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Vr Technology in Fire Safety Training

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ABSTRACT

Known as fire gas, which results from combustion, consists of many different toxic elements, including but not limited to carbon dioxide, nitrous oxides, and volatile organic compounds. In the case of construction safety training, the future presents challenges for the breakthrough of cutting-edge technology and advanced teaching and analysis methods to help students learn the spectrum of construction and safety training tasks. This article describes how virtual reality technology is used in education, primarily to teach labor protection in training courses for construction engineers, and the future trends. The literature agrees that safety is the prime concern and explores the potential of mitigating the rate of occupational incidents by introducing practical training and advanced technology. This paper reviews the existing safety training practices using virtual reality (VR) at Ikh Zasag International University (IZIU). Results from the study review show the vast gap between reality and workplace safety expectations. In efforts to close the gap mentioned above, this paper discusses the development and utilization of a VR-based training program. The safety training program utilizing VR can promote a better and safer working environment that enables clients to complete tasks with fire hazards effectively and enhance their fire cognition and intervention abilities. Experimental evaluation of fire toxicity test methods is complex and challenging to show to students in the actual field.

Keywords: Safety; Simulation; Virtual reality; Construction.

INTRODUCTION

In the era of digital transition, many new technologies have been introduced and are rapidly entering many sectors of society and economy. One of these technologies is unarguably virtual reality or VR. Students of construction engineers are often required to gain skills to determine and assess risks by going through the process of essential training, leading to their safe practices and operations. Therefore, this study tested whether construction site safety training based on VR is more effective and feasible for workers to learn the skills to identify and evaluate safety risks than traditional training methods. A total of 60 subjects (students) of IZIU were selected for safety training, and their basic understanding of safety measures was tested before and after the training. The students who participated received traditional classroom training in the first session. After that, they attended training using a VR device. As a result, VR training for firefighting and construction site work had significant advantages, as it occupied the attention and engagement of the students.

Training utilizing VR is a more effective measure, especially regarding fire safety at construction sites and workplaces. The use of VR as an enhanced training using modern technology has proven its learning advantage, and the inclusion of VR in construction site safety training could be the next phase of training methods. The two screens installed in the dedicated VR device provide separate images for the left and right eyes, so the user perceives the created virtual environment as if they had entered a real 3D space. In addition, the special-purpose device allows the user to walk in the virtual environment and touch and listen to the desired objects. Due to the popularity of VR devices, many researchers have begun studying them in the context

of modern society usages, specifically in the fields of construction and engineering expertise. "Early studies attempted to explore the potential of VR by focusing on concepts such as immersion experience as the key benefit of VR and analyzing the cognitive variables related to immersion" (Psotka 1995). According to Jumpstart Magazine, the basic idea of VR technology dates back many years, but the first headsets were made in the 1960s. Since then, VR technology has continued to evolve, and in 2014, Facebook's acquisition of Oculus marked the beginning of a universal need for VR devices (2023). Many companies such as Meta, HTC, and Samsung are supplying this type of equipment to the market. These devices are divided into two categories: those that connect to a computer and those that work independently (Figure 1). VR devices that connect to a computer have more power, better visual accuracy, and even complex simulations that can be displayed in real-time because of the calculations done on the computer. However, it is a costly option as it requires a high-performance computer. On the other hand, no additional computer is required when using a standalone VR device, and all calculations can be done on the CPU. However, the performance and display resolution cannot match that of a device that connects to a computer.

VR TECHNOLOGY IN EDUCATION

Virtual reality technology has developed rapidly in recent years and is widely used in fields such as art, games, tourism, and education. With the help of VR technology, the user can travel anywhere and experience the feeling of entering a 3D virtual environment.

Picture 1a. Computer connected item

Picture 1b. Independent item

With the help of this technology, users can learn independently or together in a virtual environment. The user can learn both theoretical and practical lessons using VR. In education, especially in training civil engineering specialists, it is possible to quickly understand the difficult concepts to imagine when faced with complex and realistic situations by understanding the labor protection course and presenting them to the users more simply and realistically. Most importantly, VR technology enables interactive learning by seeing and hearing and by choosing, touching, and looking around from different angles and

perspectives. In addition to theoretical lessons, all kinds of experiments that can and cannot be done in the laboratory can be fulfilled with the help of this technology, which is evaluated as another advantage.

For this reason, developed countries have begun to use this type of technological integration in their training. Since 2017, VR experiments have been used in classrooms in the United States, and teachers continue looking for creative and motivating ways to use VR and AR. Diversity in digital learning refers to using multiple forms of visualization and communication to enhance the learning experience. This approach recognizes that individuals have different learning motivations and strengths, so a broader range of content can be developed that considers learners' diversity. Text content, presentations, graphics, images, and videos can all be incorporated into VR. The choices range from audio, podcasts, interactive games, and hands-on activities to suit their needs. Among them are US companies such as VictoryXR, Engage, and University. For example, VictoryXR [6] has been developing various educational content based on VR and AR technology for secondary and university students for many years. Since 2021, the company has successfully created a virtual school platform. Virtual school is a relatively new concept, and it means that the environment for conducting training, such as schools, classrooms, and experimental laboratories, will be created abstractly on the computer. Students will be allowed to participate in classes and learn in a virtual environment with the help of virtual devices connected to the Internet. For our country to have the theoretical and methodological competence to integrate ICT into the curriculum, to choose a methodology to clearly and broadly express the content of the course through the optimal use of ICT; instead of transmitting information, it directs students to problem-posing, searching, and creative activities to reflect, transform information into knowledge, and improve students' ability to work independently.

Mongolian government and non-government organizations, private companies, and UNICEF Mongolia have successfully introduced e-learning. In particular, as part of the work of providing electronic educational materials in the VR environment, Mobicom Group's "Smart Education 3" project, which aims to bring equal access to education to every child, has been implemented in two schools in the capital city, such as SHD "oner" complex, ChD-57 school, and Erdenedalai sum general education school in Dundgovi province. Since six local schools have digital classrooms, more than 12,500 high school students have been able to watch virtual classes [8]. Learning with virtual technology has advantages in developing students' thinking, imagination, and creativity, increasing their activity and participation, adapting to new learning methods, and activating student-centered learning [9]. According to international research and experience, three indicators are critical for successfully implementing this form of education: students' learning style, ability to use information technology, and access to electronic tools.

Fire gas analysis

Analyzing fire gas is a significant process of conducting risk assessment, which helps understand the toxic elements produced by it and its effect on health and
safety operations. Its analysis is complex and depends on various factors of gas emission. When conducting risk assessments, gas is formed when different material
s and products burn. When analysing fire gas, toxic components are identified and a risk assessment is made. Fire gas analysis is important to understand the content and potential risks of the gas and how the fire gas can affect health and the environment.

The manometer's fire gas

pressure reading should be in the green area. When the ambient temperature increases, the nanometre reading may shift to the yellow area. The cylinder's pressure is 11-18.5 barrels. The spray distance is up to two meters. Two kilograms of fire poison is consumed in 10 seconds, so it is important to spray as quickly and accurately as possible and ensure that the fire is extinguished downwind.

Powder fire poison is divided into two types: charged and fired. Rechargeable fire extinguishers are more efficient because they are pre-filled with gas. Gas-injected powder has the principle of extinguishing fire by forming an insulating layer from oxygen.

Carbon dioxide fire extinguishers are suitable for extinguishing fires involving flammable lubricants and high-voltage wiring and electrical equipment. The temperature of carbon reaches -80°C, so it is dangerous to freeze exposed and unprotected parts of the body.
The symbols A - B - C - E indicate which type of fire poison is suitable for which kind of fire.

A. Open or smoldering fires in combustible materials such as wood, cloth, or rubber
B. When burning lubricants or flammable liquids
C. All types of flammable gases and gases
E. Extinguish the fire in electrical equipment working with voltage up to 1000W.

We give instruction such as pointing the nozzle towards the fire, pulling the lockout of the loop, and placing the fire extinguisher as far as possible to bring it closer and grip the handle tightly. Fire extinguishers are to be held vertically to extinguish the fire. Carbon dioxide cools down to -70 C, so you do not handle the nozzle with bare hands. Indeed, in practice, we never pull the lock out of the loop except in the actual fire.
Higher education institutions are faced with the need to train specialists with good digital skills, a desire for continuous learning, and a positive attitude, with a combination of theoretical and practical skills. Training is organized in classrooms, non-classrooms, and a combination of those reflected in the law and approved .

The construction engineer in charge of occupational safety and health of the legal entity applying for the license shall be a professional engineer or technician. Also, an engineer and technician with a dual profession can be registered with the legal entity for each of the dual professions they possess.

We measured our students' emotions, learning experiences, and achievement changes using Bloom's taxonomy. It assesses three learning domains: cognitive, affective, and psychomotor, and assigns to each of these domains a hierarchy that corresponds to different levels of learning. It's important to note that the different levels of thinking are defined within each domain of the taxonomy.

RESEARCH METHODOLOGY

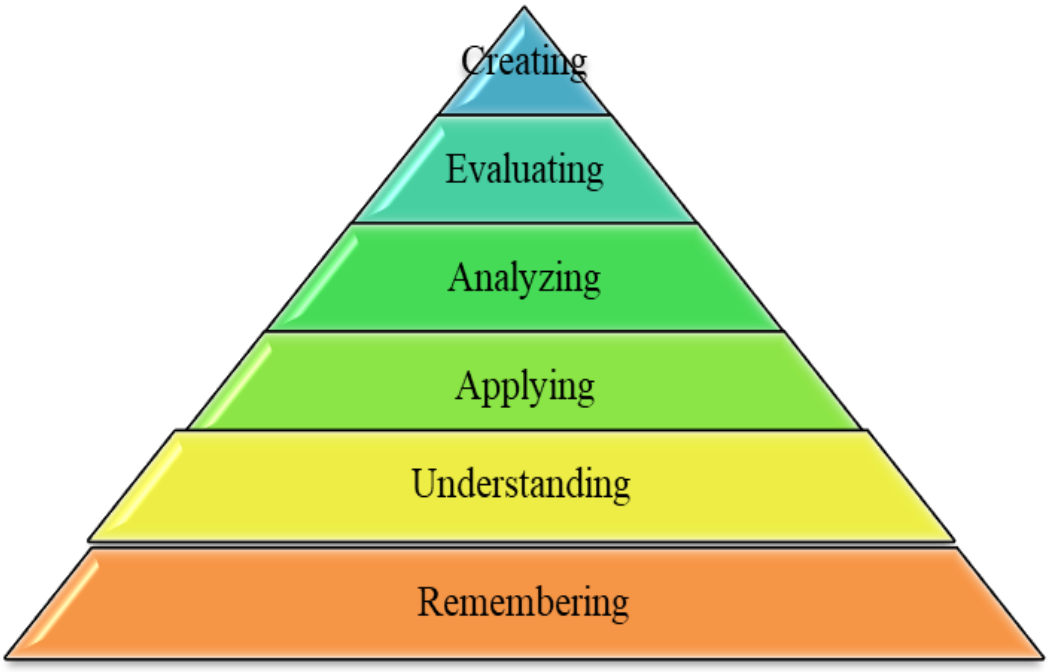
The research used document analysis, VR recording, VR content testing, lesson observation, test/task performance analysis, and modeling methods, and the results were statistically processed.

According to document analysis:

- The theoretical and methodological basis for supporting learning was taken into account to assess the differences in learning
- Learning styles of students
- Bloom's taxonomy domains

By completing tests and assignments: Students’ achievements are compared by T-test.
By differential emotions theory we measured students' emotions. The Differential Emotions Scale (DES) (Izard, 1997s) is a multidimensional self-report device for the assessment of an individual's emotions.
By Bloom's taxonomy, we measured students’ learning experiences.
Students' interest and behavior are observed: Questionnaires were processed using Google Forms, and the link was sent to each class's group chat. The information from each questionnaire was collected in a Windows Excel file. Video recordings were prepared in advance and shown in the classroom using a projector screen.
When we use VR technology in fire safety training, their **learning experiences** are improved.

Picture 2. Cognitive domain

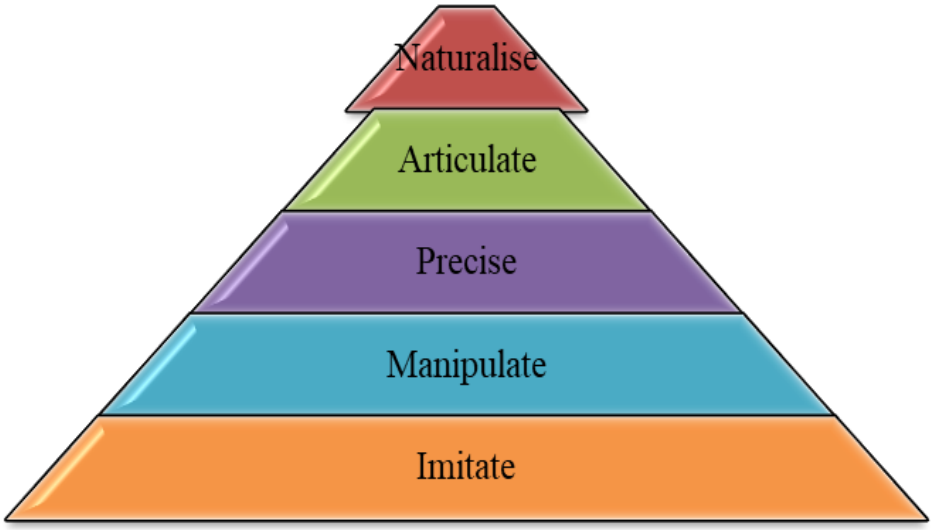


When we use VR technology in fire safety training, their remembering, understanding and applying are improved.

Picture 3. Affective domain

When we use VR technology in fire safety training, their attitudes or behaviors are improved.

Picture 4. Psychomotor domain



Their skills are improved when we use VR technology in fire safety training.

David R., Benjamin S. Bloom.2004.

RESULTS

By completing tests and assignments we measured students' achievements. Students' achievements are improved using VR learning methodology and it is proved by T-test compared the means of two groups data. The alternate hypothesis (H_a) significance level is $\alpha = 0.05$.

We used differential emotions theory to measure students' emotions. The Differential Emotions Scale (DES) (Izard, 1997s) is a multidimensional self-report device for assessing an individual's emotions.
By Bloom's taxonomy, we measured students' learning experiences.
Students' interest and behavior are observed: For each participant, the pre-test was the same as the DES, followed by the learning phase. Next was the training phase, during which participants were required to learn as much of the training material as possible, and all conditions were given the same amount of time (10 min).

After the training phase, participants completed a pre-test and a post-test consisting of DES and WBLT questions, which provided feedback on the quality of the training. The primary measure of learning performance used improvement from pre-test to post-test. This method determined whether participants with prior knowledge of the topic (firefighting) increased learning.

Questionnaires were processed using Google Forms, and the link was sent toeach class's group chat, and each questionnaire's informationas collected in a Windows Excel file. Video recordings were prepared in advance and shown in the classroom using a projector screen. The test is taken from the students with the aim of checking their level of learning content. In experimental research, tests are usually taken before and after the experiment. A pre-test is taken to test participants' background knowledge before the virtual lab test. A post-test was taken to test how much knowledge the participants gained after the experiment. This test method compares the arithmetic mean of pre-test and post-test.

CONCLUSION

Traditional teaching methods need to provide hands-on experience and engage students sufficiently to acquire safety knowledge. This study proposes an innovative building safety education system through animation using 360-degree virtual reality. The proposed VR technology method provides interactivity and engagement for students. A learning environment that brings construction site tours into the classroom to enhance students' hands-on experience and safety awareness optimizes their experiences without occupational hazards or real-life incidents. A student's satisfaction using VR was assessed through questionnaires and interviews. A progress score-based outcome comparison was conducted between the controlled group and the experimental group to assess the effectiveness of training objectively. Preliminary results show that VR-based learning is a valuable way to effectively provide students with hands-on experience and safety knowledge and to improve construction safety education by replacing traditional learning methods and eliminating the cost and time and other objective failures or losses that would have occurred during real-time experiences. This study also paves the pathway to further look into ways to promote VR for educational and learning methods that can optimize effective learning.

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