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The Impact of the Use of VR on the Effectiveness of Training in the Field of Occupational Health and Safety and Ergonomics - the Perspective of Polish Enterprises

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Abstract: Enterprises are increasingly using modern solutions to train employees in the field of occupational safety and ergonomics. This is intended to encourage active participation in such training and to shape employees' awareness of these topics. One of the solutions used may be VR technology, which allows the employees to learn about issues by presenting situations as close to real ones as possible. The aim of this article is to present conclusions from the use of VR in Polish enterprises. The advantages of this solution were analyzed according to the OHS specialists, and the difficulties with implementing it in training were also indicated.

Keywords: ergonomics; occupational health and safety; OHS trainings; virtual reality

1 INTRODUCTION

Occupational health and safety training is an important issue in providing basic safety information to employees in all countries, including Poland. The issues discussed therein, the method of conducting and the frequency of the training determine the safe performance of work by employees, the use of appropriate protective measures and the implementation of activities aimed at shaping high employee awareness in this area. This is even more important because many accidents at work are caused by inappropriate behavior of employees, e.g. in the use of protective equipment, inappropriate management of the work process and lack of caution while working (especially when using tools and machines) [1]. According to preliminary data on accidents at work in Poland in 2023, 41% of accidents were caused by employee's incorrect action. Additionally, the human-related causes of accidents include: inappropriate use of personal protective equipment (approx. 2% of accident causes), inappropriate use of work materials (approx. 10% of accident causes), non-compliance with occupational health and safety regulations and instructions (approx. 6% of accident causes). It can also be pointed out that the causes of accidents in Polish companies are often the responsibility of employers, especially in terms of: ensuring appropriate technical conditions and work ergonomics, incorrect work organization or inappropriate work tools [2]. For this reason, occupational health and safety training will be important not only in terms of achieving appropriate employee behavior, but also in shaping appropriate working conditions that will support, and in some cases even enable, these behaviors.

Occupational health and safety training (which also includes ergonomic topics) is often conducted in the form of a lecture with elements of practical exercises and task performance [3]. They often also include activating elements, such as case studies, instructional videos, and problem presentations. There is also an increase in interest in the use of VR elements in occupational health and safety and ergonomics training. The advantages of implementing this solution include [4, 5]:

- The ability to provide employees with teaching based on examples and in conditions as close to real ones as possible,
- Promoting modern technologies among employees, which can also be used outside occupational health and safety training,
- Active participation in the training through careful analysis of the examples presented,
- Encouraging employees to work in accordance with health and safety instructions and regulations by realistically showing the consequences of inappropriate behavior.

On the other hand, however, there are general disadvantages of using VR in occupational safety training in terms of: high costs of the solution, high organizational requirements, the possibility of employees experiencing discomfort related to the use of goggles (e.g. eye and headache), the need to provide a trainer with extensive knowledge about VR, the need to allocate time during training to explain how VR technology works [6].

Taking into account the developing trend of using VR in employee health and safety training, this article examines how it works in selected Polish enterprises. Five cases were analyzed (in the form of participant observation and informal interview), indicating the impact of the use of VR on the effectiveness of training, and the advantages and difficulties of implementing this solution were indicated.

2 APPROACHES USED IN OCCUPATIONAL HEALTH AND SAFETY AND ERGONOMICS TRAININGS – LITERATURE REVIEW

2.1 Obligation of Training in the Field of Occupational Health and Safety (Including Ergonomics)

According to the legal regulations in force in Poland, periodic training in the field of occupational health and safety is mandatory for every employee. They are performed at a specific frequency (e.g. for workers in blue-collar positions once every 3 years and for employees working in particularly hazardous processes once a year). The program of such

training is established and includes the following elements [7]:

- Presentation of legal regulations related to occupational health and safety,
- Presentation of threats related to the workplace and ways to eliminate them or reduce their effects,
- Rules of conduct in the event of an industrial breakdown and accident at work,
- Basic rules on fire protection in the workplace,
- Basic principles of organization and providing first aid in the organization.

Training for workers in blue-collar positions should take place in a stationary form with the participation of a trainer specializing in occupational health and safety.

2.2 Remote Training in the Field of Occupational Health and Safety and Ergonomics

Polish legal regulations allow for the organization of periodic occupational health and safety training for employees remotely, but only for managing employees, administration and engineering and technical staff. It should take the form of a course, seminar or guided self-study based on materials received from the training organizer [7]. It is important to ensure the appropriate level of education and knowledge of the person conducting the training or providing training materials, as this largely determines the provision of the most important information in an appropriate form [8].

Organizing these training courses remotely has become more important during and after the COVID-19 pandemic [9]. This is also related to the development of the trend of remote work and its inclusion in Polish law [10], as well as the need to include in training issues such as: threats when working from home, appropriate, ergonomic adjustment of the workstation, reporting accidents that occurred during remote work [11].

2.3 The Use of VR in Training in the Field of Occupational Safety and Ergonomics

VR technology is increasingly being used in health and safety training taking into account ergonomics [12], also in Poland. This is intended to familiarize employees with real conditions (but without the risk associated with hazards at workplaces), but also to encourage committed participation in the training (e.g. by using gamification elements). Employees can also test their knowledge of what to do in emergency situations in which they were not previously able to take part, e.g. fire, spread of chemical substances, accident while working at heights, which allows them to supplement their theoretical knowledge about how to behave in such situations [13, 14]. A big advantage of using VR in occupational health and safety training is the ability to shape appropriate employee behavior by showing them in real terms the possible consequences of their incorrect behavior while working (e.g. if they do not protect themselves while working at heights, they can see the effects of a fall). It is not possible to achieve this effect by conducting training only theoretically, which is why companies are increasingly turning to virtual reality solutions (also in the context of shaping safety culture of work) [15-17].

In Poland, VR solutions in occupational health and safety training are implemented in many industries, especially for employees in production positions, where there are many risk situations and a particularly quick response to noticed dangers and irregularities is required [18, 19]. Such training is characterized by a specific order in which individual topics are presented, which results mainly from the curriculum in this area imposed by legal regulations. It is possible to compare various aspects of traditional occupational health and safety training and that using VR (Tab. 1).

Table 1 Comparison of traditional occupational health and safety training and training using VR

Training aspect	Traditional training	Training using VR
Presentation of legal regulations in the field of OHS and ergonomics	The presentation can be made by reading the most important provisions in the indicated legal OHS regulations	The presentation can be made by reading the most important provisions in the indicated legal OHS regulations - it can also be supplemented with a presentation of how VR technology works
Presentation of hazards at the workplace	The presentation can be made via PowerPoint with photos from the company, and threats may also be shown when walking through the workplace	The presentation can be made via PowerPoint with photos from the company, and threats may also be shown when walking through the workplace
Rules of conduct in the event of an accident	Presentation of internal procedures related to dealing with accidents and reporting their occurrence	Presentation of internal procedures related to dealing with accidents and reporting their occurrence - possible supplementation with a VR accident module and showing situations close to real ones (e.g. ergonomics)
Presenting information on fire protection rules	Presentation of internal procedures related to fire protection and how to use a fire extinguisher	Presentation of internal procedures related to fire protection - the possibility of presenting employees with a VR module regarding, for example, what to do in a burning building or how to use a fire extinguisher
Presenting the rules of first aid	Presentation of first aid rules on a mannequin or instructional videos	Presentation of first aid rules on the VR module, e.g. how to treat a cut, what to do in the event of a heart attack, what to do in the event of choking, etc.

Source: own elaboration based on: [7, 18, 19].

There is a designated time in which topics should be discussed in order to conduct the training within one working day. For this reason, it is possible to propose VR implementation in some training sessions (Fig. 1).

It is important to devote more time to issues in which VR can be used - time is necessary to organize the station and complete the module.

Companies offering the use of VR provide various modules that can be implemented in occupational health and safety and ergonomics training, e.g. [20-22]:

- Fire protection and behavior in case of fire,
- Working at heights and the risks associated with it,
- First aid in the event of a threat to life and health,
- Ergonomics at work stations (mainly basic principles).

The topics of occupational health and safety training using VR can therefore be adapted to the company's capabilities but also to the real problems occurring in it.

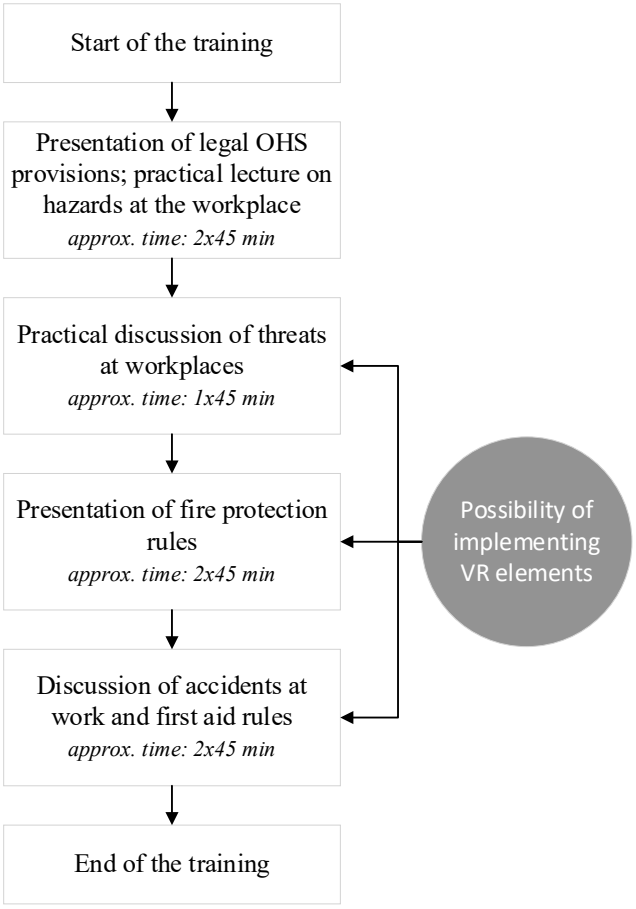

Figure 1 Possibility of implementing VR elements at individual stages of occupational health and safety training. Source: own elaboration based on: [7, 13].

3 METHOD OF RESEARCH

The undertaken research was carried out on the basis of the cases of five Polish manufacturing enterprises. They were selected due to the lack of use of VR in occupational health and safety and ergonomics training in the past (the research training was the first attempt to use this technology), as the aim was to test the feasibility of its use. The research was carried out in three main stages:

1) Analysis of the method of conducting training in the field of occupational health and safety and ergonomics in the enterprise and the method of verifying employees' knowledge (in the form of a test and questions regarding: legal provisions regarding occupational health and safety, fire protection, first aid, accidents at work and threats at workplaces).
2) Participant observation in training in the field of occupational health and safety and ergonomics (provided by an external company) using VR elements (participation in the theoretical part, participation in the practical part and participation in the test at the end of the training) - an example of the use of VR in training is shown in Fig. 2. Five employees from each selected company took part in the training.
3) Informal interview with health and safety specialists supervising health and safety training and analysis: possibilities of permanently implementing VR in health and safety training, organizational possibilities of VR implementation and barriers to implementing this technology in practice.

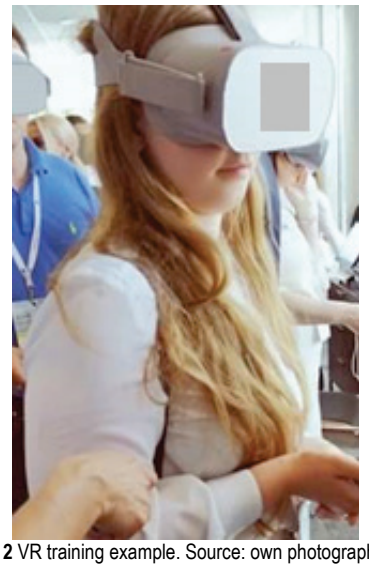

Figure 2 VR training example. Source: own photography.

The above-mentioned stages 1 and 2 took place during one working day, stage 3 was additionally supplemented with remote consultations with occupational health and safety specialists.

4 RESULTS

In the first stage of the research, methods of conducting occupational health and safety training for workers were analyzed. The training was organized with the help of an external company, in a stationary form, at the time specified in the legal regulations (lasting one working day). The training ended with a knowledge test in the areas included in the training program (the tests were archived). Ergonomics was an integral topic discussed during the meeting with employees.

In the second part of the research, a practical part of the training in the field of occupational health and safety was carried out using various VR modules in this area. During the observations, it was noticeable that the employees participated in the training willingly and with interest, but on the other hand, organizing space for performing the task seemed to be problematic. Another disadvantage was the

small number of devices compared to the number of trained employees.

After completing the training, a knowledge test was conducted among employees, the results of which were then compared with the results of previous trainings (in which VR technology was not used). An increase in correct answers was observed in three parts of the test (first aid, ergonomics and fire protection), which were related to the VR modules used (Fig. 3).

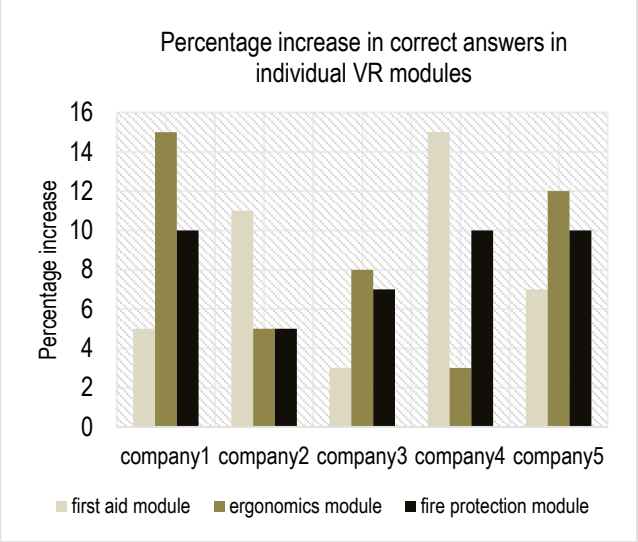

Figure 3 A noticed increase in providing correct answers in the knowledge test after occupational health and safety training using VR. Source: own elaboration.

In the third part of the research, informal interviews were conducted with occupational health and safety specialists supervising OHS training to discuss the possibility of permanent implementation of VR technology into the training. The information obtained from these conversations can be divided into opportunities and obstacles to implementing this solution. Among the advantages, occupational health and safety specialists pointed out:

- Noticeable, greater involvement and interest of employees in the form of training (previous, mainly theoretical training did not engage employees in activities, which was later reflected in the application of the acquired knowledge in practice, e.g. in the context of using personal protective equipment),
- Better results of the knowledge test conducted among employees (which suggests better absorption of information provided during the training),
- The ability for employees to test emergency situations in conditions similar to real ones - without the need to provide them, e.g. using artificial smoke simulating a fire.

On the other hand, however, occupational health and safety specialists have noticed many barriers to the permanent implementation of VR in OHS training. They pointed out the following difficulties:

- The need to provide plenty of space for employees to move freely in VR goggles (stationary traditional training requires only a room with an appropriate number of chairs, the use of VR forces movement, often without employees being aware of it),
- The need to provide much more time for training than in the case of stationary training - completing each module with limited access to goggles extends the training, which usually lasts one working day,
- Reluctance of some employees to use modern technology and some employees experience headaches and nausea after using goggles - for this reason, occupational health and safety specialists would consider VR as an optional addition to training, without replacing the traditional form.

An interesting remark is that occupational health and safety specialists did not indicate the costs of this solution as a barrier to implementing VR into OHS training. Although appropriate modules, their updates and goggles may constitute a significant expense, according to specialists, the profits in the form of greater employee involvement would be very important for the company and its safety.

5 DISCUSSION

The use of VR in periodic training in the field of occupational health and safety and ergonomics in enterprises (especially manufacturing ones) in Poland is undoubtedly subject to legal provisions in this area, which specify both the training program and its minimum duration. The legal regulations have not been significantly changed since 2004, therefore they do not take into account progress in teaching methods (including the use of virtual reality). It should be noted that more and more emphasis is placed on the employee's practical skills (especially in crisis situations related to OHS), therefore drills as part of the training should be aimed at obtaining the appropriate response of the employee, which can be ensured by conditions similar to real life provided by VR. This may be a factor that will determine the search for ways to overcome contraindications to the use of VR (e.g. health problems or high costs of implementing this technology compared to training conducted in a traditional form).

Although the article did not focus on proving the advantages of using VR in training in the field of occupational health and safety and ergonomics, it can be undoubtedly stated that it may be of great importance in the context of better acquisition of knowledge, practical experience of emergency situations and conditions of operation similar to real ones [23]. For this reason, it would be recommended to focus the legal provisions regulating OHS training in Poland on the possibility of including newer technologies as opposed to the traditional form of training.

Setting the minimum duration of training as one working day is also not conducive to implementing changes in the way training is conducted in companies (providing more time for training involves reducing work during this time and therefore losses). An interesting direction in the development of research on the inclusion of VR in occupational health and safety training in Poland seems to be determining the optimal

time to conduct training using selected VR modules. Research can also be developed to look for ways to encourage employees (especially older ones) to use VR during training and implement this solution also outside of training (e.g. providing VR stations close to employees so that they can get acquainted with its operation during breaks at work).

6 CONCLUSIONS

The results of the literature review and research undertaken indicate that the use of virtual reality elements in occupational health and safety training (including ergonomics) may be an important factor influencing the quality of these trainings and the acquisition of knowledge by employees on the use of protective equipment, response to accidents and failures, and ergonomics of workstations. Adding a virtual, engaging factor to the activity promotes better absorption of the information provided during the training and introduces elements of gamification that employees like. The use of VR also makes the traditional form of conducting occupational health and safety training (which in Poland is subject to a detailed program resulting from legal regulations) more attractive. In addition to the advantages of using VR in occupational health and safety training, there are also difficulties in its implementation in terms of ensuring a sufficiently long training time and an appropriate place to conduct it, which may be a big problem for many companies if they have deficits in these areas.

Certainly, an important conclusion from the undertaken research is the observation that the results of tests among employees conducted after training using VR are better than in the case of traditional, mainly theoretical training. Of course, this may be due to many factors (e.g. an increase in employees' awareness and knowledge in response to current activities and campaigns carried out in the company), but certainly providing conditions for practicing work situations in conditions as close as possible to real ones may promote better response when these situations actually occur.

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