

Process Safety Education – Learning at the Level of the Establishment and at the Human Level

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Major industrial accidents, such as the accidents in Seveso (1976) or in Bhopal (1984), did occur in the past. They still happen contemporarily, eg. fire in Arkema Inc. on August 29, 2017 or in BASF Corporation October 17, 2016 and there is little doubt that they will keep on occurring in the future. Lack of or insufficient learning, drawing no conclusions from accidents or even forgetting about them might be viewed as some of the reasons for such state of affairs.

Learning can be considered at the level of the whole establishment (learning organization) as well as at the level of a particular person. With the use of Peter Sange's definition of learning organization and its five characteristics: thinking systems, personal mastery, mental models, shared vision and team learning, we can diagnose the weaknesses and strengths of establishment as an organization that can learn. However the learning process of the individual depends directly on the way the lecturer delivers knowledge. The use of the division of professional qualifications into mental, practical and personality traits with the application of Bloom's taxonomy (classification of educational learning objectives) and Niemierko's taxonomy (classification used in Poland) allows us to look at training in a different, more practical way.

Training methods and organizational solutions, especially in process safety, play a key role as they transform into the need to use the acquired knowledge in practice, in a real situation, under pressure at the moment of accident. There is a reason the key elements of the system for the prevention of major industrial accidents, i.e. the safety management system and emergency plans, are based on systematic training and continuous improvement. Emerging concepts and methods of occupational safety and health management intertwined with resilience engineering, such as Safety II, Zero Accident Vision or Human & Organizational Performance can be successfully used in process safety.

1. Evolution in Process Safety and Risk Management methods

Major accidents did happen in the past, do occur at present and will take place in the future. Regardless of the triviality of this statement, it unfortunately remains true. Irrespective of how far we go back in time, we can find more or less accurate descriptions of events. System for the prevention of major industrial accidents was legally established in the first Seveso Directive in 1982 but has since evolved, moving from a technical approach, focusing on error/human factor, then on correct/inappropriate management and safety management system, to now pinpoint issues of safety culture and resilience (Jain et al., 2017).

Attempts to answer the questions: why won't we learn from past mistakes, or, if we do, not sufficiently or effectively (Kletz, 2006, Jain et al., 2017), force us to continuously improve the system of prevention of major industrial accident and limitation of their consequences. Regardless of the work on the system itself, while asking yourself for the reasons for not learning about accidents, let's stop at the verb "learn". Perhaps the problem lies not only in the imperfection of the system itself as a system to prevent major accidents and limit their effects, but in the capabilities of "learning" at the level of the entire plant, considered comprehensively as the organization, as well as an individual employee who is a part of it.

2. Organizational learning or learning organization

According to the definition in the encyclopedia Britannica *learning is the alteration of behaviour as a result of individual experience. When an organism can perceive and change its behaviour, it is said to learn.* (Encyclopedia Britannica). However, this is only one of many definitions. According to R.M. Smith (1982) the term "learning" cannot be precisely defined because of its multiple use. Learning is used to refer to the acquisition and mastery of what is already known about something, but also the extension and clarification of meaning of one's experience, as well as an organized, intentional process of testing ideas relevant to problems.

2.1 Organizational learning

In the case of an organization, whether it's a small or large industrial plant or even an industrial concern, we can talk about organizational learning. Of course the complexity of the organization has a significant impact on the multidimensionality of learning, but regardless of the size of the organization itself, the very idea of organizational learning remains constant. Organizational learning can be broadly defined as a learning process within organizations that involves the interaction on individual and collective (group, organizational, and inter-organizational) levels of analysis and leads to achieving organizations' goals (Popova-Novak and Cseh 2015). Organizational learning is more than the sum of the information held by employees. It is a continuous process throughout the organization enhancing its collective ability to accept, understand and respond to internal and external changes. Brown and Duguid (1991) describe organizational learning as "the bridge between working and innovating". However, organizational learning is neither possible nor sustainable without understanding the mechanism of its operation and the dependencies that govern it. From the early 1950s, the ideas of organizational learning were developed and modified by philosophers, psychologists, managers, businessmen and many others, especially in the downturn of the 20th century abounded in new approaches and solutions. However, it is worth to remember that organizational learning arose as an idea, a concept, idealistic in many aspects as it was and for that reason only it may be so difficult to introduce into real life (Garvin D.A. 1993).

2.2 Learning organization

In 1990, in the book "Fifth discipline", Peter Senge (1990) introduced and popularized the term "learning organization" meaning an organization that facilitates the learning of its members and continuously transforms itself. He describes an organization with an ideal learning environment, perfectly in tune with the organization's goals. Such organization is a place "where people continually expand their capacity to create the results they truly desire, where new and expansive patterns of thinking are nurtured, where collective aspiration is set free, and where people are continually earning how to learn together." (Senge 1990).

The areas where organizational learning is different from traditional learning concern the application of certain disciplines (Figure 1).



Figure 1. Five disciplines by P. Senge (owned draw)

There are five disciplines identified by Senge as being important to a learning organization:

- **SYSTEMS THINKING** - the ability to perceive an organization in a holistic way, taking into account individual components and relations between them. In systemic thinking, it is essential that in the place of total chaos one should find some laws and dependencies between particular components of the surrounding reality. „The essence of the discipline of systems thinking lies in a shift of mind:

seeing interrelationships rather than linear cause-effect chains, and seeing processes of change rather than snapshots”.

- **BUILDING SHARED VISION** - determination of the direction of organization development common for all employees. In order to maintain internal motivation to operate in a company, it is necessary to personally involve its individual employees in the activities of this company. It is extremely important that everyone feels that they have the ability (at least to a certain extent) to influence the future of the company, the direction in which its development is going, and what it does, to identify with the company. *The practice of shared vision involves the skills of unearthing shared "pictures of the future" that foster genuine commitment and enrollment rather than compliance.*
- **MENTAL MODELS** - This discipline of reflection and inquiry skills is focused around developing awareness of the attitudes and perceptions that influence thought and interaction. Working on mental models is about trying to create situations in which people can be together and feel safe. It is about skillful dealing with relations that take place among people. (For example: “ladder of inference” depicting how people leap instantly to counterproductive conclusions and assumptions.) *"Mental models" are deeply ingrained assumptions, generalizations, or even pictures or images that influence how we understand the world and how we take action.*
- **TEAM LEARNING** - conducting cooperation and exchange of views between team members, which leads to faster development of individual employees and the entire organization. By respecting the individuality and needs of individual employees (sometimes it is enough to make them feel they are heard), we can create conditions for members of the organization in which they can learn rather than being taught. *The discipline of team learning starts with "dialogue," the capacity of members of a team to suspend assumptions and enter into a genuine "thinking together." The discipline of dialogue also involves learning how to recognize the patterns of interaction in teams that undermine learning. The patterns of defensiveness are often deeply engrained in how a team operates. If unrecognized, they undermine learning. If recognized and surfaced creatively, they can actually accelerate learning.*
- **PERSONAL MASTERY** - constant self-improvement of the organization's employees in the area of acquired knowledge and methods of its utilization. An element that favors the existence and development of a learning organization is the personal involvement of members of a given organization in their work. *Personal mastery is the discipline of continually clarifying and deepening our personal vision, of focusing our energies, of developing patience, and of seeing reality objectively*

In the modern industrial plants, some of these disciplines must appear e.g. a comprehensive look at the plant or a shared vision. Key to success is exploring all five disciplines interchangeably and simultaneously, not in separation from each other. For example personal development can be seen not as an advantage, but as a threat, a desire to liberate at the expense of others. The person can decide whether to share their knowledge with the rest of the group or not. If this person leaves the group and does not share his or her knowledge, other members of the group will lose this knowledge. On the other hand, a lack of personal development will result in frustration and a desire to find a new employer. P. Senge claimed: *"Today's problems come from yesterday's solutions"*, but also *"We learn best from our experience, but we never directly experience the consequences of many of our most important decisions"*.

3. Individual learning and personal mastery as challenge

In Organizational Learning learning itself is the smallest unit at which learning can occur, but in learning organization personal mastery is a higher level in development of an individual.

People with a high level of personal mastery live in a continual learning mode. They never 'arrive'. Sometimes, language, such as the term 'personal mastery' creates a misleading sense of definiteness, of black and white. But personal mastery is not something you possess. It is a process. It is a lifelong discipline. People with a high level of personal mastery are acutely aware of their ignorance, their incompetence, their growth areas. And they are deeply self-confident. Paradoxical? Only for those who do not see the 'journey is the reward'. (Senge 1990: 142)

However, it is difficult to imagine an industrial plant as an organization in which every employee, starting with board members to end with ordinary workers, is a person striving for personal mastery. This is too an idealistic vision. Regardless, it is worth emphasizing that the personal mastery of a board member, or a director will be something completely different from the personal mastery of an ordinary worker. The key in this case seems to be the willingness to develop and self-awareness.

When trying to learn, it is easy to forget that adult learning is not the same as children's learning. An attempt to apply school patterns to adults is doomed to fail. As adults learn, they expect a different relationship from the teacher, an offer of partnership instead of obedience demand. The teacher is no longer the only source of knowledge, since it is more effective to learn from each other's experiences. Adults are able to set their own goals and are more suited to a problematic approach than to an objective approach. While learning, they are focused on solving current problems, and effective learning is connected with the direct usefulness of the acquired knowledge. Most adults ingest dependencies, relationships faster, but are slower with definitions, numbers and facts. They are, nonetheless, more aware of their own limitations and advantages than their underage counterparts.

4. Taxonomy of Educational Objectives - Bloom's and Niemierko's taxonomies

Taxonomy of learning goals can be used as a tool to increase the orientation and effectiveness of teacher, lecturer, trainer, as a means of coordinating the results achieved on an ongoing basis, i.e. to verify whether we teach effectively. It can also be used to answer how to learn effectively looking through the prism of self-improvement, self-education, but it can also be used to verify knowledge in the area of process safety, to prevent serious industrial accidents, training in which we participate or conduct. One of the applied taxonomy of learning objectives showing the holistic nature of knowledge acquisition is the taxonomy developed by Benjamin Bloom in 1956. (Bloom et al. 1956) divided into three domains: cognitive, psychomotoric and affective. Bloom's taxonomy is focused on the development of all three domains as each of them concerns different skills and attitudes (Figure 2).

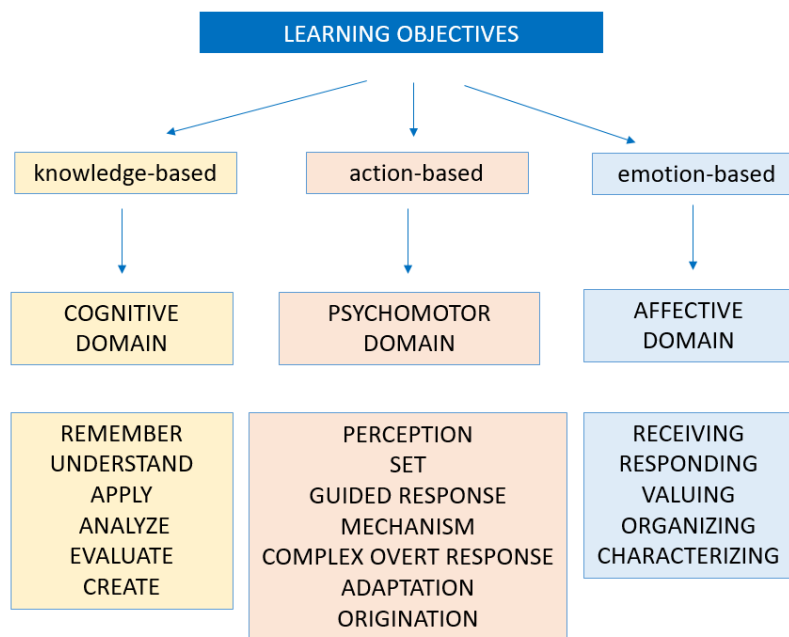


Figure 2: Taxonomy of learning objectives according to B. Bloom – include revision in 2001 (self-drawing on the base Bloom et al. 1956, Anderson et al. 2001., Kwiatkowski 2001)

Cognitive skills focus on knowledge, understanding and critical thinking. Psychomotor skills describe the ability to physically manipulate a tool or apparatus. The emotional skills describe how people react emotionally and ability to feel pain and joy of others (empathy), usually leading to an increase in awareness of attitudes, emotions and feelings. A person may have knowledge of e.g. first aid, be physically able to perform particular activities, but also needs internal conviction to do so, often overcoming their own mental limitations, e.g. before touching someone bleeding, severely injured. Taxonomies for particular domains have constantly been in development, among others, taxonomy of goals for the emotional sphere by D. R. Krathwohl (2002), for the psychomotor sphere by A. J. Harrow (1972), or E. J. Simpson (1972), as well as the concept of Bloom's taxonomy has been "revision" by Anderson et al. (2001).

The taxonomy of teaching objectives applied in Poland was developed by Bolesław Niemierko (1999), who distinguished 4 categories: remembering, understanding, application in typical situations and application in

problem situations. He defines the taxonomy of learning objectives as a hierarchical classification of these objectives (Figure 3).

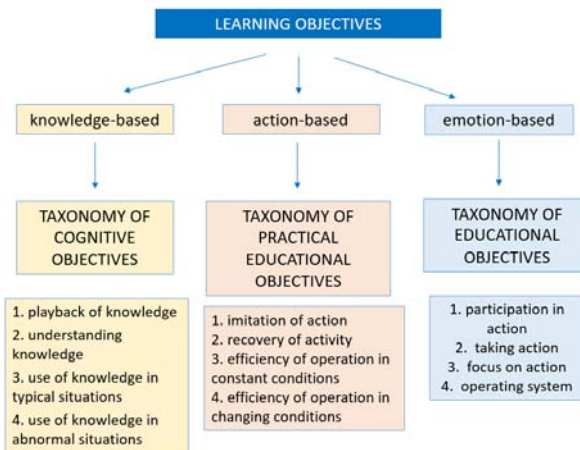


Figure 3: Taxonomy of learning objectives according to B. Niemierko (self-drawing on the base Niemierko B., 1999, Kwiatkowski 2001)

Following Bloom, it is worth being aware while learning of the necessity to work on three levels, mental, practical and emotional, and adding Niemierko's works it is not enough only to recreate, understand or apply in typical situations, but, especially in the case of process safety, this last stage is important: systemic, efficient use of messages in atypical (emergency) situations. The problem with most forms of learning is their enormous passivity. Watching slides or reading a lecture, mindless duplication of procedures or thoughtless tasting and sniffing - ending in the lack of involvement and activation of the viewer's mind. Involvement in the learning process significantly increase chances of memorizing the information and the chance to use the acquired knowledge in stressful, emergency situation (Figure 4).

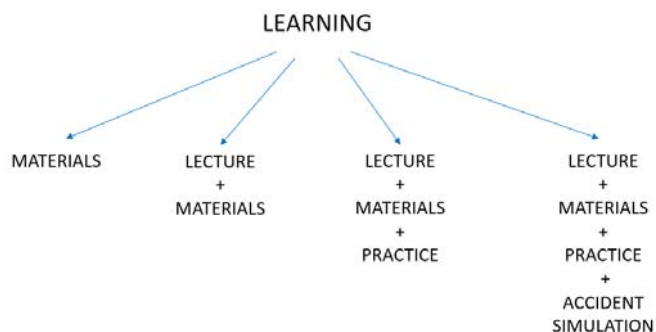


Figure 4: Training methods

Training methods and organizational solutions, especially in process safety, play a key role because they translate into the need to use the acquired knowledge in practice, in a real situation, acting under the pressure of an event, failure. There is a reason that the key elements of a major-accident prevention system: the safety management system and emergency plans are based on systematic training and continuous improvement. The question of how such trainings look like remains open, since their levels of effectiveness depend on the involvement of the management of the plant. And yet it also seems only remotely satisfactory.

5. Occupational health and safety management concepts for use in the major-accident prevention system

In industrial plants, programs to continuously improve and pursue "zero accidents" objectives are promoted, but in the event of an incident or serious accident, the morale and attitudes of employees and management change dramatically. Experience in the field of health and safety, new management concepts and methods such as Safety II, Zero Accident Vision or Human & Organizational Performance (HOP) can be successfully

used in process safety. Safety II assumes organizational learning on both successes and failures in ensuring safety. Conventionally safe workplaces are believed to be places where no accidents occur. According to Safety II, a safe workplace is defined as the presence of a capacity that allows all activities to be carried out correctly (for the benefit of safety) in a variety of changing environmental conditions. However, according to the HOP approach, human error is inevitable and as such is a symptom of problems in organizational systems. HOP proposes, among other things, the use of leading performance indicators, minimizing negative consequences and other actions leading to underreporting of accidents and hazardous situations, increasing cooperation and operational knowledge, as well as active inclusion of people who develop better safety solutions. On the other hand the philosophy of Zero Accident Vision assumes that no one should be injured because of an accident. It is a way of thinking rather than a numerical target, according to which all accidents at work can be prevented.

6. Conclusions

In summary, the article presents, in a nutshell, general concepts for use in process safety. This could be an inspiration to verification of education skills on personal or organizational level.

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