

VIRTUAL REALITY IN EDUCATION AND TRAINING WITH A FOCUS ON SAFETY AND HEALTH AT WORK

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Abstract

Currently, there is a trend of modern technology in all directions, including occupational health. It is therefore desirable to implement new modern approaches in the prevention of risks of injury to workers as a result of accidents at work or occupational diseases and to put into practice a functioning occupational health and safety education and training system that is directly linked to occupational health and financial impacts. accidents and occupational diseases.

Virtual reality training has an undeniable number of benefits. In addition to the autonomous and contactless approach, which proved to be very valuable during the COVID-19 pandemic, these include, for example: 3x faster learning process, autonomous solution that does not require training staff - saves supervisory time; 30% increase in the quality of routine work; allows you to experience hard-to-simulate scenarios; facilitates training coordination and reduces training costs in the long term. With the help of VR, it is possible to train and train employees effectively, cheaply and without language and other barriers, which are successfully broken down by using this technology. From the essence of VR training, we can assume a reduction in the number of work accidents in the range of 40 - 60 percent [1, 2, 3, 4].

It is precisely for these advantages of VR technology that we decided to create an educational system of occupational safety and health within the Research Institute of Occupational Safety, etc. (OSRI) under the auspices of the Ministry of Labor and Social Affairs. Today, due to the COVID-19 pandemic, healthcare is one of the most vulnerable occupational sectors with new risks.

Keywords: education and training, OSH, occupational safety and health, virtual reality.

1 INTRODUCTION

At present, there is a clear trend of digitization and new modern technologies in all directions. Virtual reality (VR) is a new trend. It has long been focused not only on computer games and entertainment, but also has a strong place in education. VR can train effectively, cheaply and without language and other barriers using this technology successfully demolished. Changes in approach, increased interest and use of VR in training in all areas, including health and safety and fire protection, will also bring change related to COVID-19, but also due to the fact that compared to the traditional approach to providing knowledge and experience benefits. It is thanks to the advantages of this technology that academic, educational and research organizations are becoming increasingly involved in this field. The current impact of the COVID-19 pandemic has also contributed to this, as it is necessary to look for new and contactless ways of training and education that are at the same time effective and can bring the trained person adequate competencies and experience as if they were in a real situation [5].

Occupational health and safety (OSH) and fire protection (FP) training through VR is a modern approach in preventing the risk of damage to employees' health as a result of an accident at work or an occupational disease. Virtual reality education is possible in the form of training and coaching of new and experienced employees, health and safety training or, for example, training critical situations that may occur during the work process, but their simulations in the real world are either difficult to implement or very costly.

Priorities in the field of VR in OSH currently focus primarily on risk identification, process learning of critical procedures, process learning in eliminating dangerous events, emergency management, training in operating certain types of machinery and equipment, initial training in various segments, occupational safety training when operating equipment and machines, some types of training on protection at work at heights and protection against falls, etc. We decided on the advantages of VR technology within the Occupational Safety Research Institute (OSRI), to create an educational system of safety and health protection at work, while due to the COVID-19 pandemic, we focused primarily on the medical segment. Today, due to the COVID19 pandemic, healthcare is one of the most vulnerable occupational sectors with new risks.

As part of the research project, a system of education of health professionals for health and safety training through virtual reality is being created. This is the most effective and flexible way of training employees, which can currently be offered to employees and thus increase their knowledge and experience in health and safety. Specifically, it is a training software that, in the form of credibly processed situations / procedures from the environment of medical facilities, ensures the acquisition of knowledge about skills in health and safety, thanks to which health professionals increase their knowledge and skills in the field and other negative impacts related to insufficient experience and knowledge. Due to the cooperation of an expert consortium, we created the mentioned educational system and carried out extensive laboratory measurements. The aim of our research was to combine the advantages of modern VR technology and proper education in key areas of occupational safety and health.

2 METHODOLOGY

Our goal was to create a health and safety training system. For better efficiency and usability of the solution, we decided to create both possibilities of using the VR, ie. VR application, both in 2D and complex, mobile version. We focused primarily on training scenarios for the healthcare sector. Our project started at a time when the COVID-19 pandemic was in full force and health professionals were among the most vulnerable workers who urgently needed to create more effective training conditions.

In all scenarios, we had the same solution as follows:

- Initial configuration - selection and familiarization with avatar,
- Environment - identification of which part of the environment it is.
- Scenario - the avatar informs the user of the situation in which they find themselves and what is expected of the user. With the help of an animation video, he will show him what he should do, and after the video, the user is allowed to perform individual actions to find out whether he has mastered the individual procedures.

The scenarios were a separate, very important task. For their suitability and correct setting, we chose a separate methodology of their creation, which consisted of:

- Training assessments in terms of implementation options through the VR
- Assessment of technical prerequisites for the implementation of training
- Analysis of key knowledge within the training
- Detailed training analysis - especially its benefits
- Defining the contribution of VR (experiential learning) to conventional training methods
- Design of basic scenarios (interaction, scene dynamics, avatar involvement, sound, dubbing, behavioral technique)
- Control from the point of view of compliance with the continuity of processes, etc.
- Application creation
- Testing in laboratory conditions
- Testing in real conditions
- Implementation into the process

Testing in real conditions on employees helped us to find out the contribution of VR, experiential learning to the training process in the field of occupational safety and health. 120 hospital employees working in the same departments took part in the real-world testing process. The total number was created by a combination of doctors, nurses, paramedics, and other employees who normally move around the ward. Due to the specific environment, the hospital and the scenarios were primarily focused on handling potentially dangerous objects, with which the hospital staff can come into direct contact. It was mainly about proper handling of sharp or dangerous objects such as needles, scalpel and the like. The correct deployment and use of protective equipment such as coats, disinfection and hand washing, and the like, was a matter of course.

The desktop application did not have any specific requirements during its development, it was designed to be compatible with the Windows or Android operating system. In the case of the mobile application, we focused on an application that would be usable in All in One VR glasses, Oculus Quest. We focused

primarily on Oculus Quest glasses for several reasons, such as a 360° range of use, compact controls and, last but not least, a price of € 350. The price was one of the key parameters, as we want to achieve a high range of use of the created health and safety system.

3 RESULTS

The first platform created within the OSH education system was the mobile VR itself, focused on the use of VR glasses. Since we were looking for a solution that would be simple, we chose the All-in-one solution, ie. Splices were created for Oculus Quest glasses. In the development of this platform application, we focused on the use of a real environment, direct human interaction with the virtual environment. This VR application is based on the same scenario as 2D interactive applications, but due to the possibilities it is supplemented by several supporting options. With the help of such a practical simulation, the user acquires fuller habits.

A total of 4 scenarios for health and safety and fire protection training have been created so far. These are the following:

- Entry into a specialized department - proper use of personal protective equipment
- Handling sharp objects
- Injuries from sharp objects
- Fire protection

3.1 Health and safety education system through the VR

3.1.1 *Entry into a specialized department - proper use of personal protective equipment*

The first scenario, and at the time of the COVID-19 pandemic, a very important scenario for staff training is the behavior of a person entering a specialized infectious unit, such as the COVID-19 unit for patients with disease. In the case of our scenario, we focused on the need to disinfect the hands, put on a respirator and its subsequent correct composition and disposal in a container for infectious waste. The training scenario consists of two parts, the first is the manipulation of personal protective equipment before entering the ward (we can see in Fig. 1) and then after the entry and switches to the situation after leaving the ward, ie the stay and work in the ward is not addressed in the scenario.



Figure 1. Export from VR scenario “Entry into a specialized department - proper use of personal protective equipment”.

3.1.2 Handling sharp objects

Another training scenario is the handling of sharp objects such as needles, syringes and others that are commonly contacted by healthcare professionals ((we can see in Fig. 2). Part of the training, the scenario is the person who accompanies us throughout the story and draws our attention to the essential instructions supplemented by safety requirements in the real environment. This training is also very important for the healthcare segment, because prevention is very important, a common injury is just a sharp object injury.



Figure 2. Export from VR scenario "Handling sharp objects".

3.1.3 VR scenario "Sharp injuries"

As mentioned above, sharp injuries are common, there are often accidental injuries to nursing staff, and it is advisable to practice on your own skin, how to proceed in the event of an injury. The scenario created by us is focused on the unfortunate injury of the helper and the subsequent handling of the needle, disinfection and treatment of the injection site, as well as instructions to whom the event should be reported and what examinations must be completed from a preventive point of view. Attention to procedures, reports and examinations is a very important step, as several surveys show that both nurses and doctors do not report almost one third of injuries.



Figure 3. Export from VR scenario "Sharp injuries".

3.1.4 VR scenario "Fire protection"

The fourth scenario we have created is focused on training employees how to behave in the field of fire safety in the workplace and how to act in the event of a fire. In addition to the most important tasks in the event of a fire, employees should also receive clear instructions on how to behave as risky as possible, both in the event of a false alarm and in the event of a crisis situation where a fire has already occurred.

3.2 Health and safety education system through a 2D interactive application

In addition to training scenarios in VR, we have also created interactive 2D applications that do not require any special hardware, but either a computer or other "smart" devices such as a smartphone, tablet, etc. savings and a clear standard. The application is created in the Czech language and also in English for better comprehensibility and applicability. Additional language mutations are possible in the future as needed.

The basis of the application is based on a computer-generated situation, where the healthcare professional must perform all the steps of the scenario. The goal of the application is to make it simple and unambiguous. In Figure 4, we can see the application screen within which the user has to do all the necessary steps in the help. And in the sequence that is correct in reality. If the user chooses correctly, they will be displayed in green, if not red.



Figure 4. Export from 2D interactive application.

3.3 Health and safety education system - verification of acquired knowledge

As part of the applications created for VR and 2D interactive applications, we have also created a "test" version, which is used to verify the experience and knowledge gained after training in VR or 2D interactive application. Simply put, the help has been turned off, as well as the character of the avatar that helps with the training / procedure. A trained worker must undergo training at his own discretion. If it makes a mistake, a notification will sound and the application will not release it. In this way, the person concerned can verify that the training is properly memorized and mastered or needs to be further educated. It can therefore be feedback both for those who are educated through the system and for those employers or teachers who can educate their students in this way.

3.4 Summary of achievements in health and safety education through virtual reality

The aim of our research was to combine the advantages of modern VR technology and proper education in key areas of occupational safety and health. In total, we created 4 scenarios using VR reality as part of the training process.

Based on the knowledge and requirements of the staff of the teaching hospital, we created basic scenarios focused on handling sharp objects, sharp objects injuries, entering a specialized workplace (including the correct use of protective equipment) and fire protection. In scenarios related to the possibility of infection with an infectious agent, we focused on the prevention of personnel against COVID-19. In addition to laboratory tests, we tested these scenarios in practice at the staff of the University Hospital in Pilsen. In total, there were 120 employees who voluntarily participated in testing the modern form of the training process, health and safety procedures.

The same group of 120 employees took part in all of the Procussia tests, with the aforementioned number being primarily nurses and support staff, and around 10% being doctors. Similarly, 4 scenarios were created using a 2D application, which does not require any special hardware and can be a variant for those who do not have glasses for virtual reality, as well as, for example, to repeat some steps in the event that the employee / the student wants to focus only on 1 specific thing / 1 step, etc. At the same time, test variants were created for all training scenarios to verify the acquired knowledge, both in the version of the VR application itself and for a 2D interactive application. All the staff highly praised the training provided through the VR. Therefore, the hospital management decided to use our health and safety system in the VR in real and "sharp" operation and use it to train its medical staff at regular intervals. Following the achieved results, which were above expectations, we decided to continue to create additional scenarios for the healthcare segment, so that it would be possible to subsequently use the training system across all healthcare systems in our country. The entire system of OSH training courses in VR and 2D is currently in Czech and English, and other language versions are possible if interested.

4 CONCLUSIONS

Health and safety training through the VR is a modern approach in preventing the risk of damage to the health of employees as a result of an accident at work or an occupational disease. Training in the VR is possible in the form of training and coaching of new and experienced employees, OSH training or, for example, by training critical situations that may arise during the work process, but their simulations in the real world are either difficult to implement or very costly. The VR method is most widespread in the automotive sector, where there is a high concentration of agency employees for whom training is problematic, given that there is a large turnover of these employees, which leads to the transformation of traditional training into VR. R&D priorities in the VR currently focus mainly on risk identification, process learning of critical procedures, process learning in the elimination of dangerous events, emergency management, training in the operation of certain types of machinery and equipment, initial training in various segments, safety training in control of equipment and machines, some types of training on protection at work at heights and protection against falls, etc.

As part of the research project, a system of education of health professionals for health and safety training is being created through the VR. This is the most effective and flexible way of training employees, which can currently be offered to employees and thus increase their knowledge and experience in health and safety. Specifically, it is a training software that, in the form of credible situations / procedures from the environment of medical facilities, ensures the acquisition of knowledge about skills in health and safety, thanks to which health professionals increase their knowledge and skills in the field and other negative impacts related to insufficient experience and knowledge. The created system is unique and at the same time it can be used across various industries. It can be used both in real practice in the Czech Republic and in other countries. It is already used in Slovakia, where it is, used by students of the Faculty of Safety Engineering of the University of Žilina, given that UNIZA cooperates on this issue and together we will create other training scenarios. Another indisputable advantage is the fact that within this system it is possible to use both educational / teaching scenarios of occupational health and safety in the VR and a test variant, where a trained employee must go through the whole scenario without help, thanks to which it is possible to verify his full knowledge. And due to the practicality of the whole teaching system, its use is possible for both employees and students affected in the field.

And we would like to continue in other sectors as well as in other priority areas - focusing not only on accidents at work, but also on occupational diseases and their prevention. In general, it is about reducing the number of accidents at work and occupational diseases on the basis of outputs, where they are primarily addressed by the possibilities of new technologies for education in the context of current problems and subsequently developed solutions that will have a significant impact on the frequency of occupational accidents and diseases., eg in automotive and other industrial companies, in construction, etc. For example, if we focus on ergonomics and musculoskeletal diseases (MSD), overload, vibration exposure and, for example, poor handling of loads are a big problem in the Czech Republic. Therefore, it is important to pay attention to prevention and at the same time eliminate the negative consequences of MSD to a minimum through targeted training to reduce the number of movements and practice of correct grip, proper training of load handling, etc. and at the same time link preventive exercises as a preventive measure prevention of possible health effects. The most frequently reported occupational disease in the Czech Republic is carpal tunnel syndrome, which is caused by unilateral long-term and excessive overloading of the upper limbs or vibrations transmitted locally to the hands or by direct pressure on the affected structure.

Here, the VR can significantly reduce the frequency of this phenomenon. Exercises for the prevention of carpal tunnel syndrome are known, but precision and monitoring compliance is a problem, here again the VR could help significantly. In the case of accidents at work, it would specifically involve training in recognizing dangerous situations - it would be training in real conditions of a specific area, where employees in the VR would be exposed to specific dangerous situations arising from the area where they are employed (eg construction - work at heights). In the training part, employees would try out the correct procedures and in the testing part, their busy experience would be verified in real situations. The procedure in the field of fire protection would be similar. In the case of occupational diseases, it would specifically be an exercise to prevent carpal tunnel syndrome - it is a series of exercises that is implemented in the VR environment, which will ensure their proper compliance in terms of technology and frequency of repetition. And exercises for the prevention of cervical spine problems - this would again be a series of exercises that eliminate the typical cervical spine problems, such as decreased mobility, cervical spine pain, chronic headaches, etc. VR can again provide the right technique exercises and adherence to frequency.

As is already evident today in the pilot project and due to the multidisciplinary combination of VÚBP knowledge and practical experience from the professional community, the most modern proven trends lead to effective education. Based on a successful project of the implementation of the VR in health care in the Czech Republic, we demonstrate the real benefits of this technology. At the same time, the fact that these trainings can be combined with other modern methods in the area of prevention of occupational accidents or diseases and overall minimization of occupational risks is also crucial. Currently, other scenarios are being created in the VR for the practice of good practices in occupational safety and health, which the OSRI has developed within the Institutional Support of the Ministry of Labor and Social Affairs in cooperation with the XR Institute s.r.o.

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REFERENCES

- [1] F. P. Rahimian., T. Arciszewski, J. S. Goulding, "Successful education for AEC professionals: case study of applying immersive game-like virtual reality interfaces", *Visualization in Engineering*, 2(1), 4, 2014.
- [2] S. Kavanagh, A. Luxton-Reilly, B. Wuensche, B. Plimmer, B., "A systematic review of Virtual Reality in education", *Themes in Science and Technology Education*, 10(2), 85-119, 2017
- [3] J. Hedberg, S. Alexander, "Virtual Reality in Education: Defining Researchable Issues", *Educational Media International*, 31:4, 214-220, 1994.
- [4] X. Li, W. Yi H.-L. Chi, X. Wang, A.P. Chan, "A critical review of virtual and augmented reality (VR/AR) applications in construction safety", *Autom. Constr.*, 86, 150–162, 2018-

- [5] Wang, Peng, Peng Wu, Jun Wang, Hung-Lin Chi, and Xiangyu Wang, "A Critical Review of the Use of Virtual Reality in Construction Engineering Education and Training" *International Journal of Environmental Research and Public Health* 15, no. 6, 2018.