Proactive Risk Management and Building a Safety Culture Through Modern Training Devices

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Abstract. Occupational safety and health at work is a key component of organisational management, while the human factor remains one of the main causes of workplace incidents. The aim of this article is to analyse the potential use of simulation goggles as an immersive training tool to raise employees' awareness of the risks associated with fatigue, sleep deprivation and substance use. The theoretical section is based on risk management concepts in accordance with ISO 31000 and ISO 45001 standards, safety culture, the human factor, incident prevention and modern approaches to employee training. The empirical part is based on an analysis of statistical data from the Eurostat database for the period 2015–2025, examining the relationship between the unemployment rate and trends in workplace accidents in the European Union and the Slovak Republic. The findings also highlight the importance of preventive measures focused on safety culture and the reliability of the human factor. Simulation goggles represent an affordable means of experiential learning, enabling the safe simulation of reduced work capacity and the creation of realistic model situations without the need for costly virtual systems. The article concludes that the implementation of simulation goggles into the OSH training system can significantly support the development of a safety culture and have a preventive effect on reducing the incidence of workplace incidents and serious injuries.

Keywords: risk management, immersive training, human factor, safety culture, incident.

1 Introduction

A safety culture can be regarded as a component of organisational culture that relates to the individual, work-related and organisational characteristics affecting the safety and health of employees. A positive safety culture creates an atmosphere in which employees recognise the risks they face in the workplace and remain constantly aware of them. We therefore regard safety culture as an important management tool that helps to shape employees' beliefs, attitudes and behaviour relating to safety [1]. It is defined as those aspects of organisational culture that influence attitudes and behaviour relating to increasing or reducing risk [2]. Alternatively, it is defined as a combination of perceptual attitudes and behaviours that produce performance outcomes capable of driving the

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organisation forward, and as an embodiment of attitudinal behaviour and mutual understanding aimed at creating safety performance, which is understood and becomes a priority within the organisation [3].

Common OSH metrics in corporate social responsibility reports, which are favoured by investors, relate to reporting on occupational safety and health management systems [4]. Consequently, organisations often include accident frequency rates in these reports [5–7]. Zwetsloot et al. identified six factors as key health and safety indicators. These were: whether a director was named as a health and safety champion; the level of reporting on health and safety management systems; the number of fatalities; the lost-time injury rate; the absenteeism rate; and the costs of health and safety losses [8]. Investors often push for change by demanding improvements in specific areas [9].

A high level of management commitment, a low fatalism, a high priority on safety and a high level of risk awareness appear to be the ideal combination of management attitudes in the field of safety and accident prevention [10]. As part of risk planning and prevention, organisations strive to prevent various safety incidents. The use of simulation goggles as an immersive learning tool appears to be an effective means of raising staff awareness regarding the prevention of workplace incidents. Amongst the tools utilising the principle of immersion, simulation goggles are cost-effective and, in particular, widely applicable in various work environments across different job roles.

2 State of the art review on key concepts

In the following section, we will focus on clarifying the link between risk management and the human factor in the workplace. Human capital is one of the most valuable resources an organisation has at its disposal for achieving its objectives, which is precisely why the prevention of safety incidents is one of the key areas of risk management. A system of training and education programmes is a tool for effectively raising staff awareness of safety culture; such programmes can help to eliminate staff absences from the workplace caused by accidents at work and resulting inability to work.

2.1 Risk management

The professional literature emphasises that systematic risk management is one of the key tools supporting organisations' strategic and operational decision-making with the aim of enhancing their competitiveness. The ISO 31000 standard defines risk as 'the effect of uncertainty on objectives'. According to this definition, risk and uncertainty are fundamentally interlinked; efforts to reduce or mitigate risk are efforts that address the effects of uncertainty. An effect is then defined as a deviation from expectations [11].

Whilst the general management standard ISO 31000 defines risk neutrally as "the effect of uncertainty on objectives" (which may also be positive), in the field of occupational safety and health (OSH) under ISO 45001, the concept of risk is strictly linked to negative impacts – that is, exclusively to the probability and severity of harm to human health or injury. However, an organisation does not merely seek out threats, but

also opportunities to improve safety (e.g. training using modern technologies, adapting the working environment, purchasing more modern equipment, eliminating monotonous work, etc.) [11–14].

Risk assessment plays a key role in mitigating potential risks associated with organisational activities. By implementing proper risk assessment and management, organisations can identify, analyse, evaluate, minimise and capitalise on positive opportunities arising from risks, transforming them into innovations [15,16].

2.2 Occupational risks and incidents in work processes

The assessment of occupational risks requires a comprehensive evaluation of their causes and potential consequences. Current scientific research highlights the need to take into account not only the direct impacts on employees' health, but also the psychosocial factors of the working environment, ergonomic aspects of workplaces, the long-term health consequences of exposure to risk factors, as well as the economic consequences associated with work-related accidents, staff absences, a decline in labour productivity, and increased costs for healthcare and compensation. Such a multidimensional assessment enables more accurate prioritisation when adopting measures to reduce risks. Risk assessment is essential for making informed decisions on the prevention of occupational risks. Workers' health and safety conditions can be improved through the issuance of voluntary certifications, such as ISO 45001 [17,18].

Work processes, as integrated systems, depend on the interaction between the human factor and technology [19,20]. This coexistence can lead to unpredictable situations [21], which are referred as incidents [12,22]. An incident is a work-related event(s) that occurred during the course of work or in connection with work and which resulted in, or could have led to, injury or damage to health [12]. The standard explains that the term 'incident' covers three situations:

1. Work-related accident / occupational disease: An incident in which an injury or damage to health has occurred.
2. Near-miss: An incident in which no injury occurred, but it was a very close call (e.g. a falling brick misses a worker by a few centimetres). In Slovak legislation, this is referred to as a hazardous event.
3. Accident: An incident resulting in property damage or a hazard, where an injury could have occurred but did not (e.g. a fire in a warehouse at the weekend when no one was there) [12].

In corporate practice, particular attention is paid to incidents designated as SIF. SIF is an acronym used to denote 'serious injury and failure', 'significant injury and failure', or 'significant injury and fatality' [4, 23, 24].

Several authors [16–18] have pointed out that not every injury leads to more serious incidents classified as SIFs and have introduced the category 'Potential SIF' (PSIF) or 'SIFp', which corresponds to a 'near-miss' [12]. Cooper [4] argues that a PSIF can be detected even before it occurs. This approach is referred as proactive, and a PSIF is defined as dangerous behaviour or a dangerous condition that was detected before it developed into a SIF. Cooper [4] also describes a reactive approach, in which a PSIF is either an incident that caused a minor injury which could have led to a life-threatening

or life-altering injury, or an incident in which a human factor was exposed to the release of some form of energy, which could have led to a life-threatening or life-altering injury. Parikh et al [25] emphasise that PSIFs must be addressed as early as the risk assessment process, as this is the only way to reduce the occurrence of incidents with serious implications for the human factor at the preventative stage.

2.3 Immersive training

Organisations carry out various forms of full-scale exercises (FSE), which represent the most resource-intensive approach, involving the physical deployment of personnel and resources. However, they entail significant financial costs, which limit the availability of such exercises and may create a false sense of security if they are poorly designed or executed [26]. An alternative approach to providing more practical training experiences without the logistical demands is the method of tabletop exercises (TTE), which are far more cost-effective than FSE [27,28]. Whilst these methods allow for the comparison of cognitive outcomes, they do not facilitate the development of operational and practical skills, or resilience to stress [26]. However, technological advances make it possible to bridge the educational gap between the two training options and create an environment for simulating hazardous situations in a safe setting.

Immersive technologies such as virtual reality (VR), augmented reality (AR) and mixed reality (MR) offer the potential to create an immersive training environment that 'combines the psychological realism of FSE with the accessibility and repeatability of TTE' [29,30]. Immersive technologies offer the opportunity to enrich learning experiences through increased motivation, better conceptual understanding and the development of soft skills [31,32].

The concept of immersion is based on multisensory engagement, with the aim of inducing a sense of presence through a scenario simulating a real-world environment. However, creating individual scenarios is demanding in terms of both financial resources and personnel and time. In the field of corporate safety, simulation goggles appear to be a more accessible tool for raising awareness. These work on the principle of visually distorting reality and creating a sensory barrier, which evokes authentic emotional and physical reactions [33]. Immersive learning is not a passive way of absorbing information, but rather 'learning by doing' [34]. Sensory distortion makes it more difficult to perform routine tasks; however, there is no digital feedback from the environment in response to the user's actions. The use of simulation goggles forces the individual to actively solve problems under challenging conditions, which leads to more effective memorisation and the integration of theoretical knowledge in the human mind.

3 Methodology

Paper draws upon scholarly publications and databases and is based on publicly available data. Its aim was not to strictly confirm or refute claims regarding the relationship between the number of incidents and the unemployment rate, but rather to provide a

descriptive analysis of the development of this relationship in the context of the Slovak Republic.

Data from the database of the Statistical Office of the European Union were used to analyse the incidents. Annual statistics on workplace accidents were compared with time series of data on the annual unemployment rate in the European Union and in the Slovak Republic. Unemployment data were obtained from the European Labour Force Survey and represent the percentage of the labour force (i.e. people aged 15–74). Data were available for the period 2016–2025. Work-related accidents were not recorded as absolute figures; instead, to enhance the interpretability of the results, incidence rates (number of cases per 100,000 workers) were compared across the categories of serious (non-fatal) and fatal accidents. Work-related accidents were also analysed in terms of absence from work, where the total number of periods of incapacity for work was recorded, regardless of their duration. On Eurostat, only data on work-related accidents for the years 2015–2023 were fully available; for the Slovak Republic, data for 2024 were also available. The data on workplace accidents do not include road traffic accidents or accidents involving employees in security services such as: armed forces occupations; customs and border inspectors; police inspectors and detectives; protective services workers: fire-fighters; police officers; prison guards; security guards; and protective services workers not elsewhere classified. All available data were included in the analysis.

4 Results

Statistics on work-related accidents are based on national regulations and standards governing their severity and the obligation to report them. In the Slovak Republic, the National Labour Inspectorate is responsible for compiling these statistics and bases its assessment of work-related accidents on the Labour Code and the Act on Safety and Health at Work [35]. To harmonise diverse data, Eurostat classifies work-related accidents into just two categories: fatal and non-fatal accidents (severity 4 days or over) [36].

Following on Cooper [4] – who highlighted the fact that there is a certain correlation between a country's economic development and the rate of workplace accidents – the authors decided to observe this relationship in conditions of Slovak Republic. For the comparison, they selected the unemployment rate, which, with a slight lag, mirrors the pace of economic growth and the rate of work-related incidents. Their findings are illustrated in Figures 1 and 2.

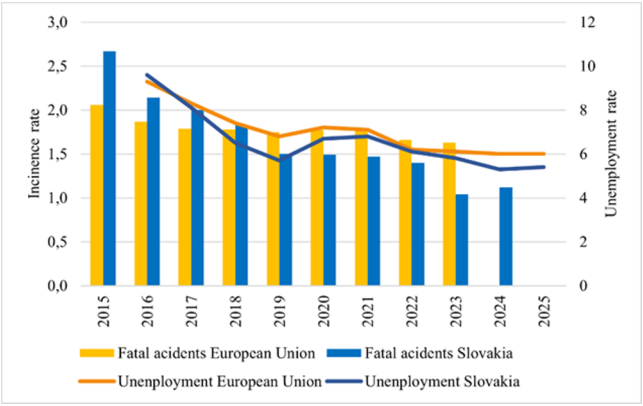


Fig. 1. Trends in serious workplace accidents and unemployment in the EU-27 and the Slovak Republic [37,38]

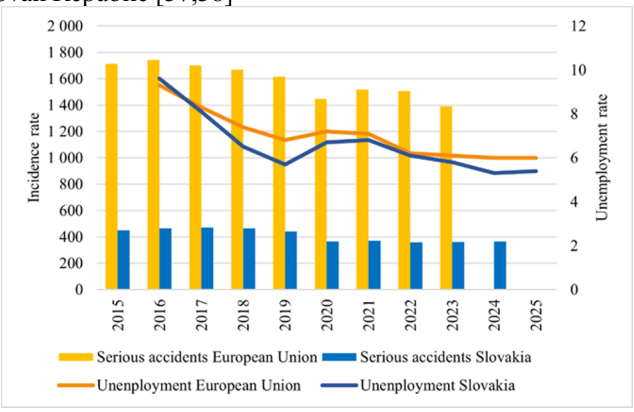


Fig. 2. Trends in fatal workplace accidents and unemployment in the EU-27 and the Slovak Republic [37,39]

Figures 1 and 2 illustrate trends in the unemployment rate and in fatal workplace accidents (Fig. 1) and serious workplace accidents (Fig. 2) across the 27 countries of the European Union and in Slovakia. For both types of workplace accidents, it is clear that their numbers mirror trends in the unemployment rate. This may reflect what is known as presentism, whereby an employee continues to work despite being ill or having suffered a minor workplace accident, but is unable to perform at full capacity [40].

However, when examining the number of workplace accidents in terms of inability to work, a different trend can be observed; see Figures 3 and 4. As the unemployment rate falls, there is an increase in workplace accidents. This may be related to:

- a shortage of skilled labour, which means that employers are forced to hire employees without experience, often facing a language barrier, who do not fully understand or underestimate safety regulations, resulting in an increased number of cases of incapacity for work;

- the psychological effect of job certainty and the associated possibilities for treating neglected health conditions.

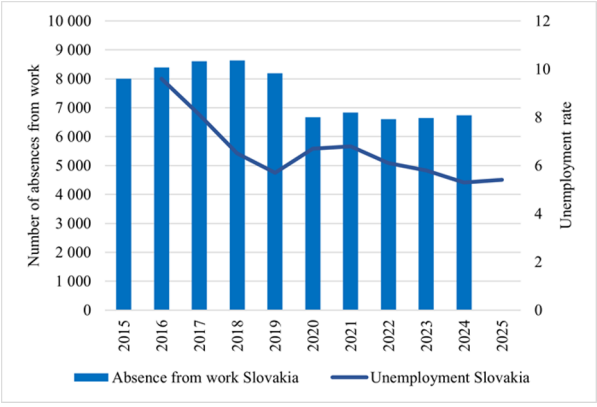


Fig. 3. Trends in work inability and unemployment in the Slovak Republic [37,41]

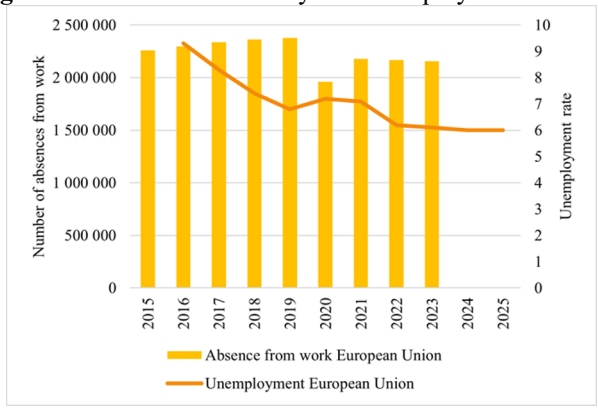


Fig. 4. Trends in work inability and unemployment in the EU-27 [37,41]

If companies are unable to choose from a pool of qualified candidates, it is advisable, as part of the induction training for new employees, to establish and reinforce their connection to the organisational culture and the safety culture that stems from it. Employees will adopt the desired behaviour and accept the procedures and standards that have been established as rules by management.

The Statistical Office of the European Union obtains data on accidents at work from the European Statistics on Accidents at Work (ESAW), which are supplemented on the basis of data provided by the relevant national institutions. However, each employer develops its own reporting method, with increasing emphasis being placed on monitoring SIFp and, above all, on the prevention of accidents with serious consequences.

The occurrence of workplace accidents is determined by a complex interaction of technical, organisational, environmental and human factors. The most common factors contributing to workplace accidents include the inadequate use of personal protective

equipment, hazardous working conditions, fatigue, work-related stress, insufficient education and training of employees, reduced concentration, and violations of safety regulations [15,16]. For this very reason, employee training in occupational safety and health appears to be a suitable tool for preventing workplace incidents. For organisations, the economic aspect of prevention expenditure is particularly important, and therefore the choice of a suitable and effective tool is crucial.

5 Discussion

Employers are increasingly drawing attention to the growing occurrence of factors that may adversely affect employees' work performance and safe behaviour. Among the significant causes of incidents and workplace accidents is poor work organisation, which may also be caused by the consumption of alcoholic beverages or other narcotic and psychotropic substances [42,43]. Work-related accidents may also be caused by excessive fatigue, sleep deprivation, psychological stress, or a combination of various forms of work-related and non-work-related stress. These factors significantly reduce the ability to perceive risks correctly, slow reaction times, and impair coordination, decision-making and situational awareness, thereby increasing the likelihood of workplace accidents and serious safety incidents. One of the tools for preventing workplace accidents is staff training (human factor). Modern approaches to training, including in the field of health and safety at work, are gradually shifting away from the passive delivery of information towards experiential and interactive forms of learning. Immersive training delivered via simulation goggles is a preventative tool aimed at raising safety awareness, developing the reliability of the human factor and eliminating risky behaviour [44]. Through experiential learning, it enables a better understanding of the consequences of reduced psychomotor ability on safe work performance, thereby promoting more effective prevention of workplace accidents. Simulation goggles can also be used as part of OSH training of employees. These simulation goggles serve as an innovative tool for simulating selected effects and are used primarily for educational purposes and in the field of prevention.

As part of prevention efforts, the following simulation goggles can be used during training:

- the effects of alcohol (intoxication, various blood alcohol levels),
- a state of intoxication combined with impaired lighting conditions,
- a state resulting from drug use or a medication overdose,
- a state resulting from the use of ecstasy,
- a state resulting from the use of cannabis,
- the effects of sleep deprivation and fatigue caused by a lack of sleep.

The inclusion of simulation goggles in practical training enables the creation of realistic simulated situations, supports the development of an organisation's safety culture, and raises employees' individual awareness of the consequences of reduced work capacity. During training, simulation goggles primarily affect visual perception and motor coordination, whilst actual intoxication also affects higher cognitive functions, decision-making, behavioural inhibition, attention and judgement. Their significance therefore

does not lie in the exact reproduction of neuropsychological processes, but in supporting experiential learning, developing safety awareness and facilitating discussion of the risks associated with performing work under the influence of factors causing reduced work capacity [44].

The implementation of simulation goggles in human factor training within the framework of occupational safety and health (OSH) and the prevention of workplace accidents should be based on a risk analysis of the specific job role and the identification of activities in which reduced work capacity may significantly affect workplace safety. Training should be conducted using simulated scenarios that replicate the real work tasks of the job role as faithfully as possible, with all activities taking place in a controlled and safe environment under the expert supervision of a trainer. Work tasks must be carried out in accordance with safe working procedures and using all the personal protective equipment allocated for the role in question. While performing a work task, the trainer records the correctness of the procedure, any errors, and, where applicable, the time taken to complete the task. During training with simulation goggles, employees gain first-hand experience of the limitations on visual perception, coordination of movements and spatial orientation.

In terms of methodology, training using simulation goggles can be implemented in the following steps:

1. Introduction, explanation of the training objectives, conditions and instructions regarding the simulation goggles and the tasks to be carried out.
2. Completion of a reference task without simulation goggles.
3. Repeating the same task using simulation goggles.
4. Professional reflection and analysis of errors.
5. Performing the task again without the goggles, applying the knowledge gained.

When performing work tasks, this proposed training procedure allows comparison of staff performance, promotes experiential learning and facilitates the transfer of acquired experience into real-world work practice.

The purchase price of VR hardware suitable for individual users starts at €500. This is a one-time investment. The use of this equipment by a commercial enterprise is associated with an annual licence fee of approximately €2,000. In the corporate sector, however, stricter security requirements apply, and the annual licence fee can rise to as much as €16,000 for a specific legal entity. As a corporation comprises several legal entities, the total annual licence fee increases proportionally. From an economic perspective, simulation goggles represent a more affordable tool for supporting occupational safety and health (OSH) training; the purchase price of a single pair is €179.00, which is relatively low compared with the potential costs associated with workplace accidents or loss of work capacity. A significant benefit of this tool is its reusability in initial, periodic and specialised OSH training, as well as in practical training for employees across a range of occupational roles. Its long service life and minimal running costs enhance allow it to be used across multiple training cycles without the need for additional financial input. From the perspective of preventive strategies, the implemen-

tation of simulation goggles can be regarded as an investment that supports the development of a safety culture, raises awareness of risks and fosters the adoption of safe behaviour through experiential learning.

At the same time, the findings of available scientific studies confirm that effective occupational safety management requires a proactive approach from organisations, regardless of their size or sector of operation.

The development of a safety culture, the use of modern methods for identifying, analysing and assessing risks, the digitalisation of OSH processes, the active involvement of employees and the systematic monitoring of safety performance indicators create the fundamental conditions for the continuous improvement of occupational safety and health and the long-term sustainability of the safety management system. The analysis of human and organisational factors plays a key role in identifying system vulnerabilities by examining both work systems and the individuals operating them. Human factors focus on understanding human behaviour and performance with the aim of reducing the likelihood of accidents. The field of human factors is inherently interdisciplinary and encompasses perspectives from psychology, social psychology, ergonomics, management and sociology [18,45].

6 Conclusion

Based on an analysis of statistical data on workplace accidents in the European Union and Slovakia, as well as findings from the professional literature, the authors highlight the need for proactive risk management, the identification of potentially serious incidents (SIFp) and the systematic development of employees' safety awareness. High-quality training of staff plays a significant role in this, as it enhances their ability to recognise risks before a workplace accident occurs.

Simulation goggles enable the safe simulation of the effects of fatigue, sleep deprivation, alcohol or intoxicating substances, which negatively affect visual perception, coordination of movements, spatial orientation and the ability to carry out work activities safely. Employees can thus, under controlled conditions, experience the consequences of reduced fitness for work without being exposed to any real danger. The personal experience gained in this way significantly increases risk awareness, promotes responsible decision-making and contributes to the long-term adoption of safe working habits. Simulation goggles are most effective when combined with expert guidance, a risk analysis of the specific workplace, practical training in work activities and subsequent reflection on the experience gained. The proposed training methodology consists of a reference performance of a work task, its repetition using simulation goggles, an expert analysis of the errors made, and the task being performed again using the knowledge acquired. This approach supports the transfer of knowledge into real-world work practice and the development of the organisation's safety culture.

Cost-effectiveness is another significant advantage. Compared with virtual reality or complex training simulations, simulation goggles represent a more cost-effective solution that can be used repeatedly for initial, periodic and specialised staff training.

Thanks to their low running costs, they are also accessible to organisations with limited resources.

The practical use of simulation goggles is particularly suitable for job roles where reduced attention, fatigue or poor decision-making can lead to serious workplace accidents (SIF). The training enables employees to safely identify their own limits and understand the link between human factors and the occurrence of incidents. In doing so, it promotes a preventive approach to safety and health at work and helps to reduce the number of workplace accidents and potentially serious incidents.

A limitation of the present paper is the availability of relevant data. At the time of its preparation, data collection and evaluation from the experimental testing of immersive glasses under real workplace conditions were still ongoing. However, the complete results were not yet available, and it was therefore not possible to formulate relevant conclusions based on the experimental validation. For this reason, the authors primarily focused on the analysis of publicly available data, from which only the basic relationships between the unemployment rate and the number of occupational accidents could be identified. Had data on the number of training sessions conducted, the number of occupational accidents, and the SIF values within specific organisations been available, the analysis of these relationships could have been considerably more detailed and might have revealed further associations among the variables under investigation. Future research by the authors will focus on the evaluation of data obtained through experimental observation and testing, thereby providing opportunities for a deeper understanding of the issue under study and for the formulation of more precise scientific conclusions.

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