KAPITEL 8 / *CHAPTER 8* [8]
TRAINING OF EMPLOYEES FOR OBTAINING A PERMIT TO PERFORM HIGH-RISK WORK USING VIRTUAL REALITY TOOLS

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Introduction

Ensuring occupational safety remains one of the most important conditions for the stable and efficient operation of industrial enterprises, especially in the context of rapid development of production technologies, intensification of work processes, and constant growth of risks associated with performing hazardous work. Accidents related to human factors still account for a significant share of the overall statistics of industrial injuries, which indicates the need to rethink approaches to professional training.

This problem is especially relevant in the context of performing hazardous types of work that require not only general awareness but also a high level of practical readiness and the ability to act under risk and make decisions in simulated emergency situations. In modern employee training practices, the main emphasis is usually placed on traditional forms of instruction, which are mostly formal, limited to familiarization with textual standards, and often do not ensure deep learning. As a result, employees are not always able to effectively apply the knowledge they have gained in real-world production environments, especially in situations requiring quick reactions and high stress tolerance.

The problem lies in the lack of effective training methods adapted to the current level of risks and psychological characteristics of employees, which would involve not only informing but also developing practical skills of safe behavior. In this context, the integration of virtual reality (VR) technologies into the process of preparing for hazardous work opens up new opportunities: recreating hazardous work situations in a safe environment, greater involvement in the active learning process, and individualized approaches to assessing knowledge and skills.

Thus, there is a need to study the effectiveness of VR technologies in the process

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of training personnel preparing to obtain a permit to perform hazardous work, as well as to develop models of such training that can improve the quality of knowledge acquisition, reduce the level of production risks, and increase the overall level of safety at enterprises.

8.1. Implementation of VR technologies for training and testing of industrial safety knowledge in various industries

As of 2023, 2/3 of the global VR device market was used in gaming and entertainment. Other industries in descending order of application include healthcare, engineering, real estate, retail, military, and education [1]. As the report shows, the gaming and entertainment industry shows a fairly high annual growth rate – over 5 years, the average annual growth rate (CAGR) reached 77%. This rapid growth is attributed to restrictions during the COVID-19 pandemic in 2020.

As of 2023, Shell is one of the leaders in implementing VR for training in the oil and gas industry [2], primarily for offshore drilling platforms. The use of VR training allows simulating emergency situations at such facilities without creating real danger to workers during training, testing knowledge, and practicing actions in such situations.

In Ukraine, in 2020, DTEK, a fuel and energy company, introduced VR training for some categories of specialists. The created simulator simulates work at a 110 kV power substation. The simulation is dedicated to the repair and commissioning of a power substation after repair [3]. The training combines the study of theory with practical tasks.

The use of VR technologies for training emergency services professionals, such as firefighters, is promising, especially where the training involves a multi-user (group) approach that allows teamwork when creating full-length avatars of participants in hard-to-reach environments. Such training is difficult to present physically in normal conditions, but it is possible to simulate such conditions under which high involvement of participants in the process is achieved. However, the authors point out the difficulty of immersion in such training [4].

In 2017, UPS was one of the first companies to use VR technology to train its drivers [5]. This allows drivers to practice realistic scenarios that they may encounter while transporting various cargoes, including dangerous goods. This innovation has significantly reduced the time it takes for drivers to start working for the company and improved the quality of training.

8.2. Advantages and disadvantages of using virtual reality technologies for professional training

The use of VR technologies in the professional training of employees, in particular for high-risk jobs, is an innovative approach that is rapidly gaining popularity in various industries [6]. VR opens up new opportunities for modeling complex production scenarios, providing a safe environment for developing the necessary skills and making decisions in stressful situations. At the same time, like any technology, virtual reality has its limitations related to the technical, organizational, and psychological aspects of its implementation.

We will consider the main advantages and disadvantages of using VR in the context of professional training of employees, which will allow us to comprehensively assess the feasibility of its integration into the personnel training system at enterprises.

Speaking separately about education, the use of VR technologies has its advantages compared to other forms of education, including:

- safe environment for practicing dangerous scenarios. Thanks to VR, you can simulate any dangerous situation without creating a real danger for those undergoing training or coaching, as well as for others, which is especially important when simulating the performance of high-risk work. You can simulate any dangerous event or situation, machine or mechanism or process;

- immersiveness or involvement of the learner in the learning process, which is much deeper than in conventional learning. Virtual reality allows you to change the scenario of events at your discretion. It allows the user to immerse themselves in a virtual world where they literally feel the place they are in. This makes the learning

process more qualitative and allows you to better absorb the material. For example, studies in the medical field have shown that surgeons trained using VR techniques perform operations 29% faster than those who used traditional methods [7];

- the ability to practice skills repeatedly. Employees can repeat the training without restrictions until they reach the required level of confidence in their actions, which makes it impossible to use this approach in real dangerous conditions;

- high quality visualization. Due to the fact that virtual reality is more visual, it allows you to better model a complex and dangerous process with any degree of detail. When studying or training, a person interacts with the virtual environment in which he or she is located, can solve problems that arise in the learning process, and experiment while performing a task, and as a result, achieve the learning goal in different ways. Virtual reality can even save a company money on training by minimizing the cost of purchasing real equipment and materials;

- high concentration and motivation. When immersed in the virtual world, virtual reality surrounds a person 360°, allowing them to avoid distractions from external stimuli and better focus on the simulated situation and the material being taught;

- individual approach. Virtual reality can be customized for each person undergoing training. The learner can do it at their own pace, choosing the most interesting tasks and material. Training can be performed at any time of the year, time of day, in different weather conditions and indoor microclimate conditions;

- saving resources in the long run. Despite the high initial costs, VR reduces the need for real equipment and materials and the cost of instruction, training, and compensation for potential incidents during training.

On the other hand, the significant potential of VR technologies in the field of professional training of employees, their implementation is accompanied by a number of limitations and challenges that should be taken into account when planning training. Let us summarize the main ones.

One of the key problems is the **high cost** of implementing and maintaining VR systems. Creating an effective learning environment requires significant investments

in the development of specialized software, the purchase of high-tech equipment (including VR helmets, touch controllers, computers with high computing power, etc.), as well as in technical support and system upgrades. Such costs are not always feasible for businesses with limited budgets, especially in an unstable economy, under martial law, or in the public sector.

Another limitation is the **inability of VR to completely replace physical interaction with real objects.** Although modern simulations reproduce visual and audio elements with high accuracy, they do not always provide a sufficient level of tactile sensations, weight transfer, resistance, temperature, etc. This can lead to the formation of partial or incomplete skills, which in real life can reduce the efficiency and safety of an employee's actions.

The use of VR can cause **psychophysiological discomfort**, in particular the so-called "cyber sickness", which manifests itself in the form of dizziness, nausea, headaches, and fatigue [8]. These symptoms are especially common among new users or when they spend a long time in a virtual environment. As a result, there is a need to limit the duration of training sessions or adapt them individually, which complicates the organization of the training process. There are conflicting data on the use of VR by people diagnosed with epilepsy, especially those with photosensitive epilepsy. Globally, 3% of epilepsy patients have photosensitive forms that are very sensitive to light stimuli. At the same time, up to 15% of all epileptic seizures occur due to photostimulation [9]. Therefore, in the process of professional selection when hiring new specialists, as well as during medical examinations, it is imperative to take into account the peculiarities of the health status when implementing virtual reality technologies, choosing the optimal duration of their use.

Implementing VR requires employees to have a certain level of digital literacy. People who do not have experience with computers and modern information systems may have **difficulty mastering the virtual environment.** This can be a barrier to learning, especially for older workers or those who do not have regular access to digital technology.

A separate danger is the possible **overestimation of one's own skills** after

completing virtual training. Due to limited scenarios or the lack of psychological stress inherent in real situations, an employee may feel overconfident in their actions. This creates a risk of incorrect behavior when performing real dangerous work, where the human factor and stress reactions play an important role.

You should also consider the **risk of technical failures**, which can lead to suspension of training or loss of training results at any time. VR systems depend on a stable power supply, software performance, and proper hardware functioning. In the event of technical problems, the training process can be disrupted, which is especially critical in cases where training has a limited time frame.

The issue of insufficient regulatory and legal regulation of VR in the field of occupational health and safety and vocational training remains relevant. Many countries, including Ukraine, still lack clear standards or guidelines that would recognize VR training as an equivalent or part of the official training program for hazardous work [10]. This creates legal uncertainty regarding the recognition of such training by competent authorities and employers.

Thus, despite its significant advantages, the use of VR in training employees to perform hazardous work requires critical analysis, adaptation to the specifics of the production environment, and support from both technical and pedagogical specialists.

8.3. A step-by-step algorithm for preparing an employee to perform hazardous work using virtual reality technologies

For the effective assimilation of knowledge and the formation of sustainable practical skills in the field of occupational safety and health when performing hazardous work, it is advisable to use a structured, phased approach to training with the integration of virtual reality technologies. Such an approach allows not only the systematization of the process of training employees but also the ensuring of individualization of the learning trajectory, flexible response to the needs of the employee, and an objective assessment of the acquired competencies. The algorithm for preparing an employee to perform hazardous work, which combines traditional and

innovative educational methods using VR modeling, is shown below (Figure 1).

Employee training includes the following stages:

a) Initial assessment of knowledge and skills.

Prior to the start of the training, a basic check of knowledge of occupational health and safety, safety rules, and experience with specific hazards is carried out. This allows us to create an individualized learning path for each employee.

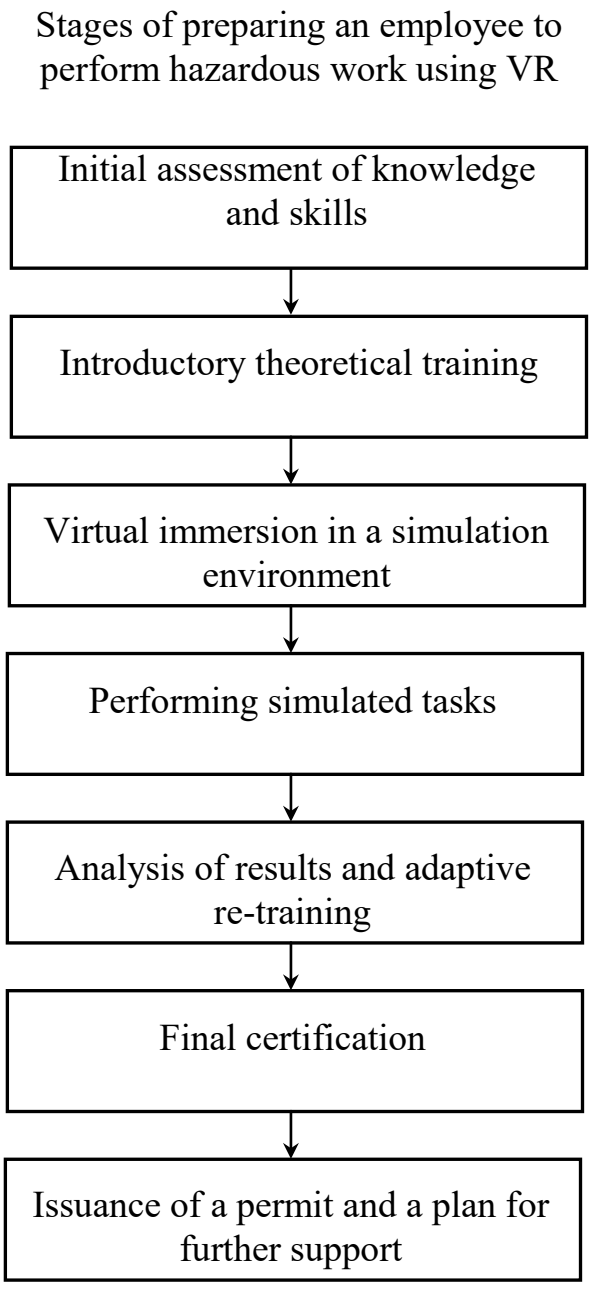

Figure 1 – A step-by-step algorithm for preparing an employee to perform hazardous work using virtual reality technologies

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b) Introductory theoretical training.

The employee receives a short course on theoretical basics, for example: familiarization with the types of hazardous work, applicable laws, permit requirements, types of risks, and necessary personal protective equipment.

c) Virtual immersion in a simulation environment.

At this stage, the employee puts on a VR headset and enters a simulated situation, such as working at height, in an electrical control room, or in a confined space. In the virtual environment, they get to know the equipment, tools, conditions, and potential hazards.

d) Performing simulated tasks.

The employee performs training tasks that simulate real-life work scenarios: checking personal protective equipment, climbing to a height, actions in case of a short circuit, evacuation from a hazardous area, etc. The software records errors, reaction time, and correctness of actions.

e) Analysis of results and adaptive re-training.

After completing the VR scenarios, the system generates feedback: it analyzes the achievements and identifies critical errors, inaccuracies, and knowledge gaps. Based on the data obtained, the employee is offered additional training modules to strengthen skills in areas where weaknesses have been identified.

f) Final certification.

The knowledge and practical skills are assessed in the format of a controlled VR scenario or in a combined manner – testing and observation of actions in a virtual environment. Based on the results, a report is drawn up to make a decision on the employee's admission to high-risk work.

g) Issuance of a permit and a plan for further support.

Upon successful completion of the training, the employee receives a permit for hazardous work. A schedule of retraining or regular VR training (for example, once every 6-12 months) is formed to maintain skills at the proper level.

This approach integrates the stages of traditional training with the capabilities

provided by VR modeling and can be used as the basis for an enterprise's internal training regulations.

Conclusions

This paper analyzes the possibilities of using virtual reality (VR) technologies to train employees to perform high-risk work. It is shown that VR training creates conditions for deeper learning due to the high level of engagement, visibility, and the ability to simulate a wide range of potentially dangerous situations in a safe environment.

The developed VR training algorithm covers all stages – from the initial assessment of knowledge to certification and planning of further support of the employee – which allows individualizing the learning process and improving its results. The article also highlights the advantages and limitations of the VR approach, which creates the basis for a balanced implementation of this technology in the occupational health and safety system.

Thus, virtual reality has significant potential in the field of vocational training but requires further research on its effectiveness, regulatory regulation, and adaptation to the conditions of specific industries. Taking into account technological, psychophysiological, and organizational factors is key to the successful integration of VR into the practice of training employees to perform hazardous work.