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A Comparative Analysis of OSH Training: Evaluating Traditional Methods Versus Interactive and Virtual Reality Approaches in the Context of Sustainability

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Abstract: Occupational safety and health (OSH) training plays a crucial role in preventing workplace accidents, ensuring compliance with legislation, and fostering a safety-oriented culture across all sectors. This article compares traditional OSH training methods with innovative approaches that incorporate interactive elements and virtual reality (VR) technologies, with a particular emphasis on their contributions to sustainability. The study analyzes feedback from training participants across various occupational roles and age groups, focusing on the effectiveness, engagement, and perception of each method. The results demonstrate that interactive training and VR-based training not only enhance participant engagement and improve comprehension of safety procedures but also promote sustainable training practices by reducing the need for physical materials, minimizing travel, and decreasing reliance on extensive on-site infrastructure. These advancements contribute to environmental sustainability within safety training programs. The paper further explores the benefits, challenges, and economic considerations associated with implementing sustainable, technologically enhanced training approaches. The findings suggest that integrating modern, sustainable educational technologies into OSH training leads to more effective knowledge transfer, better preparedness of employees for emergency situations, and a reduction in environmental impact, aligning safety training practices with broader sustainability goals.

Keywords: training; safety; health; emergency; virtual reality; interactive tools; industry; employees; HSE; crisis preparedness; sustainable jobs

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1. Introduction

This article covers ways in which the quality, the level of involvement of the audience, and, above all, the attractiveness of training in the field of occupational safety and health (OSH) or preparation for coping with various emergency situations can be improved. It also takes into account current factors such as the COVID-19 pandemic, which has made it difficult—and at times impossible—to conduct face-to-face training, as well as the ongoing development of modern technologies. This includes the use of interactive audiovisual elements, virtual reality tools, and the examination and evaluation of audience feedback. The authors created and applied several practical training models for these purposes. Based on their implementation across diverse audiences in terms of group type, gender, and age, feedback was collected to compare these approaches with traditional methods of training and preparation for crisis and emergency situations. The aim of the study is to explore how participants from different age and professional groups perceive VR-based OSH training in terms of engagement, usability, and its impact on their sense of preparedness for performing workplace-related tasks. The benefits or shortcomings of these modern training methods are then evaluated based on a comparison with conventional training approaches. The remainder of this paper is structured as follows: Section 2 provides an overview of current OSH training practices and related challenges, Section 3 explores the role of interactive elements, and Sections 4 and 5 present the implementation and use of virtual reality (VR) in training environments. Section 6 summarizes participant feedback, Section 7 discusses the implications of the findings, and Section 8 concludes the paper with final observations and recommendations. The final section of the paper provides specific examples of several forms of training and an analysis of their expected impact on participants. The research question for this article is the following: How can modern technologies like virtual reality improve the quality and engagement of OSH training compared to traditional methods?

2. Current Training Methods

2.1. OSH Training

The aim of OSH training in most companies within the European Union is not the expected effort to increase employee risk awareness. Their aim is primarily to protect themselves (employers) so that in the event of an accident, there is no doubt that they have not neglected their duty to provide employees with additional and adequate information and guidance on health and safety at work. However, the impact on employees is exactly the opposite. They lose their attention even when the areas to be covered in this form of training are listed, and it is very difficult to keep them engaged during this training.

The employer (in the Czech Republic) is obliged to train employees so that, according to the Labour Code,

> *"To ensure that employees, . . . , according to the needs of the work they perform, sufficient and adequate information and instructions on OSH protection according to this Act and according to special legal regulations, in particular in the form of acquaintance with the risks, the results of risk assessment and the measures for protection against the effects of these risks that are relevant to their work and workplace."* [1]

The Labour Code does not specify how often the training should be carried out, how long it should last, and who can carry it out. The implementation of this requirement can then vary widely in practice. The most common form of such training is then often limited in practice to mass training of a few persons, sometimes up to dozens. The content of the training encompasses a range of areas, including occupational safety, fire protection, legal requirements, and environmental protection. Such training can last for several hours or sometimes even an entire working shift.

It could be said that only the visual form of training has changed in the last 40 years. From whiteboards and bulletin boards, we have moved on to overhead projectors and digital displays. Fortunately, thanks to modern means of communication, the more progressive trainers use diagrams, photographs, and videos in their presentations. This certainly increases the attractiveness and value of the information conveyed; however, today, it is possible to go much further.

2.2. Practical Training of Integrated Rescue System (IRS) Units Through VR

The classic form of paper-based training with the necessary information and working procedures for emergency services and crisis management should be combined with practical or experiential learning. A popular form that is gradually becoming more common is e-learning using classic 2D projection (video). Other methods based on E. Dale's theory can also be used for more effective learning. He created the so-called learning pyramid, where the lecture represents the top of the pyramid. According to the modified pyramid, a lecture has the lowest learning efficiency [2].

Figure 1 illustrates that the efficiency of the learning process increases significantly when as many perceptions as possible are employed. Two examples of successful and effective VR solutions for training firefighters and emergency managers are provided: Firefighter VR and FLAIM VR.

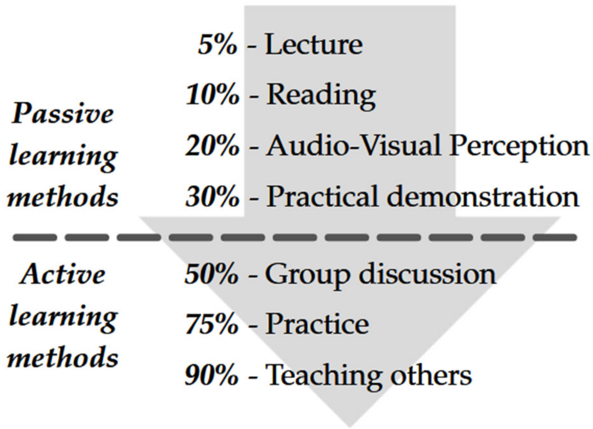

Figure 1. "Learning Pyramid"—average retention rate [2].

Firefighter VR is an advanced training platform developed by Northdocks GmbH with the support of the German Association of Factory Firefighters. It utilizes virtual reality to provide realistic and safe training for firefighters. The platform features simulations of fire scenarios in residential, office, and industrial settings, as well as exercises in evacuation, victim rescue, and the use of thermal imaging cameras. It also includes training in the use of firefighting equipment, such as pumps and breathing apparatuses, and in responding to hazardous material incidents. Emphasis is placed on teamwork, communication, and managing stressful situations. The platform provides detailed feedback and performance analysis to support continuous skills improvement [3,4].

FLAIM VR is an advanced firefighter training platform that combines high-fidelity virtual environments with physical interfaces to deliver a fully immersive, multisensory training experience. Developed through more than a decade's worth of research at Deakin University's Institute for Intelligent Systems Research and Innovation, the system replicates realistic fire behavior, including smoke, flame spread, flare-ups, and explosions. The FLAIM Trainer provides safe simulations of hazardous environments such as airports, aircraft, warehouses, and mines. It incorporates physical components like the self-contained breathing apparatus (SCBA), hose reels with reactive force, and thermal suits to closely mirror the physical demands of firefighting. The system tracks biometric data, such as breathing patterns and fatigue, enabling detailed performance feedback and the optimization of training. Fully portable and deployable in under 15 min, the platform supports frequent training and promotes environmental sustainability by reducing the need for live fire exercises, conserving water, and limiting exposure to harmful substances [5,6].

These examples were selected to illustrate the potential complexity of actions and procedures and the aim to replicate real-life responses as faithfully as possible in the training of participants.

2.3. Preparing for Crisis and Emergency Situations in the Workplace

Theoretical knowledge of emergency conditions is the basis on which managers try to prepare the operator of a particular technology during training. Practical experience, however, is something non-standard. If an employee has this practical experience—e.g., a chemical spill—it means that either the normal safety features and employee preparation for this situation have failed or that it was a controlled event (e.g., an emergency drill or simulation). However, the exercise does not provide the strong experience and exposure to the situation that is necessary to create a solid foundation for dealing with a similar situation in the future. In the field of first aid, very sophisticated methods of masking and portraying would-be victims have long been used to evoke strong emotions in rescuers, including inducing feelings of fear and increased stress, but also to more deeply cement the correct procedure in the rescuer's mind for possible use at a time when this help will literally be vital. Thanks to the rapid development of computer technology as well as various accessories, today's video game industry is able to create virtual environments and models of people and animals that are almost indistinguishable from the real thing. The use of these tools in the field of industrial safety should lead to an increase in crisis preparedness not only for emergency services but also for ordinary employees, who play a key role in the timely management of an emergency situation in the workplace.

3. Interactive Elements in Training

3.1. Visualization

Images, photographs, and videos are commonly used in employee training. They can capture the attention of the audience better than plain text—see the learning pyramid in Figure 1. Particularly in the field of workplace accidents or near misses, it is very easy to demonstrate the consequences of bad behavior with photographs from investigations of these incidents or industrial closed-circuit television(CCTV) footage. However, principles of data protection and commercial confidentiality must be considered carefully in these situations. In addition to learning from events that have already happened, animation and modeling of crisis scenarios, 3D animation, or the use of virtual or augmented reality can also be used.

3.2. Interaction

Interaction or active involvement of the audience in the training is difficult for several reasons. First of all, interaction is limited by the number of listeners. The more listeners there are, the more difficult it is to draw them in, engage them, or determine their roles [7]. Active involvement of the entire audience during online training is almost impossible. Another limitation is the diversity of the collective or their cultural archetypes. Still, most training sessions, especially online ones where the trainer does not have visual feedback from the audience, cannot be effective without some interaction elements. If no feedback is required from the audience, they can easily stop paying attention to the training altogether [8]. Modern ways of interaction include programmable presentations with procedural content generation, quizzes, questionnaires, or the creation of mind maps. Many of these programs are freely available on the internet [9]. Another very powerful tool is role-playing, where listeners can try out model situations [10]. These tools can be used to immerse the listener in the content and make them forget about the outside world [11]. In the following chapters, there are concrete examples of how to use these tools in practice.

4. Virtual Reality and Its Involvement in Education

4.1. Education in Schools

Since the first universities in ancient Greece, education has been concentrated in places where information is gathered, i.e., libraries, universities, and schools. In the 21st century, the vast majority of information has already moved into the data world, but education remains largely fixed to a physical location, not the source of information. It is clear that in such a flood of information and (especially) misinformation, people need skilled educators to help them navigate. However, the pandemic measures have shown how many educators are not prepared for the disconnection from the building (books, didactic tools) and the transition to the digital space [12,13]. There are already a lot of digital didactic aids available, especially for primary school grades 1 and 2. Many of them can also be displayed in 3D, such as the Assassin's Creed Origins—Discovery tool [14]. Another interesting example is the SkyView app, where children can explore the known universe to learn about stars and constellations. The BBC's 1943 Berlin Blitz project is also worth mentioning [15].

4.2. Education in Health and Emergency Preparedness

Virtual reality is becoming an invaluable tool in educating healthcare professionals. With the ability to simulate real-life situations in a safe and controlled environment, VR allows doctors, nurses, and other healthcare professionals to practice complex procedures without risk to patients [16]. As an example of the use of VR scenarios in healthcare, the VR Medical division of the Pilsen-based company CIE GROUP creates scenarios for the training and education of medical staff and for helping patients during recovery and rehabilitation. VR Medical has developed sophisticated VR scenarios that are used to rehabilitate patients with neurological and orthopedic diagnoses. These scenarios help patients increase their range of motion, overcome range of motion limitations, and reduce pain perception during exercise. The virtual environment is tailored to motivate patients and support their cognitive abilities, orientation, and planning [17]. In the field of crisis management, virtual reality is proving to be an effective tool for training emergency response teams and crisis managers. ETC Simulation—Advanced Disaster Management Simulator (ADMS) is an advanced VR simulator that enables realistic training in emergency management, from natural disasters to man-made emergencies. ADMS offers training in a 3D environment using artificial intelligence, allowing for dynamic adaptation of scenarios according to the reactions of the participants, creating a comprehensive environment for improved decision-making and crisis response. This simulator is used globally to improve the capabilities of crisis managers, commanders, and emergency responders [18].

4.3. On-the-Job Training

Microsoft is developing an environment for doctors using their HoloLens where they can study the bloodstream in detail, enlarge, manipulate, or even dissect individual organs in the body, and practice other procedures. Similarly, professionals such as engineers and designers already routinely use 3D modeling for their projects. These 3D models only gain plasticity and realism when using VR glasses, where the user can rotate the model and walk around it from all sides [19]. VR tools are essential to an effective learning process. With these tools, the listener is drawn into the content, letting them forget the surrounding world [20]. This process is commonly used in the video game industry, and it is only a matter of time before information technology (IT) development companies start to focus on this area or the development tools become so simplified that companies will prepare such training themselves.

5. Concrete Use of VR Tools in Practice

The authors' research involved the application of VR in several practical training modules. Pětvaldský T. participated in the development and subsequent implementation of VR modules created for a specific company involved in integrated steel production. Between 2019 and 2024, they created several modules for OSH training using VR or PC-based training. Kočkár S. and his team from the Department of Crisis Management, Faculty of Safety Engineering, University of Žilina, participated in the project "Teasers for training firefighters within immersive environments" (FightARs), which ran from 2020 to 2023 under the Erasmus+ program. The aim of the project was to test the possibilities of using augmented reality (AR) technology, specifically HoloLens 2, for training firefighters and crisis managers. HoloLens 2 allowed students and professionals to train in environments combining real-life situations with AR technology. During the project, the advantages and disadvantages of using HoloLens 2 were also evaluated, such as short battery life and overheating, highlighting its benefits for simulating crisis situations [21,22]. After the successful completion of the FightARs project, he and his team are now involved in the project "SAFAR—situational awareness training of firefighters within an immersive XR training site", which runs from 2023 to 2026 under the Erasmus+ program. This project focuses on testing AR and VR technologies in the training of firefighters and crisis managers to improve their situational awareness. The Faculty of Security Engineering (FSE UNIZA) collaboration is developing scenarios focused on CBRN-e (chemical, biological, radiological, nuclear, and explosive threats) training, specifically on the detection and localization of contaminated objects. The VR/MR Meta Quest 3 device is used for this purpose, as opposed to the HoloLens 2 device from the previous FightARs project. Within the HoloLens 2 environment, specific applications such as Remote Assist Dynamics 365 and Guides were used for selected scenarios designed for crisis managers in industrial settings aimed at familiarizing them with certain general operational tasks. The main objectives of the SAFAR project include introducing modern technology into training programs and preparing trainers for digital transformation. The project supports standardization of training procedures and tracking of trainee progress [23].

5.1. VR Modules for the Practical Training of Employees in an Integrated Steel Company

The basic method is the use of a VR headset and prepared OSH training modules for employees. The modules were created by modeling real operations into which various safety hazards were simulated. The aim was to transfer elements of the OSH training, such as fault finding or hazardous situations, into the VR environment. Employees were tasked with completing up to 20 tasks and then, at the end of the module, seeing how successful they had been or how they compared with their colleagues.

The following training modules are currently completed and in use:

Machine Shop Hall—a basic module (captured in Figure 2 below) where employees try to find common risks in the workplace or machines. Among the 20 risks are, for example, an unsecured hole, missing covers on rotating parts, and damaged wiring from an electrical appliance. There are also employees in the area who are not using all the prescribed personal protective equipment (PPE) or violating the smoking ban.

Figure 2. Example of a machine shop hall module (Autor).

Rolling Mill Hall—compared to the above, this module is more focused on working with suspended loads and risks associated with transport vehicles and material storage. Among the 20 tasks, there is a complex one that consists of tying a bale of rolled material, suspending it with chains, and then signaling to the crane operator to take the bale to the warehouse.

Energy Hall—this module is specialized for a very specific area of employees, namely for maintenance workers who, as part of their training, learn how to properly disconnect and secure different energy sources (water, gas, steam, electricity). They look for the right valves and controls to disconnect, then use Lock Out, Tag Out (LOTO) elements to secure them.

Steelworks Hall—the module is designed to train the correct use of fall protection equipment and to make the user aware of the risks in cases of choosing the wrong equipment. On a crane runway, roof, or scaffold, employees must select and use the correct fall protection equipment. If they choose the wrong ones, they may risk falling from several meters or dying due to electric shock from contact with the overhead wires that power the crane bridge. This module is very suggestive, and the experience of falling from the roof, in particular, is not very pleasant for VR users.

The training and testing lasted approximately three hours. Participants first completed a theoretical part focused on risk identification, followed by a practical section involving task performance within specific VR scenarios based on the steel manufacturing company environment mentioned above (approximately 12 min per person). The technical difficulty was moderate, as operating in a VR environment requires basic handling skills. Cognitive demands varied by scenario—the rolling mill and mechanical workshops were more general, while the power plant and steelworks required specialized knowledge. Physical demands were low due to the short duration and minimal physical activity involved. In total, 75 individuals participated in the full training and provided feedback. Approximately 80% of them were primarily shop-floor employees and their direct supervisors from the respective operational areas—the main target group, representing the majority of individuals who typically perform the real-life tasks represented in the VR scenarios. The remaining participants included managers, administrative staff, and students on internships or excursions. This participant composition was intentionally selected to cover a wide range of age groups and multiple vertical levels within the organizational structure, ensuring the broad applicability and relevance of the training results. Although the company employs nearly 2000 people, large-scale testing and data collection were not feasible due to hardware and time constraints.

5.2. Student VR Training with Immersive Factory VR on FSE UNIZA

Immersive Factory (IF) is an advanced training platform using VR for interactive OSH training. It simulates realistic work environments where participants identify risks and learn proper procedures for preventing workplace accidents. IF offers a wide range of scenarios, from production halls and construction sites to warehouses and hazardous substance laboratories, allowing for individual and group training with immediate feedback [24]. Testing of the platform at the Faculty of Safety Engineering at the University of Žilina (FSE UNIZA) showed that 83% of students found VR training more effective than traditional OSH methods, and 71% reported better memorability of safety rules. The results confirm that interactive VR training promotes active learning, increases participant engagement, and offers realistic simulations of work hazards in a safe virtual environment. Each student completed a scenario lasting approximately six minutes, during which they were tasked with identifying around ten safety hazards in a simulated warehouse environment. The limited time frame encouraged focused observation and efficient risk identification. The scenario required moderate technical and cognitive effort, as students needed to operate the VR system and apply relevant safety knowledge. Physical demands were minimal due to the use of teleportation-based movement, either through a gesture or controller input. IF thus represents an effective and scalable alternative to traditional OSH training, with the potential for further expansion into different sectors. Virtual reality allows complex situations to be practiced without compromising the safety of participants, thus making a significant contribution to the prevention of workplace accidents.

6. Comparison of Traditional and Modern Training Methods

6.1. Feedback from the Practical Training of Steelworks Employees

At the end of the staff training, anonymous feedback from participants was obtained via a questionnaire. It included the following questions:

(a) Information about the participant—gender, age, job title;
(b) Information about their experience with VR—how they liked the training, whether they had previous experience with VR, whether the training had any benefit for them, whether they felt uncomfortable using VR;
(c) Compare what is a better form of training for the participants in terms of information transfer, practicing a practical skill (e.g., bindery training), practicing theoretical knowledge (e.g., boiler room operator training or integrated management system training), and solving a problem.

For the purpose of this research, 75 questionnaires were evaluated from different groups of employees, different age categories, genders, or job titles (production or administrative worker or manager). Students were also included in the research to obtain more diverse responses. By evaluating anonymous questionnaires, the authors compared traditional training methods with experimental VR training (see Table 1 for details).

Table 1. Composition of the training sample (Autor).

	No.	Percentage
Total	75	100.00%
Gender		
Male	48	64.00%
Female	27	36.00%
Age		
<30	22	29.33%
30–45	23	30.67%
>45	30	40.00%
Profession		
Shopfloor worker	37	49.33%
Office worker	20	26.67%
Student/Internship	18	24.00%

As shown in Figure 3, participants aged 30–45 evaluated the training most positively, with 78.26% of them rating the VR modules as either “very positive” or “good”. The group over 45 years old also reacted positively, with 66.67% expressing satisfaction. Interestingly, the group under 30 years of age, often assumed to be the most digitally fluent, showed slightly lower overall satisfaction (61.90%).

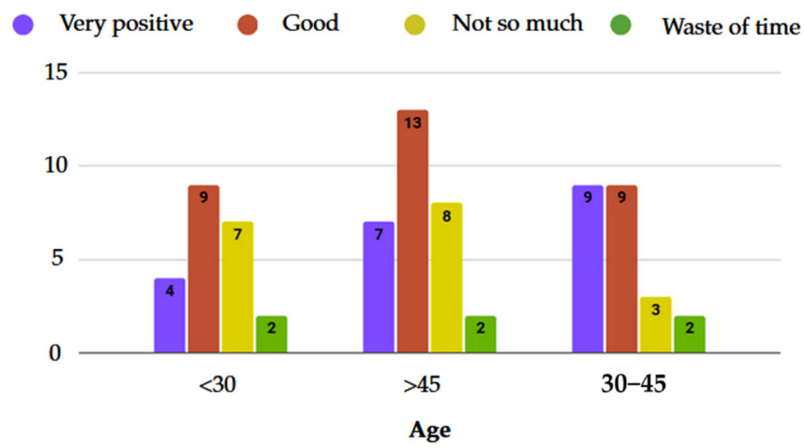

Figure 3. Perceived quality of VR training by age group (Autor).

This outcome suggests that the acceptance of modern training tools such as virtual reality is not solely tied to digital affinity or youth but may also relate to perceived relevance, personal experience, or professional maturity. The middle-aged group (30–45) possibly found the VR modules most relevant to their daily operational responsibilities, which may explain their stronger positive response. Overall, virtual reality training was positively received across all age categories, challenging the notion that this method is best suited only for younger participants. The feedback reflects broad applicability and highlights VR as a promising and inclusive training tool, especially in high-risk industrial settings.

Participant feedback revealed differing preferences regarding the use of traditional versus interactive methods depending on the training objective. As shown in Figure 4, traditional formats (lectures, presentations) were most frequently identified as more suitable for the transfer of knowledge (54 respondents) and the exercise of theoretical understanding (47 respondents). These findings suggest that participants view conventional approaches as more effective for structured instruction and the delivery of formal content. Conversely, interactive methods (such as VR, video-based tools, and gamified modules) were strongly preferred for practicing practical skills (47 respondents) and solving specific problems (48 respondents), highlighting their value in promoting active learning and applying knowledge in realistic scenarios. The results indicate that these two approaches are not mutually exclusive but rather complementary, with traditional methods well suited to foundational explanation and interactive methods excelling in experiential reinforcement and decision-making development. A thoughtful combination of both can significantly enhance the overall effectiveness of training programs.

In addition to these two hypotheses, the following conclusions were drawn from the questionnaire:

(a) Training modules with VR were more appreciated by women than men and by workers more than students and administrative staff. Participants in the 30–45 age group were the most interested.
(b) More students than other professions, more men than women, and, as expected, participants with an age below 30 had previous experience with VR.
(c) Less than one-quarter of the audience (22.66%) felt sick when using VR tools. Some trainees were so worried about VR that they did not attend the training at all. However, these were not included in the survey.

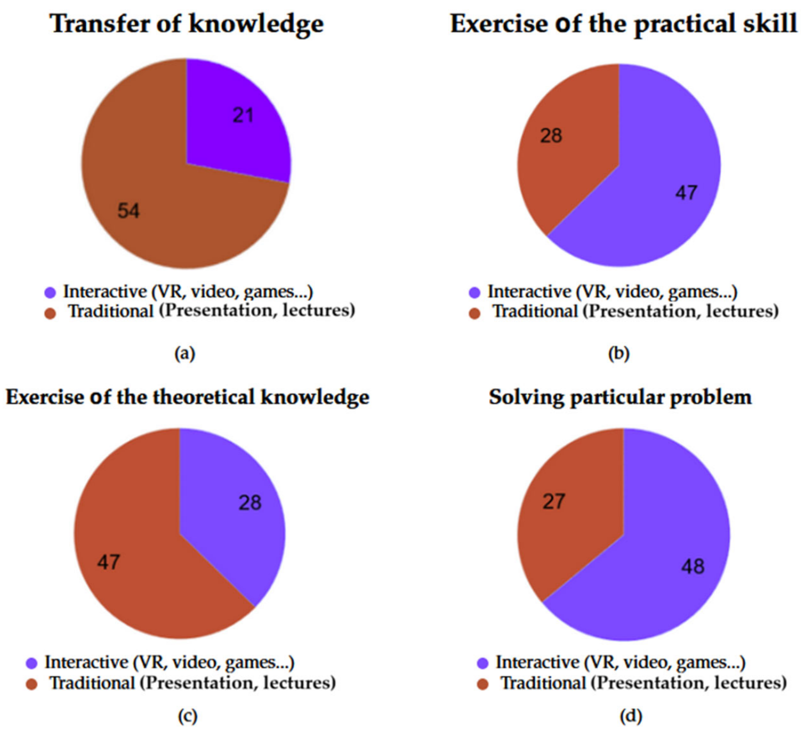

Figure 4. Users' opinions about the usage of the VR tool for different types of training (Autor).

6.2. Feedback from the Practical Training of FSE UNIZA Students

The pilot testing of OSH scenarios in VR took place at the Faculty of Safety Engineering of the University of Žilina in Žilina within the teaching at the Department of Crisis Management (FSE UNIZA). Testing was conducted using the Immersive Factory (IF) application, which contains various scenarios aimed at identifying risks in work environments. The aim was for students to identify potential risks in the simulated environments within a limited period of time. After the scenario, students were briefed on the risks that were not identified and received feedback in a debriefing session.

After finishing the scenarios, each student completed an anonymous questionnaire that identified their gender and focused on subjective feelings about the training, previous experience with VR, evaluation of the use of VR in OSH education, and preferences for how to use VR. A total of 56 students from three study programs—Crisis Management (KM), Safety Management (BM), and Emergency Services (ES)—participated in the survey.

As shown in Figure 5, the analysis revealed notable differences in user preferences and evaluations based on field of study and gender. In Figure 5b, students from Crisis Management expressed the most favorable responses: 10 out of 22 rated the training as "very positive", 11 as "good", and only 1 gave a "mixed" evaluation. Emergency Services students also responded positively, with 55.56% evaluating the training as "very positive". In comparison, Safety Management students were more reserved, with only 6 out of 18 rating it "very positive", 11 "good", and 1 "mixed". Figure 5a reveals clear gender-based differences in control preferences. Among female participants (n = 23), 16 preferred hand-tracking, whereas only 7 opted for controllers. Male participants (n = 33) showed a more balanced distribution: 14 chose controllers, and 19 preferred hand-tracking. Notably, Crisis Management students, who gave the highest overall training evaluations, also showed a tendency to favor controller-based interaction, suggesting a potential link between control type and perceived training effectiveness. Although most participants completed the training without issues, four students (7.1%) reported experiencing mild discomfort, such as nausea or motion sickness. This finding underscores the importance of considering individual tolerances when implementing immersive technologies. These insights highlight the necessity of a user-centered, flexible, and adaptive design approach in the development and deployment of VR training. In addition to ensuring content relevance (as reflected in stronger responses from students whose study focus is closely aligned with scenario topics), it is essential to consider users' preferred modes of interaction and their physical comfort levels. Solutions such as customizable control schemes, adjustable environmental settings, and modular training content can help accommodate diverse user needs. Properly designed VR systems can thus enhance both user satisfaction and the overall effectiveness of knowledge and skill acquisition.

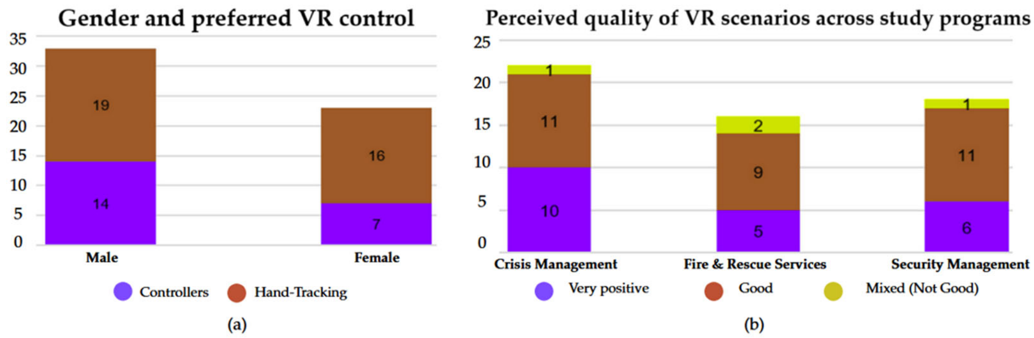

Figure 5. Preferred VR control by gender and perception of VR scenarios by study program (Autor).

As illustrated in Figure 6, notable differences in previous experience with virtual reality (VR) technology were observed between male and female participants. Among male respondents, 48.48% (16 out of 33) reported prior experience with VR, compared to only 34.78% (8 out of 23) of female respondents. This disparity may be attributed to varying levels of access to technology, individual interest, or general exposure to digital tools. Despite the lower proportion of prior experience among women, their responses to the VR training were predominantly positive. The majority of both men (48.48%) and women (65.22%) rated the training as "good", while the proportion rating it as "very positive" was 42.42% among men and 30.43% among women. Additionally, 13 participants (23.21%) reported experiencing nausea or discomfort during the VR training. While not a majority, this group represents a significant portion of users whose needs must be considered in both the design of VR content and the technical parameters of its delivery. These findings underscore the importance of developing training experiences that are sensitive to varying levels of user familiarity and physiological tolerance, thereby enhancing accessibility, comfort, and overall effectiveness.

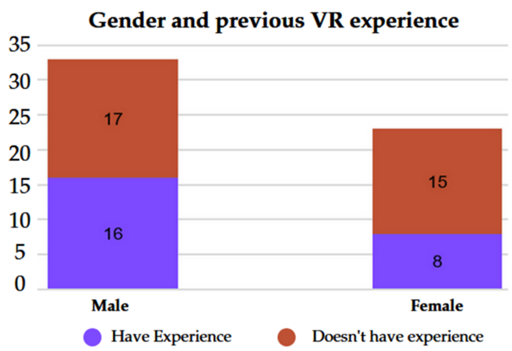

Figure 6. Previous VR experience by gender (Autor).

7. Discussion

Modern VR-based training demonstrates clear advantages over traditional approaches, particularly in practical skills development, hazard identification, and problem-solving. Given the continuing incidence of occupational accidents across the EU, Slovakia, and the Czech Republic [25], such innovative methods are increasingly relevant. The age group 30–45 years rated VR training most positively, likely due to technological proficiency and workplace safety responsibilities. Data from both industry employees and university students confirmed that VR promotes active engagement and improves risk recognition. For instance, students at FSE UNIZA identified approximately ten hazards in a six-minute scenario. However, 22.66% of all participants (17 from industry, 13 students) experienced discomfort, indicating the need for improved ergonomics and broader accessibility. Cost and the lack of expert staff also remain limiting factors [26]. Differences in interaction preferences were observed, with men generally preferring controllers, while women favored hand-tracking [27], underscoring the importance of a tailored training design. A comparison of the two groups showed that industry workers completed longer 12-minute modules simulating complex operations, while students trained in a shorter 6-minute scenario focused on theoretical knowledge. Both groups showed high engagement, confirming the adaptability of VR across different learning environments. Discomfort was slightly lower among students (23.21%) than employees (22.66%), possibly due to design differences or varying tolerance levels. The potential of VR in occupational safety and crisis management is expected to grow, given its scalability and safety [28,29]. Dai et al. highlighted technical limitations, such as image blurring and latency, when using mixed reality in construction settings [30], while Leder et al. demonstrated VR's superiority over PowerPoint presentations in enhancing learning outcomes and risk perception [31]. In the context of emergency preparedness, VR represents one of the few safe and scalable tools for training personnel in scenarios that are difficult to replicate in real life. Realistic simulations enhance both reaction time and readiness, and their effectiveness can be further supported by tools such as ALOHA [32,33]. The findings presented in this article align with the existing literature and offer practical guidance for the broader implementation and advancement of VR-based safety training.

8. Conclusions

This article presents the results of VR training involving 131 participants—75 employees from a steelworks company and 56 students from the FSE UNIZA. The scenarios differed in complexity and duration, enabling a comparison between industrial and academic settings. Findings confirmed that interactive VR increases engagement and improves hazard identification, with the most positive feedback from the 30–45 age group. Gender-based control preferences emerged, with women favoring hand gestures and men preferring controllers. Mild discomfort (e.g., nausea) was reported by 22.66% of participants (17 from industry, 13 students). While implementation is still challenged by costs and limited expertise, increased accessibility and simpler development tools are gradually overcoming these barriers. VR training in OSH has several disadvantages, including very high costs for equipment and content development, potential technical issues, and user discomfort such as motion sickness or eye strain. Furthermore, VR may not fully replicate real-life emergency scenarios, and access can be limited for some trainees due to financial or physical barriers. Additionally, users unfamiliar with VR might require extra support to engage effectively, and the immersive experience could lead to distractions. There are also safety concerns related to physical movement within VR environments, which could cause injuries if the training area is not properly secured. Technical issues like image blurring and latency can also affect the quality of simulations, and differences in interaction preferences suggest that the training design should be tailored to user needs. Despite these challenges, VR remains a promising and scalable tool for safety training, especially for scenarios that are difficult, risky, or impractical to replicate in real life. The study offers a quantitative and qualitative sample of interactions where immersive methods replaced conventional training, providing useful insights for VR implementers, developers, and researchers. Future work continues within the SAFAR project, focused on CBRN-e training scenarios and interactive 360° video content, aiming to expand format diversity and better address user-specific needs. As part of this project, a scenario will be created for Kia Slovakia s.r.o. for the plant in Žilina, where we will focus on its subsequent testing in a real-life environment while working with a forklift. We will then test and verify the possibilities of using it in other plants. The project is also developing another 20 scenarios in different countries to improve emergency preparedness training for rescue services.

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Abbreviations

The following abbreviations are used in this manuscript:

AR	Augmented Reality
CBRN-e	Chemical, Biological, Radiological, Nuclear and explosive threats
HSE	Health, Safety and Environment
IF	Immersive Factory
IRS	Integrated rescue system
LOTO	Lock Out, Tag Out
OSH	Occupational Safety and Health
VR	Virtual Reality
XR	Extended Reality

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