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The Evolution of Health and Safety Training Needs of the Mining Sector in Greece and EU †

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Abstract: The aim of this article is to present priority themes covered by the Health and Safety training programs of the Greek and European mining industry during the last decade. Mining is considered as an industry presenting high occupational risks. The International Labor Organization (ILO) estimates that 1% of the world's labor force is engaged in mining, yet mining accounts for 5% of occupational fatalities. Despite the use of advanced technologies in a safer working environment and "the zero harm-zero accidents target", mining accident statistics indicate that despite the gradual decrease in fatality rate, safety performance has reached a safety plateau. In order to further improve this performance, training and promotion of a safety culture through implementation of mine safety plans and enhancement of technical and non-technical skills at all levels of management are prerequisite measures. Currently, training is increasingly relying on immersive virtual reality to simulate complex operations in potentially dangerous environments. Open-cut or underground mining simulators provide safe, replicable and cost effective environments for miners to be trained and for engineers and managers to test different conditions, new ideas, strategies and scenario outcomes, without exposing employees in real time hazards. High-end training programs have the potential not only to improve workplace safety conditions but also to contribute to more effective management and finally to a more sustainable mining industry.

Keywords: health and safety in mining; risk management; training simulators; sustainable mining; training needs; safety culture; risk factors

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1. Introduction

Training is commonly recognized today as growth of industry with new tools and delivery systems [1], whereas education and training are widely considered as means for obtaining a competitive advantage [2]. Training is being adapted to the changes occurring at the business that it serves, and workplaces have considerably changed in the last decades since the first Occupational Safety and Health Act (US Labor) [3,4] and Framework Directive for the fundamentals of European Safety and Health Legislation, were implemented [5]. Injuries and illnesses that were unrecognized at that time now contribute significantly to the present OSH burden [6]. The workforce has also changed, and the number of employees over 50 years of age and workers under 18 years of age is also increasing [6]. Regarding the mining industry, there have also been profound changes in the work organization. New sophisticated technologies are transforming the sector's operations. As a result, the type, level and mix of skills required is changing, affecting many working positions. Up skilling and reskilling programs are needed so that employees are trained in new mining processes that will extend the lifespans of mines. Lifelong learning programs are required for all skill levels of employees, including managers and supervisors, to ensure a smooth transition to mechanization [7]. While advances in technology may result in novel tools for conducting on the job training, the identification of the envisioned outcome of training schemes and the knowledge and skills of individual trainers will always be the most critical components. A major concern in the mining industry today is how to train the present workforce in addition to the expected influx of new and less experienced miners and mine operators as the cohort of older workers retire. A problem of recruiting and attracting new people is also looming, according to European Agency of Safety and Health at work [8].

2. Major Causes of Accidents Incidents in the Mining Industry

According to research on accidents' causes in European and Greek mining industries, the most frequent areas that cause accidents in mining are as follows: external physical threats; poor quality of supplied material; geological disturbance; improper strata control; inadequate training facilities; shortage of skilled employees and de-employment of unskilled employees; inadequate communication systems; poor supervision; spontaneous combustion; improper surveying; explosives and blasting; haulage machinery; slips and falls; lack of awareness; sealed off panels; inadequate supply of spare parts; use of uncalibrated instruments; lack of ventilation; other fires; poor illumination; unsafe behaviours; poor crisis management; off road and underground haulage tracks; cranes and derricks; workers with experiences of less than 5 years; bolting machine; long-wall; car transport; car shuttle; graders; gas drainage and drilling equipment; psychological factors; fatigue; occupational stress; and unsafe behaviours. Based on these accident causes and major risks, the training areas are defined [9–12].

Literature data and assessment of best practices in the mining industry also suggest that unsafe behaviours are one of the main reasons for occupational accidents [12]. Therefore, in order to improve safety in the workplace, emphasis is needed on behaviours that employees adopt during their daily work. OSH training supports the employees in acquiring knowledge and skills to perform the same tasks in a safer manner [12,13].

Regarding training methods, studies suggest that more engaging methods such as the ones involving the active participation of trainees, especially those applied in the actual field, are the most effective in promoting safer behaviours [14]. It was also confirmed that conventional training methods (expositive) have more positive results when they are coupled with techniques that require the involvement and active participation of employees [15,16].

Risk perception plays a fundamental role in risk management and support of prevention strategies, since behaviour of individuals will depend on the interpretation of the situation and, therefore, the ability to observe. This is the reason why more simulation and case scenarios are needed for employees to sharpen their critical ability and their alertness regarding risk management [17].

The Health Belief Model (HBM) is a model that focuses on cognitive factors that are considered causal mediators of behaviours [18]. This model was later adapted to the OHS field, supporting the employees to become more predisposed to adopt safe behaviours.

Shields and Boyce reported that one of leading causes of deaths in emerging scenarios is not the distance to emergency exit, but the delay in communications to the occupants of the situation. Other important factors affecting behaviour are as follows: alertness, mobility, social affiliation, role and responsibility and familiarity with the workplace [19].

Tancogne–Dejean and Laclemence identified overconfidence, excessive control, fatalism, affectation, social withdrawal and non-vigilance due to the existence of technologies and regulations as factors that limit risk perception. Although overconfidence can be detrimental to risk perception, this factor can also reduce stress and negative emotions in emergencies [20].

The above findings support the need for further research on factors that contribute to mining industry lost time accidents with a need for further documentation on the possible contribution of mental health hazards [21]. This is important as the accidents related to mental health issues have dramatically increased in the workplace recently [22]. Other studies have reported that burnout; job stress and lost time were related to poor health outcomes including lower quality in life [23].

3. Risk Assessment and Emerging Risks That Affect Training in Safety of the Mining Industry

Occupational health risk assessments in the mining and metals sector are especially complex because of the breadth and range of the above activities. A high incidence of accidents is often linked with inappropriate or ineffective training materials and methods as well as not properly perceiving and recognizing hazards. Most training tasks (such as escaping of disasters and mine rescue) cannot be practiced in the real world, introducing virtual reality as a suitable technology to overcome the problem [24].

The mining and metals sector often encounters cases of stress and other adverse mental health and wellbeing effects that are attributable to occupational factors including shift work. Another potential adverse health impact is chronic fatigue caused by the intense physical demands of mining and metal activities [25]. The fatigue that contributes to accidents in the mining industry refers to cognitive fatigue rather than physical fatigue from demanding physical work. Cognitive fatigue is usually caused by a lack of sleep or wakefulness outside of normal daylight hours. This kind of mental fatigue inhibits the brain's ability to interact with the body, which is comparable to impairment by alcohol [26].

In industries such as mining produce conditions where fatigue within the workplace is unavoidable. Underground miners are at an especially high risk for fatigue [27,28] due to overnight work schedules and days spent underground with artificial light sources further disrupting sleep patterns. For this reason, applications studying the tendency for accidents due to fatigue are currently under thorough research [25–28].

4. Training Needs of the Mining Industry

According to ICMM [29], training includes formal "off-the job" training, instruction to individuals and groups and on-the-job coaching and counseling, and it determines priority issues to be targeted in a work training program. Training is not a substitute for proper risk control, but it prevents injuries and fatalities at the mining site and it improves efficiency [30]. Any training program should be flexible for employees' working conditions and respectful of the different levels of knowledge of every employee involved [31].

Training can be covered in three areas [29]: 1. Organizational needs: information concerning the organization; 2. Job-related needs: These fall into two main types-management needs non-management needs; and 3. Individual Needs: the needs for personal development.

The quality of safety and health education is the degree to which organizations providing these trainings and educational courses will increase the likelihood that desired educational goals are reached and are consistent with current professional and academic knowledge [32]. For this reason, an assessment of training material, according to Kickpatrick's model of training [33], trainers or health and safety managers should be also taken into account.

Training programs should keep employees involved and be able to react to different emergency scenarios. Extended research revealed that the integration of practical activities and brainstorming to solve specific scenarios could be an excellent strategy to improve knowledge, especially in emergency response [34].

Traditional modes of managing occupational health have been focused on consequence management (a focus on the disease or the risk/accident) with less focus on managing the cause, i.e., the control of health risks in the workplace and the prevention of exposure [35]. This requires preventive management.

Virtual Reality (VR) offers great potential as a training tool to the extractive industry's being, by enabling sharing of mining operations data, visualization of unseen and buried ore body (or even gas seams) training simulations and high-risk task practice, without exposing operator to any actual danger [36].

Van Wyk and Villiers suggested that due to its features, VR could be an e-training tool for simulating hazardous situations more frequently than would be encountered in the real world and to simulate situations that have not previously occurred in actual fields but that still could be encountered [37]. Linquin Cai et al. tried to build up a methodology for modelling risk behaviours in coal mines [38] by adding a risk accident analysis and prevention, followed by the incorporation of fuzzy logic in the risk model developed. The results indicate that the proposed approach could effectively reconstruct and assist accidents risk analysis.

Baiwei Lei [39] et al. tried to develop a rescue drill training system by using a 3D max modelling software, which was constructed upon a standardised drill script. The main objective was to improve the ability of promptly analysing the disastrous situations and acting accordingly, reducing the demand on human resources, equipment and materials for emerging drills [39].

However, the use of VR in safety instruction and training could possibly have an ambiguous effect on risk perceptions, since the participants can become accustomed to virtual environments of leisure and are sometimes unable to correctly estimate hazard levels in risk perception [17].

5. Health and Safety Training in the Greek Mining Industry

Regarding the Greek Mining Industry, based on reported data by the Greek Mining Enterprises Association for the period 2010–2021 [10] and interviews with health and safety managers of Greek mining industry, the major training material on health and safety for the last decades are summarized in the following table. Training materials are categorized according to the training areas mentioned above. As observed in the table, some of the training materials may address more than one area.

The table (Table 1) was based on non-disclosable data of greek mining member companies of greek mining enterprises association and it is originally made by the authors according to the categories of training needs mentioned above.

Table 1. Categorization of training material of Greek Mining Industry, according to training areas mentioned above 2010–2020.

1. ORGANIZATIONAL NEEDS	2. JOB RELATED NEEDS	3. INDIVIDUAL NEEDS
First aids-Safe patient handling	Drilling	Addictive substances and work environment
Infectious diseases—hygiene conditions and disease prevention	Explosives and blasting (design-storage, handling, execution of blasts)	Infectious diseases—hygiene conditions and disease prevention
Showers and eye wash	First aids-Safe patient handling	Showers and eyewash
Disaster management	Confined spaces	Disaster management
Ergonomics	Ergonomics	Defensive driving
Operation of automated units and control rooms (PLCs, IoT, Fuzzy logic and AI)	Operation of automated units and control rooms (PLCs, IoT, Fuzzy logic and AI)	Operation of automated units and control rooms (PLCs, IoT, Fuzzy logic and AI)
Disaster site training and emergency response teams	Fire prevention and fire fighting	Fire prevention and fire fighting
Warehouses	Explosive, poisonous, suffocating and flammable atmospheres and corrossive, flammable, poisonous, suffocating liquids and chemicals	Warehouses
Evacuation and emergency planning	Lockout-tagout (LOTOTO)	Ship loading
Incidents investigation, records keeping statistics	Scat folding and fall protection	Fatigue

Table 1. *Cont.*

1. ORGANIZATIONAL NEEDS	2. JOB RELATED NEEDS	3. INDIVIDUAL NEEDS
Loading and transportation of blasted material, unloading to silos, hoppers and piles	Electric equipment	
Ventilation air quality	Ventilation air quality	
	Noise, vibration and in general physical hazards	
Facility safety measures and procedures	Working under extreme environments	
Process equipment HM units, Froth flotation separators, electromagnetic separators,	Process equipment HM units, froth flotation separators, electromagnetic separators	
Ionizing radiation, protection and shielding	Ionizing radiation, protection and shielding	
Tools and electric tools	Tools and electric tools	
Fire prevention and fire fighting		
Facilities security	Conveyor belts, shuts, bins and bunkers	
Design of systems and facilities aiming total safety	Loads lifting (cranes, raising tools, wire-ropes)	
Violence prevention	Works at height	
Risk management and crisis management	Working with fuels	
Conflict management	Hazardous materials	
Train the trainers	Shafts and working with shafts	
Addictive substances and work environment	Working with equipment operating at high temperatures	
	Behavioural and communicational training	

Characteristic examples of implementation of best practices on health and safety training of Greek mining Industry [10,12,30] include the following: supervision seminars; "walk the talk"; involvement of all employees in training of health and safety with top down bottom up training design; motivational program "ALLAZW" for reinforcement of safety culture, implementation of ISO concerning Energy Isolation; IVMS in vehicle monitoring systems; rewarding and not a punishment system for best behaviours and best practices of health and safety; "health and safety coffees"; ergonomic and special physical remedies for the prevention of musculoskeletal disorders; X"SWISS CHEESE" methodology; "BE READY" building performance; good driver with system; fatality elimination control; "Going for Zero"; ICAM awareness; dust measurement campaigns; and LMRA (last minute risk assessment and rescue case scenarios).

6. Conclusions

Given that the most common cause of accidents is unpredictable risky behaviour, training is focused at a great extent in behavioural simulations and crisis management, where employees can test their behaviours without being exposed in real dangers. For specialised and interactive virtual environments able to offer qualification and training on safe behaviour and to minimize hazardous performance and risk assessments, adequate task performances aligned with ergonomic design principles and OHS digitization are but some of the potentialities of VR technologies in the OHS field [36].

On the other hand, OHS knowledge and motivation could become relevant variables of safety performance within virtual environments as a collateral benefit of health and safety prevention, particularly when young employees are involved.

The mining industry is advocating a shift towards a controls-based approach for managing risks by using the critical control management process, reinforced by leadership and safe behaviours. Ideally, all risks that cannot be eliminated or substituted would have a technological or engineering control solution in place that would prevent harm [31].

Overall, the main difficulty of emerging simulations or modelling technologies (Virtual or Augmented Reality) used in OHS training of mining is to develop specific skillsets in order to be able to perform environmental factors modelling and to draw conclusions suitable for becoming the basis for improving OHS strategies [40].

Finally, difficulties may be encountered in the implementation of sustainable training, since they are often considered as an extra load in their daily work. The training of employees of the mining industry is always imperative, not only in the logic of demystification but also with the aim of projecting the benefits of implementing sustainable practices. A change of culture is sought since the development of a consistent training strategy implies the knowledge of guidelines and regulations that allow employees to abtain a holistic vision of sustainability and informed decision making. [41,42].

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