Using Virtual Environments Simulation to Improve Construction Safety: An Application of 3D Online-Game Based Training

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Abstract. Construction safety is consistently an important issue in the Architecture, construction and engineering (ACE) industries and attracts continuously effort to worldwide. However, lives are deprived every year due to construction accidents. Taking the United States as example, in 2009 there are 18.8% fatalities occurred in construction. Different efforts have been taken to enhance the safety and mitigate the accidents frequency, and the educational information technology is one of them. Meanwhile with the fast development of internet, the virtual environments based 3D online games present constructive educational features for safety training, especially to the young generations. This approach is especially applicable in construction as most construction-related accidents are destructive and are dangerous to teach in a jobsite-based training. This paper presents the new training application that uses 3D online computer games for electrical hazards awareness enhancement in the U.S. construction industry.

Keywords: Safety Training, Construction, Information Technology, Online Game, Virtual Environment.

1 Introduction

According to the Census of Fatal Occupational Injuries (CFOI 2010) [1] from the U.S. Department of Labor the workers in construction industry continue to incur the most of fatalities among all economic sectors. In 2009, there were 816 fatalities in construction which accounts for 18.8% out of a total of 4,340 fatal work injuries records. About 1 in 5 occupational deaths are related to construction industry. As same as in the United States, the severe safety situation and poor safety performance of the construction industry persists to give international cause for concerns [2]. Meanwhile, the electrical hazard in construction safety is worthy of more attention because of its destructiveness. Most of accidents involving electrical shocks cause severe tissue damage or death [3].

Most accidents are related to human behaviors and worker training turns to be a key element to mitigate the occupational injuries and to increase the capacity of a
person to respond in ways appropriate to the situation facing them [4]. Information technology has been applied as an effective tool to fit this objective in various ways. This paper presents a new training application that uses educational-game based learning theory and Virtual Environment (VE) simulation, and discusses how information technology could be applied to improve the electrical safety in the U.S. construction industry.

2 Educational Games in Training

Training becomes an axiomatic part of accident prevention strategies, but what the effective training is has been a question for hundreds of years that. Dale illustrated that the best way for training and learning is to do the real thing and to simulate the real tasks to obtain experience (see Figure 1) [5]. Similarly, Rubinsky and Smith [6] found that experience of their simulated accident was a better training aid than demonstration of it or a description of it, when the criterion of number of "accidents" and retention over time were used.

Back to the construction industry, workers are often able to keep new information in mind for several days and possibly weeks after the attend safety training or view safety videos. Workers who have not truly internalized safety procedures by them may cut corners as other job demands compete with safety for their attentions [7]. In this regard, based on either research or experience, the simple answer to effective training is practice.

However, the problem is that practice by doing in an industrial setting is often prohibitively risky, which is why safety training exists in the first place [7]. Workers may receive on-the-job feedback only after they make mistakes. Although there are several ways to make learning more active and engaging, an educational game would best serve this context because it focuses on teaching a specific body of knowledge, completing a defined goal, immediate feedback, and safety [8]. Taking advantage of the current information technology, the training-purposed 3D games may help to simulate scenarios to enhance trainees the safety awareness but in a physically safe environment.

![Fig. 1. Dale’s cone of experience](image-url)