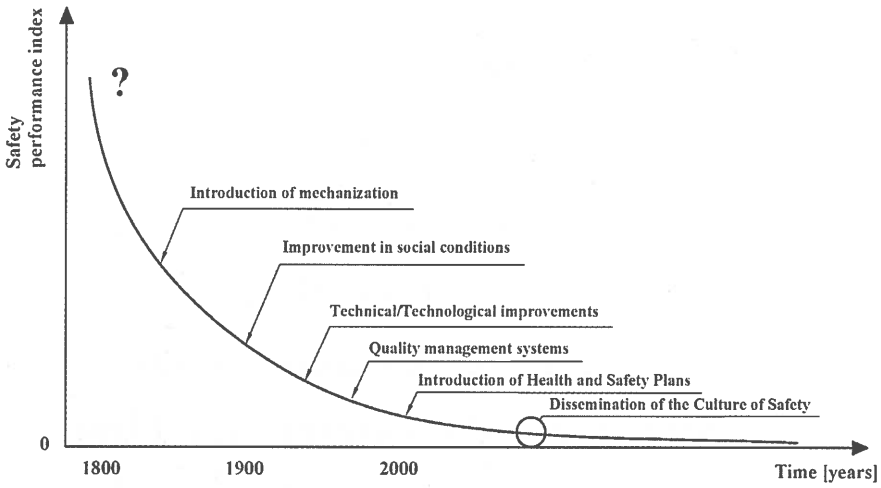

Fig. 1. The decreasing trend of the Safety performance index: currently, the results are very close or, in some recent cases, achieved the goal of ZERO fatalities, and a low number of severe injuries.
Il trend decrescente dell'Indice di performance della sicurezza: ad oggi, i risultati sono prossimi o, in certi casi recenti, raggiungono l'obiettivo di ZERO infortuni mortali, ed un basso numero di incidenti gravi.

2. The Culture of Safety and its dissemination

The Culture of Safety, is *the enduring value and prioritization of worker and public safety by each member of each group and in every level of an organization* (Von Thaden and Gibbons, 2008).

First, it is important not to mix the two distinct concepts of: a) Culture of Safety, and b) Information Formation and Training – IFT. Where the Culture of Safety is missing, the IFT process, mandatory by law, results in a hodgepodge of procedures written in an evident personal approach (Reason, 2000), without any reference to a serious Risk Analysis (the already mentioned *paper-based safety* appears again).

The international literature on the Culture of Safety – as result of a multidisciplinary approach – is very wide indeed; the Authors, operating within *The General Safety Issues and Goals in Turin Universities – TGSIGTU* research project, propose the following numbered list as a summary of a challenging critical effort to classify and organize the different covered sub-topics:

2.1. The value of the Culture of Safety dissemination (in compliance with the Safety and Health Regulations and Standards)

"Before to start the process of Culture of Safety dissemination, it was necessary to define what Safety was. It became of pivotal importance to confine the meaning of Safety and define a common agreement on what we should have focused on" (Hollnagel, 2014). One of the pivotal changes in the Safety conception was the change from *Safety I*, intended as the non-occurrence of an unwanted event, so a "non-event", to *Safety II*, defined as the ability to succeed under expected and unexpected conditions alike, so that the number of wanted outcomes is as high as possible (Eurocontrol, 2013). Finally, considering Safety as a factor of a *well working system*, it could be object of systematic research, in order to increase the information level on the latest trends in this field and, being multidisciplinary, to spread the knowledge to all practitioners involved in the system management.

Safety became a real Science (Dennett, 1995), so it had to fit with the "four sets of institutional impe-

ratives taken to comprise the ethos of modern science: universalism, communism, disinterestedness, and organized skepticism" introduced by the American sociologist Robert K. Merton in 1973.

Nowadays we can state that Safety is a system of organized and systematic knowledge production, considering the *scientific system* as the unity of *actors* (research groups and scientific communities, institutions, etc.) that conduct the *researches*, and, through complex *structures* (journals, papers, books, ...), spread the knowledge at different levels to create a real *educational system* (Aven, 2014).

Following this line of thought, and gaining a clear overview of the situation, it is clear why the dissemination should be wide. It became obsolete to think that accidents occur inevitably in many hazardous technical systems (Perrow, 1999), whereas we started talking about "chain of causes" as in the Heinrich's domino model (Heinrich, 1931) or Swiss cheese model (Reason, 1997) about the line-up of barriers' failures.

In this light, every barrier failure is a cause, but the Identification of Causes is not sufficient to make an effective Prevention: accident analysis is a *backward-looking* process, whereas making recommendations is *forward looking*. Therefore, the study of occurred accidents can be helpful to prevent identical accidents in identical scenarios (Hopkins, 2014).

Additional references on this topic: Aven T., 2014, Hollnagel E., 2014, Edwards J. R. D. *et al.*, 2013, Merton R. K. 1942, Perrow C., 1999.

2.2. Starting point: work related accidents and health impairments

Even if the data are somehow approximated, and diversified among the EU Countries, figures are impressive, the more since the average age of fatal accident victims is 38÷40 years; given a life expectancy of approximately 78÷80 years, the yearly total loss due to work related fatalities can be estimated in more than $1{,}3*10^5$ years!

In Italy, an average value not far from three work-related fatalities/day is still recorded, included the categories of workers not considered by the National Institute for Work Injury Insurance – Inail. Alike, the consequences of the past underestimation of the criticality of overexposure conditions in the workplaces – especially to chemical and carcinogenic pollutants – are today dramatically manifest.

The main causes of this situation are:

- *the technological context, notwithstanding the important progress also in terms of Safety and Health,*
- *the evolutionary socio-economic scenario,*
- *the more and more diversified composition and origin countries of the workforce,*
- *difficulties in the implementation of preventive measures in complex and constantly evolving production situations.*

Starting from the analysis of national and international databases, training designers should analyze occurred work-related accidents in the NACE sector where they are going to intervene, in order to find out the main Risks connected to the activities, and, consequently, design an as effective as possible training (Cirio *et al.*, 2015).

Additional references on this topic: International (ILO, OSHA DOL) and National (INAIL) work-related and health impairments statistical data.

2.3. The need of a specific competence in techniques, technologies and OS&H;

A thorough analysis is of pivotal importance, using suitable tools to better understand the reasons of deviations occurrence, and why practitioners involved noticed – or did not notice – the anomaly, and did not break the chain. By means of special techniques (e.g. Computer-aided Cause Consequence for Prevention – CCCP), they could easily understand the Chain of Intermediate Events up to the Root Causes, and find the breaking point., Borchiellini *et al.*, 2017a).

In some accidents analyzed within prosecutors' mandate, we confirmed that one recurrent cause is the lack of a general Culture of Safety (Cirio *et al.*, 2016) of all people involved at the different levels.

A study developed at Politecnico di Torino, underlines how in many cases the analysis points out remarkable disconnections between:

- *the general Design, and a throughout Risk Assessment,*
- *the Safety Management conceived at the Design phase, and the implementing phase* (Borchiellini, *et al.*, 2016).

Additional references on this topic: Borchiellini. *et al.*, 2017b, Spencer M.L. and Spencer S. M., 1993.

2.4. Culture of Safety at all levels

It is necessary to collect data and information from all the levels of the system: a spread awareness is important because individuals' erroneous assumptions let events go unnoticed or misunderstood, and often rigidities of human belief and perception can lead to disregard the complaints and warning signals from outsiders. This leads to judgment errors, cognitive lapses, deficient supervision and communication difficulties that Safety scientific orthodoxy sees as critical in creating a discrepancy between a safe system and an actual system state (Reason, 1997). It is important to highlight that a failure is the result of a chain of event that someone, somewhere, did not anticipate or did not stop on time (Weick and Sutcliffe, 2007).

So, managers' education needs an empowerment in decision making under conditions of uncertainty and historical understanding (as individual and organizational memory), and in communication capabilities also towards low-level workers. Furthermore, the empowerment of lower-ranking individuals and reminding them of their responsibilities is important: the prevent-harm ethics, i.e. awareness and knowledge on the OS&H themes, becomes the fundamental approach (Feldman, 2004).

Moreover, to improve the OS&H awareness, every *link of the chain* should be considered: to ensure Safety in the whole system, from the first to the last stage of the work, none worker of the site should be neglected in the top-down assessment.

Decision makers in particular need to find common language and concepts to legitimately have a confrontation with low-level workers to reach a better balance between conceptual and operational knowledge.

Additional references on this topic: Dekker S. and Nyce J., 2014, Perrow C., 1984, Westrum R., 2014, Reinhold K. *et al.*, 2014, Shallcross D. C., 2013, Kim Y. *et al.*, 2016, Schulte, P.A., Stephenson, C.M., Okun, A.H., Palassis, J., Biddle, E., 2005.

2.5. *Goals to reach in terms of basic knowledge / competences of workers and other actors*

It is necessary to clarify the basics of workers Safety Culture's gaps, and the necessary educational interventions.

In particular, the combination of technological and economic changes and Europe's demographic challenges (e.g. the immigration and the ageing of the working population), make that necessary in the Member States.

According to the Brussels European Council of March 2006, lifelong learning is essential to achieve the Lisbon objectives in terms of:

- **Knowledge** as the "*understanding of* or *information about* a subject that you get by experience or study, either known by one person or by people generally" or "the state of *knowing about* or *being familiar with* something" (Cambridge dictionary). It can be referred to a field of study or a job in the context of European Qualifications Framework "EQF"; knowledge is described as *theoretical and/or factual.*
- **Skill** is *the ability, practice, aptitude, etc., to do something well* and, in the context of EQF, skills are described as *cognitive* (involving the use of logical, intuitive and creative thinking), and *practical* (involving manual dexterity and the use of methods, materials, tools and instruments).
- **Competence** as a *cluster of related abilities, commitments, knowledge, and skills that enable a person (or an organization) to act effectively in a job or situation.*

In the context of EQF, competence is described in terms of *responsibility and autonomy*.

Applying these concepts to Safety & Health problems at workplaces, would be necessary to identify, analyze the deviations and every gaps in the system, and intervene to obtain safer and healthier workplaces, trying to involve all the co-workers.

According to the previous chapter (Culture of Safety at all levels) each level of responsibility has its own requirements: so, from the Prevention through Design – PtD phase to the execution time, actors involved must have *Competences* in the sense of combination of knowledge and skills that enable them to act in a wide variety of situations.

Additional references on this topic: ILO, 2011, European Directive 89/391 and its D.Lgs 81/08 and s.m.s. ITALIAN Enforcement, European Directive 2006/42/CE, European Parliament Recommendation, 2006.

2.6. *Find target*

Educational system should stem from the important concept of having precise and obtainable objectives of each activity, measurable and defined at the outset (Tyler R.,1949).

It is necessary to bear in mind that the vast majority of students who will attend Safety & Health training sessions are adults who already possess knowledge, skills, and competences to work in their current occupations, or sincerely believe they have. If some behavior is not coherent with correct safety (e.g. foreign workers) the problem becomes challenging. Workers have a wide experiential base: over time, they have accumulated a lot of concepts and a practical approach to learn and operate (Brookfield *et al.*, 1995), so that they directly connect the "Basics" learned examining reality, and often they are not willing to accept uncritically what is being said.

From this perspective, it becomes of pivotal importance to understand what should be the correct approach with this kind of learners. The first who thought that adult education processes should be distinguished from the more common *pedagogy* (Greek: *child-leading*), was the American educator Malcolm Knowles (1913-97), who popularized the term andragogy (Greek: "man-leading") coined by German educator Alexander Kapp in 1833. This term refers to the method and practice of teaching adult learners, the adult education: through it, Knowles explained his collection of ideas about adult learning processes, and he turned it in a real Science to "understand" (theory) and "support" (practice) lifelong education of adults (Knowles, 1973).

It is important to know that, due to the fast evolution of work situations, some purposes can emerge subsequently to the design and schedule, the intervention should then be developed and delivered continuously taking into account that *Safety Competences can occur in any*

period of people's life or at any stage of their career.

As OSHA states "*Quality in Occupational Safety and Health training provides the tools to protect workers' health and lives and to prevent work-related injury or health impairments. Effective training develops workers who are educated and empowered to improve the working conditions in their workplaces*", giving them an active role.

Additional references on this topic: Almklov P.G. *et al.*, 2014, Laberge M. *et al.*, 2014, Knowles M., 1970 – 1980 – 1989, Knowles M. *et al.*, 1984, Becker G., 1964, Mc Clelland D.C., 1973, Mulder M. *et al.*, 2006.

2.7. Subjects / organizations involved

The dissemination of Culture of Safety requires a comprehensive methodological approach to make workers be part of the organizational system, to support processes in place and to deal with changes and potential arising problems. It is important to draw an exact organization chart to identify people involved and their position in the organization, in the decision making process and, above all, their duties and responsibilities in OS&H matters.

Before to start the educational process, it is necessary to make them aware about their role, since adults need to know the reason for learning something and are most interested in learning subjects having immediate relevance to their work and/or personal lives. The need is to implement their skills continuously, at all levels, in the economic interests of both the company and the worker and, last but not least, the social need to respond positively to the risk of exclusion, deprivation and marginalization (Knowles *et al.*, 1984).

Of course, Employer has to comply the Regulations that cover specific topics and their scheduling in terms of both time and discussion of theoretical aspects and practical developments, to be in line with the official requirements.

Employers should identify the global and specific needs of people involved in the organization – the learners – and their background, the structured courses and the Training intervention on specific Safety issues (deriving from a thorough Risk Assessment). The final goal is to have an integrated system, resulting in a positive change of the situation, of the behaviors and of the way to face the OS&H matters, not only a huge quantity of paper that demonstrate that some IFT was organized.

To make people change, and consequently to improve the System, it is necessary to make workers aware and keen to participate in this change (the *Education → Learning → Change* process).

Additional references on this topic: Safe Work Australia, 2011, safeworkaustralia.gov.

2.8. Overview of best practices: Context and learning needs assessment, Specific population

"Information flow" means a transmission of details, but more information is not necessarily better.

Good information should have these characteristics:

- it provides answers to the questions that the receiver needs answered;
- it is timely;
- it is presented in such a way that it can be effectively used by the receiver (Westrum, 2014).

The information flow is deeply linked to the Culture of Safety of the organization (Curry *et al.*, 2011).

As already stated, adults are voluntary learners, they should understand the reason and decide they need to learn something: they learn needed information quickly if they realize that matter and methods are relevant to make their lives easier. Moreover, if they are experienced, it should be good to encourage them to share their experiences and knowledge. Adults learn more when they participate in the learning process and when they know where they are heading: adults need to be involved and actively participate in the class. *Field training* is a good opportunity because they learn better by doing, they need to "try-on" and practice what they are learning.

Additional references on this topic: Patrucco M., 2003, Debernardi M. L. and Patrucco M., 2004, Labagnara D. *et al.*, 2016, García-Herrero S.*et al.*, 2013, Arezes P. M. and Swuste P., 2012, Hale A. and Borys D., 2013, Eeckelaert L., Starren A., van Scheppingen A., Fox D., Brück C.,2011, sharwood project, osha.gov/dte/

2.9. Dissemination of the Culture of Safety in a quality approach

The education and the training processes require a comprehensive methodological approach to be an integrated part of the organizational system. They should be enforced to deal with hanges system evolution and related problems.

Having a written quality assessment and control plan will help to ensure the high-level of an overall training program. "*Quality control plan*" is not the same as "*training evaluation*": it can ensure that each element of the system has been done well, is achieving its goals, and provides a tool to review periodically the program and improve it if needed.

Similarly to the Safety Documents, the training program also needs to evolve following different phases. Project Designers should periodically review the written Quality assessment & control plan, and appropriately update to be sure that the program:

- includes all applicable regulatory changes;
- implements course updates that

have occurred during the preceding period;
- integrates new training technologies;
- integrates new modules within the training program.

The current training system is experiencing a strong evolution: linked to changes in the social context and the educational objectives, it is changing its own processes. This is a challenge for the educational process that must quickly adapt to these changes: a quick and effective change can only occur if there is a continuous process of monitoring aimed at identifying influential factors on the system and its shortcomings.

As discussed in Sorlini and Patrucco 2017, in the International meeting "the basic role of the clients of great infrastructural operations in the promotion of the Culture of Safety: management and communication strategies, contractual aspects, case histories and best practices", SiTI, Turin, Politecnico, May 12th 2017, the dissemination of the Culture of Safety is an essential step towards an increasingly effective preventive action.

In line with the general engineering approach – confirmed by the transposition of the OS&H European Directives – the setting and management of the Safety and Health of Work, together with the Protection of third parties and Environment, have been since many years based on both PtD and Management in a System Quality approach.

On the other hand, the most obvious concepts of Safety-Quality are:
- Safety, such as Quality, becomes clearly visible when it fails;
- Safety, such as Quality, must be understood and shared by all involved;
- Safety, such as Quality, must be managed with preventive and non-corrective actions;
- Safety, such as Quality, must first be culturally understood and implemented by those with high decision-making power.

With special reference to the last point, we should not read it in the sense of identifying decision makers who, according to an approach dating back to the last century, are exclusive providers of Safety towards subjects whose only obligation is to comply with procedures, often generic and unclear, but should be understood constructively as part of a widespread dissemination of the Culture of Safety.

Universities also can play their part: we can find an example of synergic and multidisciplinary collaboration that made possible to achieve appreciable results (Borchiellini *et al.*, 2015).

Additional references on this topic Drucker P. F., 1999, Edwards J., Davey J., Armstrong K., 2013, Larsson Tholén S., Pousette A., Törner M., 2013

2.10. Not only Information, Formation and Training, but Promotion

Some practitioners consider the training process as a "philosophy", whose core idea is that the *Health and Well-being are an achievement / individual and collective responsibility* (e.g. Taylor, 1995) whereas others (e.g. Ewles and Simnet, 1999) consider the planning phase as a set of activities:
- *Education / Communication: addressed to those who hold power in the organization;*
- *Prevention of Occupational disease and impairments to reduce the social impact;*
- *Health protection: legal, fiscal measures, policies…*

In Authors' opinion, Promoting Safety and Health has a wider range than Prevention (whose purpose is the continous maintenance over the time safety and health status), and requires that:
- workers check their Safety and Health, and the influencing factors;
- the whole community is involved (as individuals and groups) in promoting initiatives concerning Safety and Health for the benefit of all the organization members, but also of a wider circle of stakeholders.

Additional references on this topic: Cooper M.D, 2000, Pisaniello D. L., Stewart S. K., Jahan N, Pisaniello S. L., Winefield H., Braunack-Mayer A., 2013.

3. Conclusion

If we consider the Occupational Safety and Health conditions along 1.5 centuries, e.g. from the beginning of the modern industrialization, an impressive progress appears evident, thanks to the improvements of mechanization, social conditions, techniques and technologies, results of epidemiological research work, and the introduction of Quality systems and European approaches to the OS&H.

However, European and national statistics on accidents and occupational health impairments show today a still unacceptable situation.

On the basis of an in-depth analysis of the data, Authors confirmed that one essential step to correct the scenario consists in a substantial enhancement of the dissemination of the Culture of Safety, a theme of their work within the TGSIGTU project (a formalized research cooperation Politecnico – Università di Torino).

Since the Culture of Safety is clearly based on a broadly multidisciplinary approach, covered by very wide international literature, in the present work the Authors implemented the result of a challenging and important critical effort to classify and organize the different covered subtopics, precious as a key reading and reference for framing and analyzing in an unbiased approach the OS&H system faults in real cases.

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