Research on Construction Safety Education based on BIM- Virtual Reality

Tingting Song, Weidong Liu

{15735044260@163.com}

School of Humanities, Shanghai Institution of Technology, Shanghai 201418, China

Abstract. Safety accidents in the construction industry will seriously threaten the lives of workers, cause enterprises to be unable to complete on time and cost overruns, forming a negative social impact, and the dynamic and complex construction process makes it more difficult for construction personnel to identify risks in the construction process than in other industries. The ability of risk identification is acquired through training and experience, while traditional education methods cannot meet the needs of building safety education. Virtual reality technology provides a new way and possibility for the safety management of construction engineering. This paper analyzes the risk factor identification and safety education system of the application of virtual reality technology, constructs the construction safety education management system from the two aspects of " recognition" and "teaching", proposes the construction safety education framework based on BIM- virtual reality.

Keywords: Virtual reality; Safety education; Virtual education; Risk identification; BIM

1 Introduction

Safety accidents in the construction industry will seriously threaten the lives of workers, cause enterprises to fail to complete on time and cost overruns, and form a negative social impact. Moreover, the dynamic and complex construction process makes it more difficult to identify and prevent construction safety accidents than other industries. According to a notice issued by the General Office of the Ministry of Housing and Urban-Rural Development, PRC on work safety accidents in housing and municipal projects in 2020, a total of 689 work safety accidents and 794 deaths occurred in 30 provinces (autonomous regions and municipalities directly under the central government) and the Xinjiang Production and Construction Corps. The death toll in 13 provinces (autonomous regions and municipalities) increased year on year, and in some regions, the total number of accidents was large, the number of accidents was large, the death toll increased year on year, and the death and injury accidents occurred from time to time [1]. However, the causes of construction engineering safety accidents are various and complex, including human factors and physical factors, among which there is mutual connection and interaction[2]. Risk identification and prevention and control measures can reduce the occurrence of safety accidents. The ability to identify risks is acquired through training and experience.

Traditional education methods cannot meet the educational needs of building safety. Field trips are dangerous and experience is not strong. Virtual reality, as a technology that enables

ITEI 2022, December 23-25, Harbin, People's Republic of China

DOI 10.4108/eai.23-12-2022.2329172

users to move with multi-sensory devices and interact with simulated situations, provides a new way and possibility for risk identification of building engineering safety management. For the construction of construction engineering, by using virtual reality technology and combining with BIM, the relevant personnel can clearly simulate the possible situation in the construction process, realize the identification of construction risks, and take corresponding measures to reduce the occurrence of safety accidents. At present, there have been many researches on this aspect [3-6]. By simulating the safety scene and accident scene of electrical construction site, workers can identify the cause of the accident by simulating the accident situation. Getuli uses mobile based virtual reality (VR) + augmented reality (AR) to carry out the framework of experiential construction safety education. These studies do not pay much attention to the identification of risk factors before education. The education system mainly focuses on interactive personalization, convenience and the effect of educational evaluation, but the process of risk factor identification is conducive to improving the safety program and improving the educational ability of instructors. Analysis of the application of virtual reality technology of safety intelligent management risk factors identification and safety education system, construction safety education management system from the two aspects of " recognition" and "teaching", proposed construction safety education platform based on BIM-virtual reality construction scheme, to provide reference for site construction safety.

2 Risk factor recognition

In order to identify risk factors and improve the quality of education, risk factor identification. The process is shown in Figure 1.

2.1 Scenario construction

Scenario construction includes workflow, risk factors, and security regulations, and requires significant effort in planning scenarios, designing scenarios, and implementing data collection. To this end, the site object library presented by Getuli's[7] BIM Based field Object Library for VR Safety training experiences helps to take an important step forward in facilitating and standardizing an extremely time-consuming task.

In order to construct the risk scenario, the first is the selection of safety accident scenario. In the previous major accidents of construction projects in China, the branch and sub-projects with greater risks represented by earthwork and foundation pit collapse, lifting machinery injury and scaffold collapse and the height fall accidents caused by them are the key and difficult points of risk prevention and control. Construction crane accidents are mainly caused by outstanding problems such as illegal command and illegal operation. Scaffolding collapse accidents are mainly caused by the lack of safety protection measures, personnel in key positions do not perform their duties, and the implementation of mandatory standards is not in place. These two types of construction scenarios can be chosen as the main direction of safety accidents. Specific scenario construction requires in-depth interviews with field staff, safety managers, management and other stakeholders, combined with experience and previous data, to analyze the causes and impacts of existing accident cases, so as to select the accident process to be applied to risk scenarios.

The second step is to determine the risk point. Through field investigation or field staff, safety managers, management and other stakeholders to deduce the site risk points, and analyze the causes and effects of existing accident cases at home and abroad, to determine the risk points.

2.2 3D modeling

The site itself model, safety equipment and members are realized with 3D models to form a virtual reality environment and standardize the virtual survey procedures of the construction site

2.3 Reduce risk point

Designers, construction managers and other personnel can reduce construction site accidents through preventive measures in advance, but the problem lies in: although the construction designer is the creator of every safety risk, but due to the lack of field experience, often the ability to identify the risk of the site environment is weak; Managers and supervisors with years of experience are also unable to identify all hazards in their working environment [8]. Getuli[9] et al. used BIM and virtual reality technology to improve work area planning of construction activities by promoting safety-related information sharing among partners, so as to avoid safety accidents caused by conflicts between work Spaces and paths. Sacks[10] et al. used virtual reality technology to conduct simulation design safety consultation. Participating designers can clearly understand security risks in a safe environment. In 32 virtual construction danger scenarios encountered, they discussed with the construction manager their impact on the generation or prevention of each risk as designers, so as to explore a safer construction scheme. In Sacks et al. 's study, an attitude questionnaire was specially designed for designers to modify the design scheme, and designers are more inclined to take safety measures instead of changing the design scheme. These studies show that after the preliminary risk scenario is modeled, relevant decision makers can identify the source of danger in the construction site and construction process, so as to choose a safer design scheme and a more reasonable scheduling to change the physical environment of the construction site to improve the safety of the construction work or take protective measures to reduce the risk points, which is conducive to improving the awareness of relevant personnel on risk identification. Improving the quality of education while identifying exploration routes in the virtual environment improves workers' efficiency in using the education system.

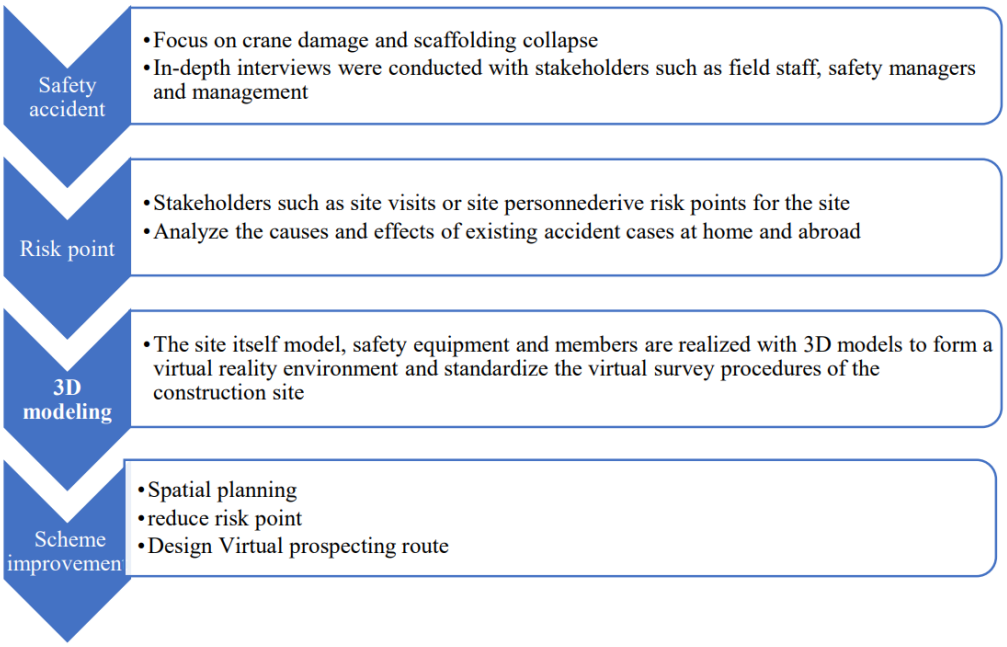

Fig. 1. Risk recognitionflow chart

3 Safety education system

Due to the limited conditions, traditional education teaching methods and tools cannot provide students with realistic and practical safety experience, while virtual reality technology has been verified. Through the use of immersive virtual reality equipment modeling and simulation to explore the construction site, users can be provided with visual stimulation, trainees' attention can be improved, and workers can better identify environmental risks [11].

Users of the VR safety education and training system participate in the training through the head display equipment and controller conduct simulation according to the set survey route under the guidance of the manager which are respectively used to view and interact with the 3D environment. The educational effect was evaluated according to the data of trainees in the simulation process..

4 Framework

The framework considers the impact of a work safety atmosphere. On the one hand, in the process of reducing the risk points in the construction process, it can help employees to understand each other, so that designers can understand the safety situation faced by construction workers. On the other hand, it can improve the knowledge level of managers and determine the virtual exploration route, which makes the education process more efficient. It helps build the trust of construction workers in management, both of which contribute to a safe work atmosphere. And the safe atmosphere is conducive to the risk identification and education process.

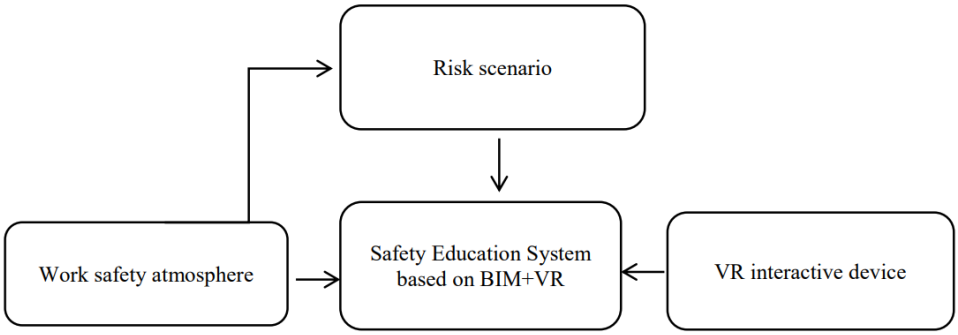

Fig. 2. Safety Education System framework based on BIM+VR

5 Conclusion

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(1) The effect of physical environmental factors in risk identification is limited by the designer's attitude and the cooperation between the designer and the construction manager. If the designer insists on the design with a high degree of risk, he can only ensure the safety through appropriate safety measures;

(2) It is also a big challenge whether members can cooperate highly. The communication between workers and managers is crucial for risk identification. Only by information exchange and cooperation between BIM-VR technology collocation personnel to find out the risk points in the project can we well complete the construction of risk scenarios, establish the field object database, and follow instructions to complete personalized user interaction.

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