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RESEARCH ARTICLE

SAFETY TRAINING IN CONSTRUCTION SITE USING VR-TECHNOLOGY

[1*]DOLZODMAA Namid and [2]KHULAN Ojgoosh

[1]Ikh Zasag International University, National University of Mongolia
[2]Institute of Engineering and Technology

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***Corresponding author:**
DOLZODMAA Namid

ABSTRACT

Virtual reality (VR) technology is rapidly entering many fields, such as industry, medicine, art, tourism, and education. One common challenge for construction safety training is the lack of means to create high-fidelity digital environments to simulate and support required safety operations and assessments. Traditional workforce training and field safety data analysis methods often need to be revised to help students grasp the true complexity of construction operation and use, which could significantly impact the quality of future construction and safety training tasks. This article describes how virtual reality technology is used in education, mainly to teach labor protection in training courses for construction engineers, and the future trends. Safety is a critical issue for the construction industry. The literature argues that human error contributes to more than half of occupational incidents and could be directly impacted by effective training programs. This paper reviews the current safety training status using VR at the Ikh Zasag International University. Results from the review evidence the gap between the status and industry expectations on safety. To narrow this gap, this paper demonstrates the development and utilization of a training program based on virtual reality (VR) simulation. The VR-based safety training program can offer a safe working environment where users can effectively rehearse tasks with fire hazards and ultimately promote their fire cognition and intervention abilities. Its visualization and simulation can also remove the training barriers caused by electricity's features of invisibility and dangerousness.

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INTRODUCTION

In the era of digital transition, many new technologies have emerged and are rapidly entering many sectors of society and economy. One of these technologies is virtual reality. Students' ability of construction engineers to identify and assess risks is acquired through training and experience and is one of the main factors that determine their behavior and thus safety. Therefore, there is a need to focus on the effectiveness of traditional security training. This study tested the hypothesis that virtual reality (VR) construction site safety training is more effective and feasible for worker learning and recall in identifying and evaluating construction safety risks than similar training using traditional methods. 60 subjects (students) of IHOU were trained in building safety, and their safety knowledge was tested before and after the training. The students who participated in the training received traditional classroom training in the first session. After that, they were trained using a VR device for a certain period of time. VR training for firefighting and construction site work had significant advantages, VR training was more effective in maintaining the attention and concentration of learners.

Training with VR has been more effective over time, especially in the context of fire safety in 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 is essentia 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, touch and listen to the desired objects.In recent years, Virtual Reality (VR), in particular, those head-mounted devices, as an immersive computing and visualization technology have seen explosive development. Inside the broader civil engineering community, extensive research efforts have been devoted to VR-related applications in various use cases. 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). 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

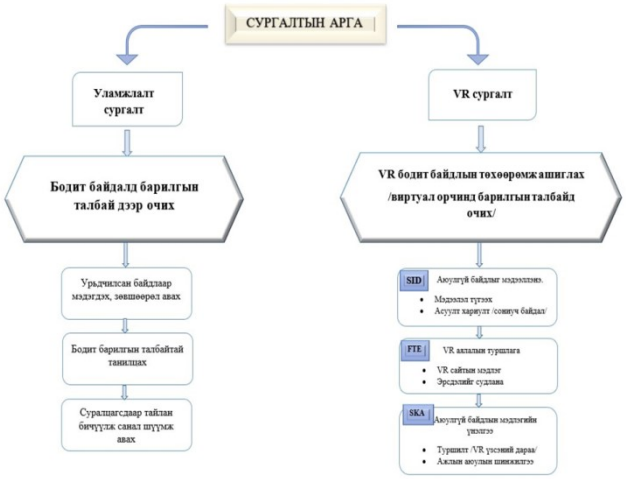
of a universal need for VR devices. Now many companies such as Meta, HTC and Samsung are supplying this type of equipment to the market. These devices are divided into two categories: those that connect to a computer and those that work independently (Figure 1). VR devices that connect to a computer have more power, better visual accuracy, and even complex simulations can be displayed in real time because the calculations are done on the computer. However, it is a costly option as it requires a high-performance computer. On the other hand, when using a standalone VR device, no additional computer is required, 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. 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 get the real feeling of entering the 3D virtual environment. (1).

Picture 1a. Computer connected item

Picture 1b. Independant item

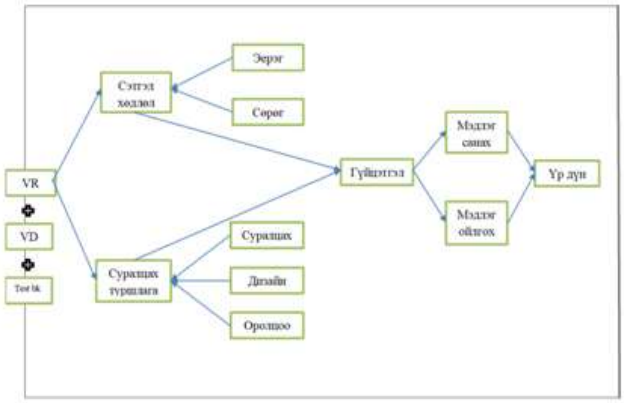
With the help of this technology, users can learn independently or together in a virtual environment. The user can learn both theoretical and practical lessons in a virtual environment. (2), (3), (4), (5). In the field of education, especially in the training of civil engineering specialists, it is possible to easily understand the concepts that are difficult to imagine when faced with complex and realistic situations by understanding the labor protection course and presenting them to the users in a simpler and more realistic way. Most importantly, VR technology enables interactive learning, not only by seeing and hearing, but also by choosing, touching, and looking around from the desired angle. In addition, in addition to theoretical lessons, all kinds of experiments that can and cannot be done in the laboratory can be done with the help of this technology, which is another advantage.

For this reason, developed countries of the world have begun to use this type of training in their training. Since 2017, VR experiments have been used in classrooms in the United States, and teachers are looking for creative and motivating ways to use VR and AR in their classrooms. Diversity in digital learning refers to the use of multiple forms of visualization and communication to enhance the learning experience. This approach recognizes that individuals have different learning motivations and strengths, so that a wider range of content can be developed that takes into account the diversity of learners. Text content, presentations, graphics, images and videos in VR. Choose from audio, podcasts, interactive games, and hands-on activities to suit your 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 developed a virtual school platform. Virtual school is a relatively new concept, and it means that the environment for conducting training, such as schools, classrooms, experimental laboratories, etc., will be created abstractly on the computer, and students will be provided with the opportunity 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 (7).



Disign 2

Mongolian Government and Non-Government Organizations, private companies and UNICEF Mongolia are successfully introducing 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 2 schools in the capital city, such as SHD "oner" complex, ChD-57 school, and Erdenedalai sum general education school in Dundgov province. Since 6 local schools have digital classrooms, more than 12,500 high school students have been able to watch virtual classes (8). Learning using 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, 3 indicators are very important factors for the successful implementation of this form of education: students' learning style, ability to use information technology, and access to electronic tools (10).



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 these. that was reflected in the law and approved (11).

Construction engineer specialist Requirements for the specialist of the organization with a special license to engage in construction activities 6.12. The 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 he/she possesses. (12)

RESEARCH METHODOLOGY

Document analysis, VD recording, VR content testing, lesson observation, test/task performance analysis, and modeling methods were used in the research, and statistical processing was performed on the results.

According to document analysis:

- Theoretical and methodological basis for supporting learning taking into account the differences in learning
- International experience to support learning, taking into account differences in learning

By completing tests and assignments:

Intellectual ability of students

Learning styles of students

Students' characteristics and behavior are observed: Questionnaires were processed using Google form, and the link was sent to the group chat of each class, and the information of each questionnaire was collected in a Windows excel file. Video recordings were prepared in advance and shown in the classroom using a projector screen (2000 × 1200, 60 Hz).

In VR mode, Meta Quest Ocolus 2 (KW49CM) (Figure 1) device was used. The device will display 3D environment at 3600 degree, circle diameter up to 2m, hand control model JD96CX(Right), LX39EM(Left).

RESULTS

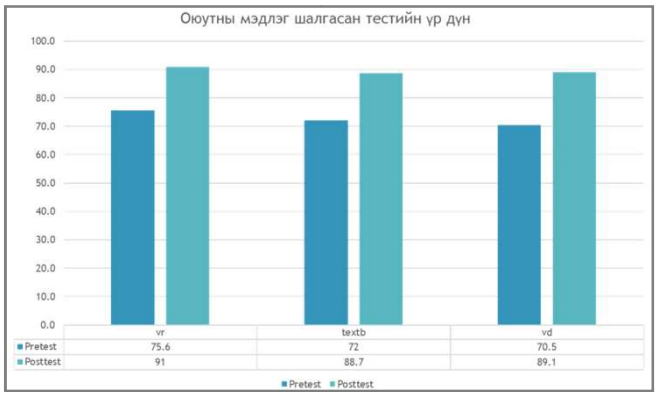


Table 1

Group	Pretest	Posttest	Difference
VR	75.6%	91%	15.4%
TEXTB	72%	88.7%	16,7%
VD	70.5%	89.1%	18,6%

Table 2

Group	Pretest	Posttest	Difference
VR	9.07	10.92	1.85
TEXTB	8.64	10.64	2
VD	8.46	10.69	2.23

Table 3

Anova: Single factor				
Summary				
Groups	Count	Sum	Average	Variance
VR	13	24	1.846154	0.807692
TEXTB	14	28	2	1.538462
VD	13	29	2.230769	1.858974

CONCLUSION

Traditional teaching methods fail 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 VAS method provides interactivity. A learning environment that brings construction site tours into the classroom to enhance students' hands-on experience and safety awareness. A VAS method was developed and the ability to use VR was assessed through questionnaires and interviews. A progress score-based outcome comparison was conducted between VAS and conventional methods to objectively assess the effectiveness of training. Preliminary results show that VAS is a valuable way to effectively provide students with hands-on experience and safety knowledge, and to improve construction safety education.

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