

The Use of Virtual Reality in Construction Safety Training

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The emergence of virtual reality has seemingly limitless possibilities in the construction industry. One of the most significant applications of this technology in construction, is its use in virtual reality safety training, as it allows for more immersive and retainable training programs. Construction VR training programs have been developed to allow workers to train in a safe working environment and develop the necessary skills in recognizing hazardous jobsite situations. The purpose of this study is to measure the effectiveness and potential of virtual reality construction training as it compares to traditional industry training through attitudinal research. To this end, a survey of twelve questions was sent out to construction industry members using the Construction Management Advisory Council database to gauge how widespread virtual reality training is, if it is more effective than traditional safety training, and if it should be the new industry standard for construction training. The responses to the survey indicate that virtual reality safety training is still minimally used and not fully understood in the construction industry. A minority of the respondents were familiar with the technology and could not give definitive answers regarding its effectiveness or place in the future of safety training.

Key Words: Virtual Reality, Safety, Construction Training, Effectiveness, Future Technology

Introduction

Safety is the most important thing on a jobsite, and proper safety training is essential for allowing a project to be successful. Construction is consistently rated as one of the most dangerous industries in the world, and in 2019, the industry accounted for 20% of all workplace fatalities in the United States (OSHA). To combat the danger that is present in construction, The Occupational Safety and Health Act, instituted in 1970, mandates that employers are to provide health and safety training for all employees. Construction safety training is a vital part of the industry because of the level of danger presented in the field. A worker's safety is dependent on the extensiveness and retainability of the training they receive, as well as the training of their fellow workers. However, one of the main issues with construction safety training is that in its current state, it is not highly engaging, and consequentially less retainable (Barak, Perlman, & Sacks, 2013). The leading construction course is called OSHA 10, a ten-hour course that covers general construction hazards and is recommended for entry level construction workers. An even more extensive 30-hour course is also available and recommended for senior level construction workers, foremen, and safety managers. However, it has become more apparent that the ability to recognize hazards and dangerous situations is a learned trait which is much more effectively cultivated through real-life experience rather than low engagement courses. The invention of virtual reality training programs has become part of the solution to the safety crisis in construction due to its realistic simulation capabilities.

Literature Review

Virtual reality is a technology which uses software to create a simulated environment for its user. An immersive virtual environment, or IVE, is a computer-generated environment that gives a person a sense of being within a real situation by engaging the person's senses and reducing or removing their perception of the real environment (Barak, Perlman, & Sacks,). IVE virtual reality has been implemented in the construction industry to simulate jobsite situations and to train workers in proper safety protocols. By wearing a virtual reality headset, a worker can be thrust into realistic construction situations without the threat of any danger. Researchers have stated that visualization technologies such as VR can efficiently improve current safety training programs and improve workers' hazard recognition skills (Balali, Han, & Heydrain, 2020). Through the use of an IVE, a worker can experience a realistic simulation and gain the necessary training to prevent future dangerous situations on the jobsite.

Virtual reality safety programs are designed with the purpose of simulating jobsite situations without the presence of any real danger. They allow for workers to practice operating machinery or identify hazardous conditions numerous times in an engaging environment where there are no life-threatening consequences. One of the main benefits of virtual reality training is that it forces trainees to pay attention to their environment. A study done in 2013 showed that the trainees who used virtual reality were alert for the entirety of the training period, whereas those who underwent traditional training lost their concentration after the first hour (Barak, Perlman, & Sacks, 2013). Maintaining a trainee's concentration is vital for ensuring that what is being taught can be recalled in the future, especially in an industry as dangerous as construction.

Virtual reality is the future technology of construction, yet its applications and potential have not yet been fully realized by the industry. Construction is notoriously slow at adopting new technologies and therefore it might take years before virtual reality is readily used in the industry. Many companies have a 'wait and see' mentality where they watch if others are using the technology to improve their operations and then choose to invest in it for themselves. This mentality, however, only allows for the industry to catch-up with the new technology years afterwards and does not allow for constant innovation and improvement. Research has shown that VR can be an effective platform for safety training and a substitute for on-site training (Balali, Han, & Heydrain, 2020). The technology however has to be further integrated and proven to be effective before any widespread implementation can be seen.

While virtual reality holds many capabilities in the construction industry, there are some limitations that may hinder its implementation. One of the primary hesitations of adopting virtual reality programs is that it is costly. The investment into virtual reality may be too great for construction companies due to the technology being so new and unexplored in its capabilities (Ahmed, 2018). Another drawback that has been explored is that the technology may only be more effective in younger trainees who are more familiar with technology. This is an advantage for training future generations of construction workers, however workers who are less technologically advanced may struggle. The greatest challenge VR faces is that there is a lack of overall knowledge regarding the technology and its wide range of applications (Ahmed, 2018). This will most likely be solved through future research and more widespread acknowledgment of the technology in upcoming years.

Methodology

To garner the information needed to complete this study, a survey was sent via email using the Construction Management Advisory Council (CMAC) member database as well as to Construction Management alumni through the CM department of Cal Poly. The twelve-question survey was comprised of nine multiple choice and fill-in questions, with three questions asking for clarifications of answers. A total of 41 responses of industry members' opinions were collected and the data has been compiled into Figures 1 through 6 below.

The objectives of this survey are as follows:

- To discern how widespread virtual reality safety training has been adopted in the construction industry
- To discover the effectiveness of virtual reality safety training as compared to traditional safety training
- To discover industry members' opinions and knowledge on virtual reality safety training
- To determine if virtual reality safety training should be the future of construction training

Survey Analysis

Survey Questions:

1. What is your job title?
2. How many years have you worked in the construction industry?
3. What sector of construction do you work in?
4. In general, do you believe that construction safety training can be improved to reduce injuries and fatalities?
5. Are you familiar with virtual reality safety training?
6. Has your company adopted virtual reality safety training?
7. Have you experienced a general hesitation of adopting technologies like virtual reality?
8. Do you believe that virtual reality safety training is more effective than traditional safety training?
9. Do you believe that virtual reality safety training is the future of the construction industry?

Background Questions

Table 1		
<i>Job Title Response</i>	<i>Count</i>	<i>Subcategory</i>
Apprentice Electrician	1	Entry Level Position
Field Engineer	3	Entry Level Position
Project Engineer	4	Entry Level Position
Business Development and Client Management	1	Business/Executive Positions
Executive Vice President	1	Business/Executive Positions
Executive Vice President Estimating	1	Business/Executive Positions
Owner and President	1	Business/Executive Positions

President	1	Business/Executive Positions
Senior Vice President of Operations	1	Business/Executive Positions
Vice President	1	Business/Executive Positions
Vice President and General Manager	1	Business/Executive Positions
Vice President of Construction	1	Business/Executive Positions
Vice President of Development	1	Business/Executive Positions
Vice President, Marketing	1	Business/Executive Positions
Vice President, Operations	1	Business/Executive Positions
Building Information Modeling Manager	1	Construction Technology
Information Technology Director	1	Construction Technology
Virtual Design and Construction Manager	1	Construction Technology
Area Superintendent	1	Project Management/Superintendent
Assistant Project Manager	1	Project Management/Superintendent
Director of Construction	1	Project Management/Superintendent
Project Executive	2	Project Management/Superintendent
Project Manager	8	Project Management/Superintendent
Senior Project Manager	2	Project Management/Superintendent
Superintendent	1	Project Management/Superintendent
Safety Director	1	Jobsite Safety Roles
Safety Manager	1	Jobsite Safety Roles

Table 1: Job Title of Respondents and Respective Subcategories

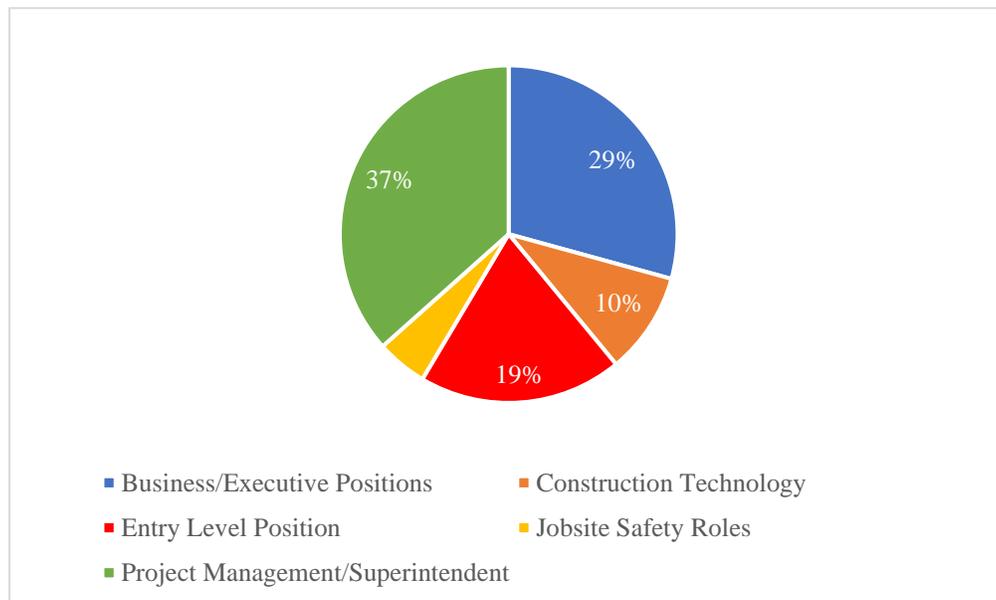


Figure 1: Job Title of Respondents

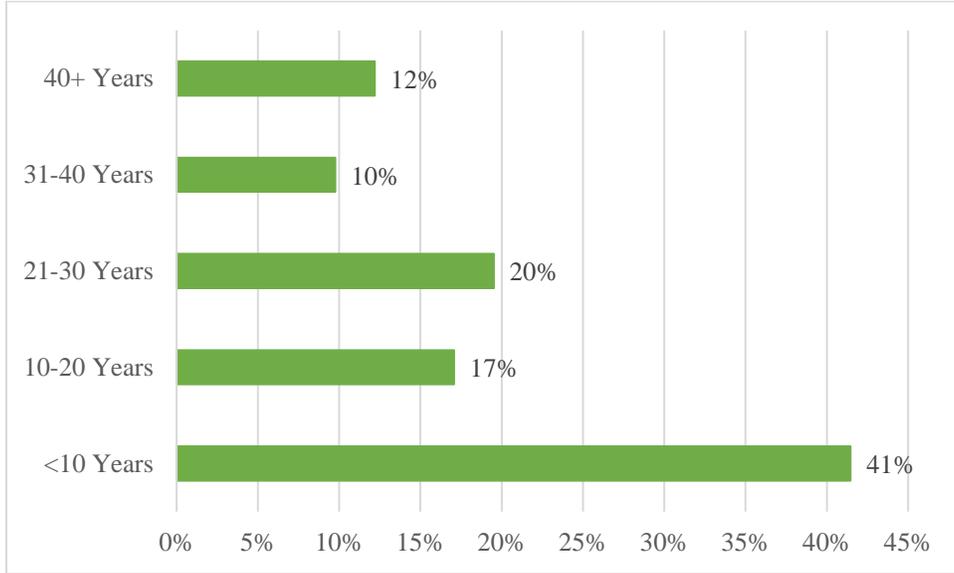


Figure 2: Respondent's Years Worked in Construction

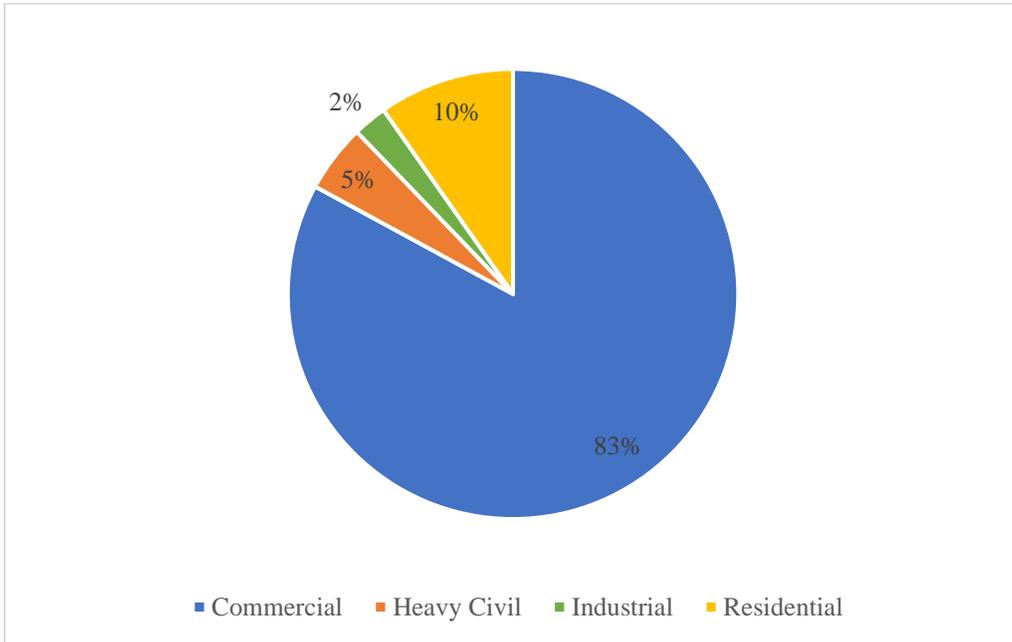


Figure 3: Industry Sector of Respondents

For ease of comprehension, each job title response was broken down into one of five subcategories: Project Management/Superintendent, Construction Technology, Business/Executive Positions, Jobsite Safety Roles, and Entry Level Position. Table 1 illustrates how each job title response was categorized and Figure 1 shows the breakdown of these positions. Project Management/Superintendent receives the most responses making up approximately 37% of the respondent’s job titles.

An important piece of background information was the years worked in the construction sector of the respondents. Due to VR being a relatively new technology, it can be assumed that younger industry workers would be more familiar with the technology. This concept was explored with later questions as seen in Figure 4. The average years worked in the construction industry of the surveyed group is 18 years putting the average age of the respondents at approximately 40 years of age.

A majority of the survey respondents work in the commercial sector of construction, making up approximately 85% of the surveyed group. Construction workers in the commercial and heavy civil sector would be most likely to use VR technology due to the larger size of the projects.

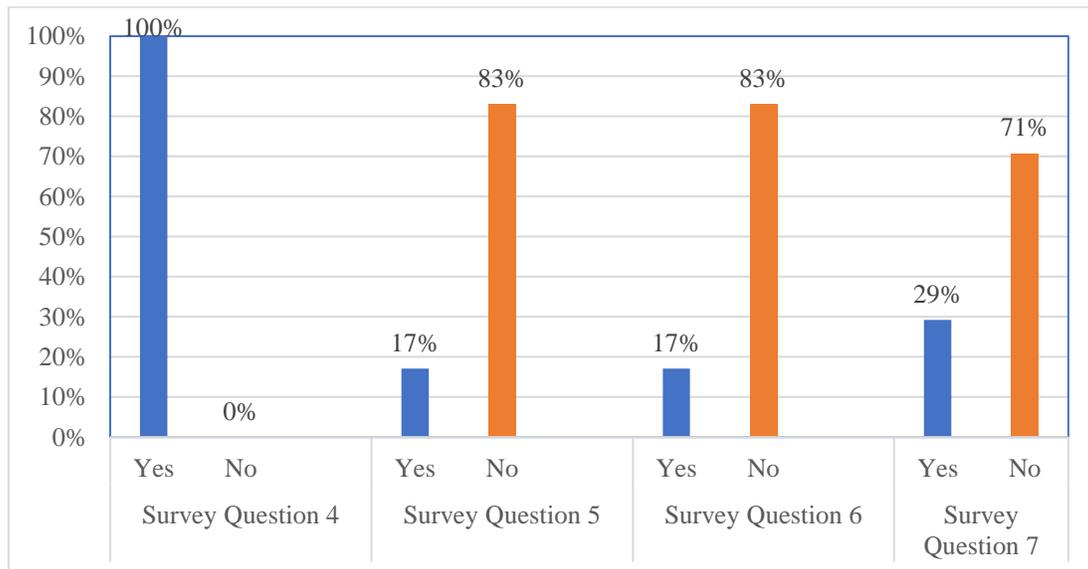


Figure 4: Survey Responses for Questions 4-7

Survey Question 4 asks ‘In general, do you believe that construction safety training can be improved to reduce injuries and fatalities?’ This question receives a unanimous ‘Yes’ response which is an encouraging response. Safety training should always be improved upon as it is one of the most important parts of the construction process. Without proper safety training, workers can put themselves or their coworkers at risk, and therefore this should be the main focal point for all construction companies.

Survey Question 5 asks ‘Are you familiar with virtual reality safety training?’ This question truly illustrates a lack of widespread knowledge of the technology as only 17% were familiar with VR.

Survey Question 6 asks ‘Has your company adopted virtual reality safety training?’ This again returns very low results as only 17% of the respondent’s companies had adopted VR. The data from this question shows that while VR has been adopted by some companies, a large majority of the industry have not explored the new technology.

Survey Question 7 asks ‘Have you experienced a general hesitation of adopting technologies like virtual reality?’ The purpose of this question is to gauge whether there may be a work culture bias against adopting newer technologies like VR, and the results prove otherwise. A large majority of the respondents said there was no hesitation of adopting newer technologies like virtual reality.

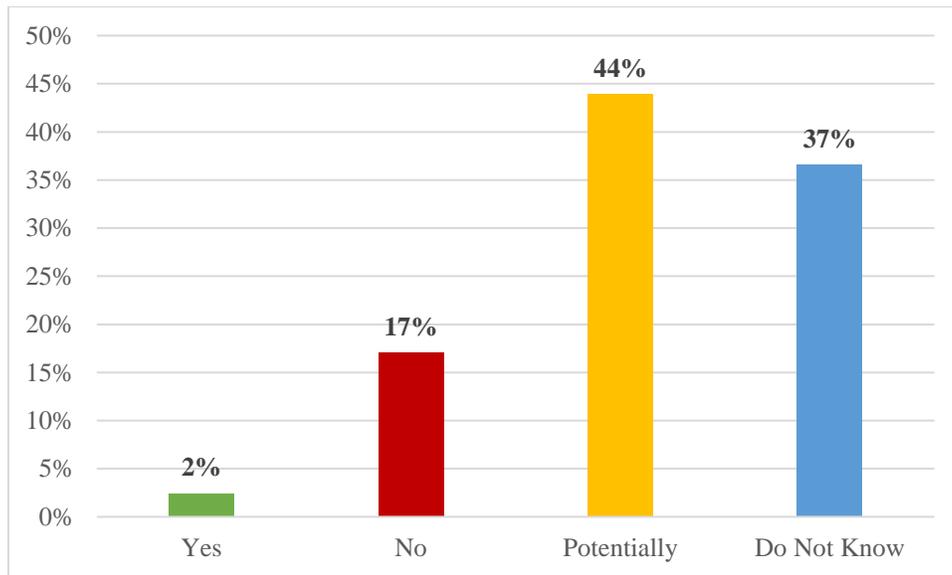


Figure 5: Question 8 Do you believe virtual reality safety training is more effective than traditional safety training?

The question posed in Figure 5 receives a mixed response with a majority of the respondents opting for inconclusive answers. The ‘Potentially’ and ‘Do Not Know’ options were chosen by 81% of the respondents which may illustrate a lack of overall knowledge of virtual reality technology and how it compares to traditional safety training. This question also has a subpart which asks for clarification on one’s answer, and many of the answers shared the same sentiment that one-on-one in person training was the most effective form of safety training. However, it became clear by reading through the responses that many did not fully understand virtual reality technology. Due to the COVID-19 pandemic, many construction companies have had to adopt virtual practices by communicating through Zoom or similar means of communication. Many of the respondents believed that virtual training would be training through technology similar to Zoom, where the trainees would simply be learning remotely.

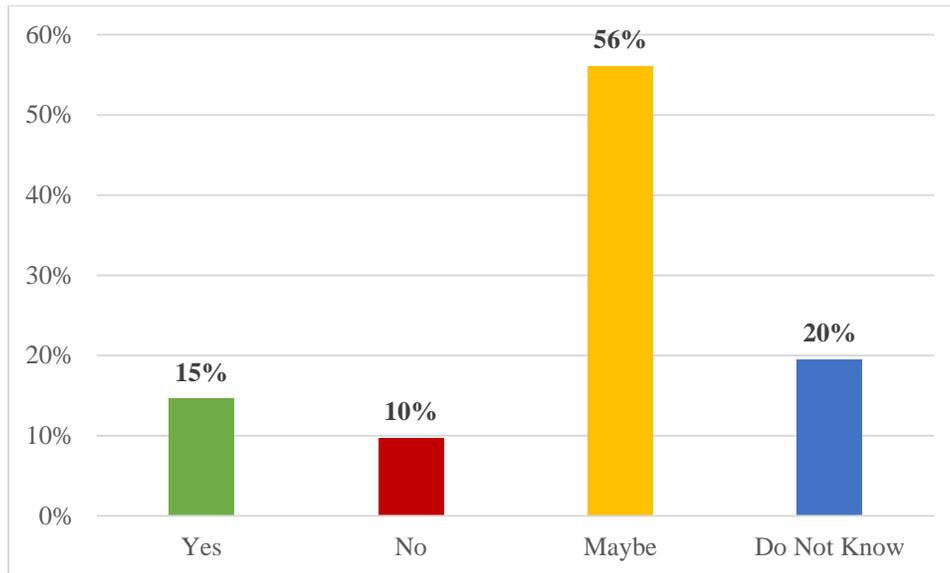


Figure 6: Do you believe that virtual reality safety training is the future of the construction industry?

The question posed in Figure 6 also receives a mixed response with a majority of respondents opting for inconclusive answers. The ‘Maybe’ and ‘Do Not Know’ options were chosen by 76% of the respondents which illustrates a lack of understanding of the technology. The purpose of this question was to gauge whether respondents saw the technology being used in the future of safety training, however this question is hard to answer without a solid comprehension of the technology. As indicated in Survey Question 5 in Figure 4, a minority of the respondents were familiar with VR, which made it difficult to answer with a definitive statement.

Conclusions

Safety is the primary point of importance on a jobsite and proper safety training is crucial for a project’s success. While countless safety measures have been implemented in construction, the industry is still incredibly dangerous for workers. The invention of virtual reality technology has become a part of the solution for this safety issue due to its ability to train workers within realistic jobsite simulations without the presence of danger. While virtual reality seems to have limitless possibilities in the construction sector, its potential has not been realized by many industry members. Research has proven the effectiveness of the technology in its use for construction safety training, however the overall lack of knowledge of the technology hinders its ability to be implemented across the industry. This research paper sought to discover industry members’ opinions regarding virtual reality safety training’s effectiveness compared to traditional training and its future place in the industry. The survey did not return many conclusive results. A minority of the respondents, 17%, were familiar with VR technology and the same percentage of companies had adopted virtual reality safety training. Due to the lack of familiarity with the technology, the respondents could not make conclusive statements regarding the technology’s effectiveness or potential. One promising component of the survey was that the question regarding whether or not safety training could be improved received a unanimous ‘Yes’ response. Safety training is an incredibly important aspect of

construction as the lives of workers and success of a company is dependent on it. As long as industry members actively seek new ways to improve safety training, construction will continue to progress and prosper.

Future Research

There were some oversights in this study that may be resolved with future research into the topic of virtual reality safety training. Due to the lack of overall understanding of the concept of VR safety training, many of the respondents had different perceptions of the concept than what was being asked. As the technology becomes more advanced and more advertised, the results may differ in the future. A potential solution to this issue would be to actively seek industry members who have used virtual reality safety training and hear their opinions on the technology.

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