HAZARD RECOGNITION AND CONSTRUCTION SAFETY TRAINING EFFICACY STUDY USING VIRTUAL REALITY (VR)

A Thesis

By

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ABSTRACT

The majority of construction site incidents occur due to a lack of hazard awareness among workers on jobsites. This lack of awareness is despite mandatory construction safety training, typically in the form of written content (safety manuals) or of images depicting hazards. To reduce jobsite injuries and fatalities, general contractors have started adopting Virtual Reality (VR) to impart safety training to jobsite personnel. VR safety training is typically an immersive simulation comprising potential safety hazards embedded into a virtual jobsite; users are required to identify these hazards within a specified time frame with the expectation that they will be more adept at recognizing hazards on an actual jobsite, resulting in a fewer number of accidents. This study seeks to identify the actual impacts of VR on construction safety awareness among participants. The research addresses the following question: Does VR safety training increase hazard recognition awareness to a greater extent than conventional safety training? The method used for this research included: (a) assessing participants' construction safety awareness after receiving VR training and comparing it against their past construction safety awareness; (b) assessing participants' construction safety awareness after receiving conventional training and comparing it against their past construction safety awareness, and (c) comparing the delta or level of improvement observed in part (a) against levels of improvement observed in part (b). The research objective was to determine if VR training can offer greater improvement in safety awareness. Participants were asked to complete a multiple-choice Qualtrics questionnaire. The results of the study showed a statistically significant knowledge gain advantage with the use of VR.

Keywords: Immersive Virtual Reality, Simulation, Construction Safety, Hazard Recognition

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LITERATURE REVIEW

One of the strategies that can reduce the likelihood of jobsite accidents is training workers to detect hazards and to avoid or prevent them. Construction workers' lack of awareness of hazards has been observed to be a key contributing factor to the occurrence of accidents according to Abdelhamid and Everett (2000).

According to Agirachman and Shinozaki (2021), researchers have been investigating the potential of virtual reality (VR) technology for architectural design for years. Researchers investigated the ways virtual reality affects the architectural design process, education, cooperation, and practices of a variety of stakeholders. VR, for example, can assist people who are unfamiliar with traditional architectural representations to better understand the design process. In addition, virtual reality (VR) can be used to provide immersive sessions for design team members, potentially removing the need for travel. Designers can also simulate specific environment models and noise levels to test a design with a variety of user reactions.

Burke et al. (2006) argued that alternative methods of safety and health training are often less effective than training that includes behavioral modelling. The latest findings cast doubt on the public health workforce's existing dependence on more passive computer-based and remote training methods. However, the specific criteria that improve the relative effectiveness of safety and health training programs in decreasing or preventing worker injury or sickness remain unknown from these qualitative reviews.

As the integration of deep learning and computer vision is a new area of construction research, the conclusions of the research sparked new areas of study that will help enhance effective safety, performance, and productivity (Fang et al. 2020).

Construction sites are in a constant state of transition, changing on a daily basis. This constant change is a challenge for safety managers, who must be able to accurately predict hazardous conditions as much as possible before they result in injuries or fatalities in the workplace. Information and sensor technology advancements offer the potential to protect employees from injury. They do, however, rely on data collection methods that may be too slow for managers to act on the information received (Gheisari et al. 2014).

Hallowell's (2010) research results indicate that subcontractor selection, management support, and commitment, are the most cost-effective safety program features. The hiring of a full-time safety manager and maintaining records, on the other hand, are the least cost-effective program features. When resources are limited, managers can utilize the information offered in this research to guide resource investments, strategically pick a subset of safety program components, or justify additional resource investment in accident prevention.

Organizations that sincerely believe in a zero-injury ideology will likely explore using different indicators of safety performance than the usual measures. While using lagging indicators, the necessity for a safety program adjustment is often not understood until at least one injury has occurred. As a result, using a different method is a realistic and promising option to consider (Hinze et al. 2013).

Owners and designers in construction companies at all levels of management, construction workers, inspectors, and educators must work together to make construction as safe as possible Holt (2008).

Jeelani et al.'s (2020) training protocol included several new and unique training elements aimed at improving the trainees' hazard awareness and management skills. Furthermore, particular outcome factors were used to assess the success of training in increasing hazard awareness and management. The results show a 39% increase in hazard awareness and a 44% increase in emergency preparedness effectiveness.

Jin et al. (2019) reviewed over 500 journal articles in the field of construction safety; the study used a scientific mapping approach that included bibliometric search and relevant research analysis, followed by an in-depth qualitative discussion. It was discovered that there had been a large increase in construction safety publications over the last decade, particularly since 2012. It could also be said that construction safety is a long-standing and ever-evolving research domain that is constantly updated with fresh information (e.g., IT, BIM, VR).

Construction is a very diverse and complex ecosystem that involves more than twenty trades and a variety of specialized employees. As a result, construction is considered a high-risk business. During projects, accidents happen frequently and unavoidably. Despite the focus on construction site injuries, the industry's incidence rate is twice that of the industry average. This plague creates additional challenges on construction projects, including cost overruns and scheduling delays (Le et al. 2014).

Li et al. (2018) conducted an in-depth investigation into the causes of construction accidents. Hazardous site conditions, unsafe worker behavior, unsafe work sequences, and high-risk equipment operation are all important contributors to construction accidents.

Lucas et al.'s (2008) research in safety training is one of the very few examples of the use of virtual reality (VR) for construction safety training. The findings, as well as the discussion surrounding VR, indicate several significant benefits of virtual reality environments for construction safety instruction.

Mohamed and Chinda's (2011) developed a model in collaboration with a created index to assist organizations in planning the most effective safety implementation approach to meet their safety objectives within a specified timeframe.

Nnaji and Karakhan's (2020) findings of their research study are important to industry practitioners and researchers in terms of technological implementation constraints and hurdles, as well as ways for overcoming these limitations and obstacles. Overcoming technology implementation restrictions and acceptance barriers has been projected to boost the construction industry's adoption of technology for safety management.

According to Pham et al. (2018), construction sites are some of the most complicated and risky locations in which to work. As a result, to ensure the safety of building projects, knowledgeable and skilled professionals are required. Construction safety education at the tertiary level can help students gain practical safety knowledge and improve their safety awareness before they are permitted to enter a construction site. However, safety topics are not adequately addressed in most construction curricula. Furthermore, traditional approaches fail to provide practical experience and sufficiently engage students in developing safety knowledge.

Given the current state of safety training, virtual reality (VR), which emerged over two decades ago, has the potential to offer substantial benefits. VR has been applied and proven beneficial to various industries and educational disciplines. It is capable of immediately displaying threats to trainees without jeopardizing their safety. In addition, research has demonstrated that VR safety instruction retains trainees' attention better than traditional classroom training. Finally, VR may be utilized to give trainees a sense of control over their surroundings, thereby reinforcing their learning (Sacks et al. 2013).

Sanni-Anibire et al. (2020) revealed that a variety of causes of accidents, such as the use of PPEs and arrangements for working at heights, obtained high-risk ratings. The researcher found that if necessary precautions were not taken, high temperatures due to weather led to heat stress and sunburns. In addition, site conditions, which frequently included blowing sand and silica dust, had the ability to cause lung problems.

According to Seo et al. (2015), object detection is a technique for scene-based identification of safety issues such as failure to wear PPE or presence of a damaged portion of the structure. Object tracking is the process of tracking 2D or 3D trajectories of project entities such as equipment and workers; it provides information about their locations and movements, which can be used to identify unsafe acts or conditions such as equipment speeding, proximity between equipment, or proximity between workers and equipment.

Wilkins (2011) expressed major concerns about the effectiveness and content of current construction safety training in the United States. His assessment of 105 construction workers who had completed the ten-hour Occupational Safety and Health Administration (OSHA) "Construction Safety Training Course" found that they were dissatisfied with the manner in which the courses were offered. Wilkins emphasized the importance of training, including content relevant to the trainees' life, having a skilled trainer present the material, and augmenting training with practical resources that are easy to understand.

In two case studies, building information models (BIM) were successfully implemented using a safety rule-checking platform for fall hazard detection and prevention. An algorithm was able to locate potential fall hazards in concrete slabs and leading edges, as well as offer installation instructions (e.g., bill of materials, visualizations) for corresponding fall protection equipment that virtually resolves the identified hazards in a BIM. The findings suggest that the proposed method is successful in recognizing and visualizing possible fall risks, especially during safety design and planning stages (Zhang et al. 2015).

In the construction sector, VR simulations have been reported to be efficient for safety instruction. A VR-based safety-training program offers an interactive training experience where the users engage with an immersive virtual 3D environment. This interactive training allows users to strengthen their cognitive skills and awareness, which in turn improves their understanding of the training content. VR may also help to foster a safety culture that encourages construction workers to follow safe work practices. Because of its adaptability, VR simulations can arguably be continuously and iteratively re-developed more easily than can more static applications (Zhao and Lucas 2015).

Zou's (2011) case study shows how construction firms may foster and develop a strong safety culture. When members of management, workers, and other participants of the construction supply chain have the right beliefs, values, and attitudes and adopt appropriate behaviors, and when the organization has an integrated safety management system that accommodates not only policies, regulations, and site conditions, but also human factors, the vision of zero incidents and injuries on construction sites becomes feasible.

PROBLEM STATEMENT AND RESEARCH QUESTIONS

VR has been in existence in the US for several decades. However, even with the expansion of adoption of VR by several construction firms, the question about how efficiently training can be conducted for hazard recognition on an actual jobsite needs to be further explored. In addition, evidence regarding correlations between construction industry experience or OSHA training credentials of individuals and their hazard awareness knowledge is insufficient.

To address this problem, this research was guided by the following questions:

1) Does VR improve hazard recognition awareness?

2) Is the VR experience convenient for users compared to conventional methods of training?

3) Do immersive visuals help with safety knowledge retention more effectively than conventional training methods?

4) Is there a correlation between participants' demographics and their respective safety awareness?

RESEARCH OBJECTIVES

This study aimed to determine if VR safety training is potentially more effective for increasing participant knowledge retention than more conventional training methods.

The primary objective was to measure, using a multiple-choice Qualtrics questionnaire, increases in participants' construction safety awareness after conducting the VR training, and to compare it to more static methods of training. The results of the study indicated whether users' scores correlated with significant knowledge gain toward construction safety awareness.

RESEARCH ASSUMPTIONS

This research assumed that students are an appropriate proxy for construction workers on a jobsite.

RESEARCH LIMITATIONS

This research has some limitations. For example, only nine hazard categories were taken into consideration where in reality, there are more. Also, The Haskell Company provided the VR simulation and potential hazard visuals; this made it impossible to make adjustments to the visuals. Additionally, it must be acknowledged that there were several confounding variables in this research. For example, the control group's video took the form of a passive presentation whereas the VR simulation was interactive. Additionally, the control group participants watched a video of an actual jobsite whereas the VR simulation was digitally rendered. Finally, this research study was limited to recruiting Texas A&M University student participants who fell between the age categories of 18 to 35 years, which is not necessarily representative of the demographics of actual workers on a construction site.

RESEARCH HYPOTHESIS

The hypothesis for this research was that immersive VR simulation training is more effective in increasing a participant's construction safety and hazard recognition awareness compared to conventional methods of safety training.

METHODOLOGY

This research study was conducted in collaboration with Texas A&M University and The Haskell Company. The research secured Institutional Review Board (IRB) approval before proceeding, as required. A total of 100 participants were initially recruited via email. At the end of the study, a total of 63 participants had taken part in all the modules of the research. The study was conducted over approximately two months with a total time commitment time of two hours for each participant, which consisted of the user taking two surveys (demographic and post-completion) requiring five minutes each, watching a safety awareness video for a one-hour, engaging in a VR simulation for 15 minutes, and taking a pre-test, post-test and second post-test which required ten-minutes per test. Participants for the research study were recruited by sending an initial recruitment email and a demographic survey. Demographics such as participant's gender, age, disciplinary major at Texas A&M University, years of construction industry experience, OSHA training credentials and prior experience with VR were collected. Students were recruited in such a manner that there was a diverse population with respect to their initial response from the demographic survey. Participating students were divided randomly into two research groups based on their responses. After the two research groups were formed (experimental group and control group), participants were emailed a link to complete a pre-test quiz administered through Qualtrics. The pre-test included several multiple choice questions containing graphics with potential safety hazards and their respective categories (e.g., guarding, housekeeping, crane, trenching, elevated platforms, fire protection, electrical and welding) on a jobsite, there was a "Safe" category as well as a category entitled "no potential hazard present." Participants were required to identify the hazard category from a dropdown list by choosing an option that they deemed appropriate; this helped to assess their past knowledge about construction safety. Participants also watched a one-hour safety awareness video to contribute to their safety knowledge. After two-weeks, the experimental group participated in the VR safety training simulation (approximately 15 minutes per participant). The virtual simulation consisted of a jobsite exposed to several potential safety hazards that participants identified within an allocated time of 10 to 15 minutes. This contributed to collecting data from users to assess how they performed in terms of identifying the associated safety hazard correctly in a virtual surrounding. The control group watched a 360-degree recorded VR video showing a construction jobsite tour. Both the experimental and control groups took a post-test quiz after their respective VR slots; the post-test quiz was similar to the pre-test, but with different pictures of hazards. After a two-week gap from the completion date of the post-test, both groups were sent a second post-test quiz similar to the first two tests containing different pictures to determine their knowledge retention after the passage of time. Finally, a post-completion survey was circulated to participants of both groups asking them to rate their research experience based on several aspects on a 1 to 5 points scale. Participants were compensated for their time and effort with a $70 Visa gift card at the end of the study. This research used a quantitative approach to compare participants' scores before and after being exposed to the VR safety training. A Qualtrics survey was used to conduct a series of tests; other appropriate statistical tests using Minitab were conducted as well.

RESULTS

To collect results, the participants were divided into two groups: an experimental group (EG) and a control group (CG) based on their responses from the demographic survey. The selection was made to maintain a relatively equal balance between both the groups based on gender, age, experience in the construction industry, prior VR experience, level of study at Texas A&M University and OSHA training credentials.

As shown in Figure 1, approximately half of the recruited population were graduate students and the rest included undergraduate students across all academic years of study.

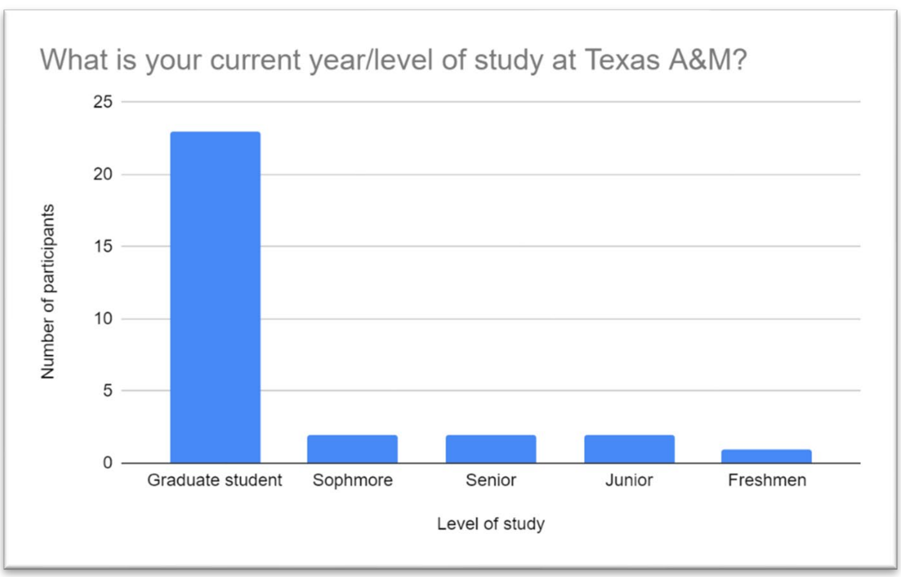

Figure 1. Self-reported level of study for selected participants

As shown in Figure 2, the study populations were selected to create a diversity of participant work experience in the construction industry in terms of the number of months and years. Work experience ranged from no prior work experience to participants with more than three years of construction work experience. There were considerations in terms of selecting participants based on their prior use of any VR headset.

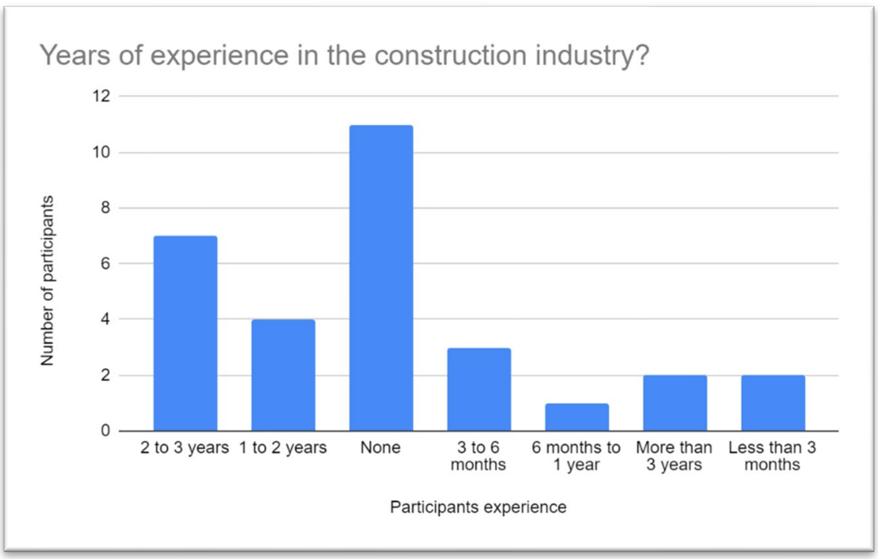

Figure 2. Number of years of participants' work experience

According to Figure 3, there was an approximately equal number of individuals who had previously used VR (including gaming) and those who had not.

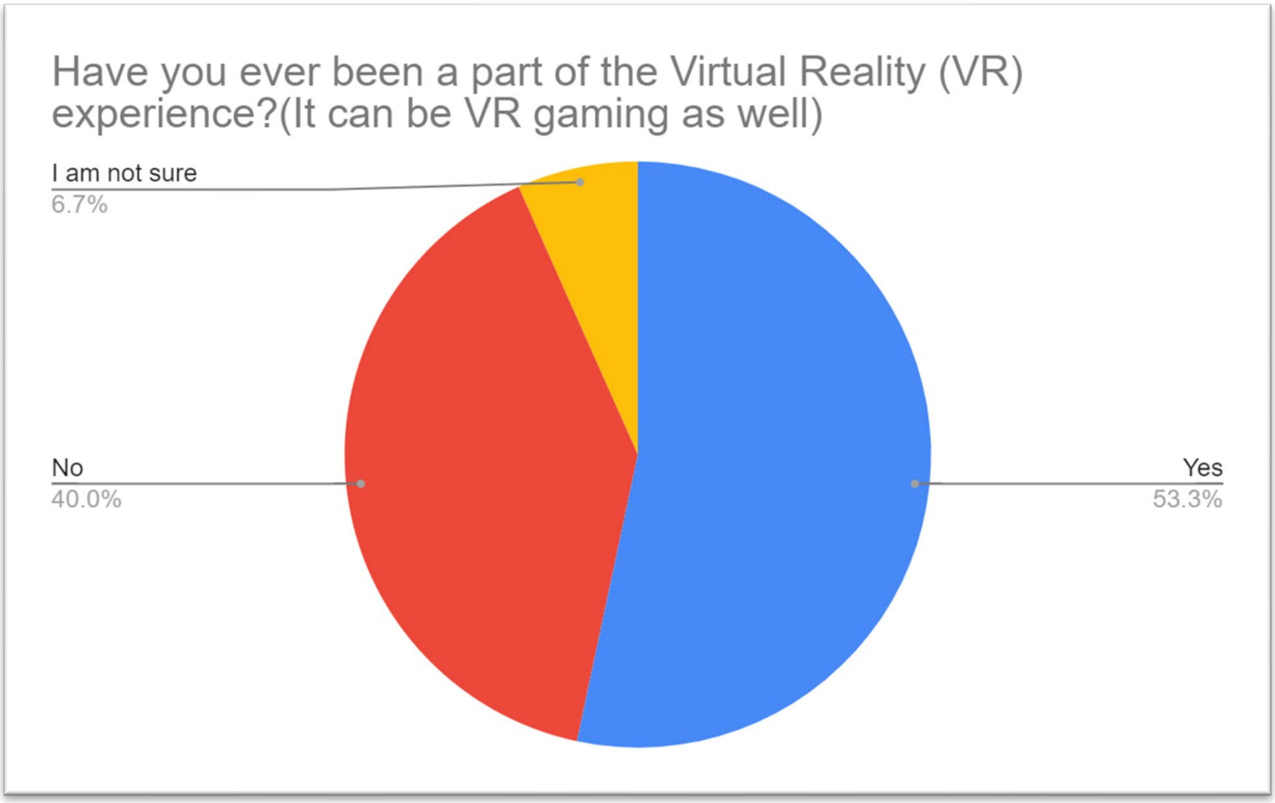

Figure 3. Participants' responses when asked about their prior experience with VR

Data obtained from the demographic questionnaire shows that an above-average number of participants (63.3%) had not taken OSHA training before participation (Figure 4).

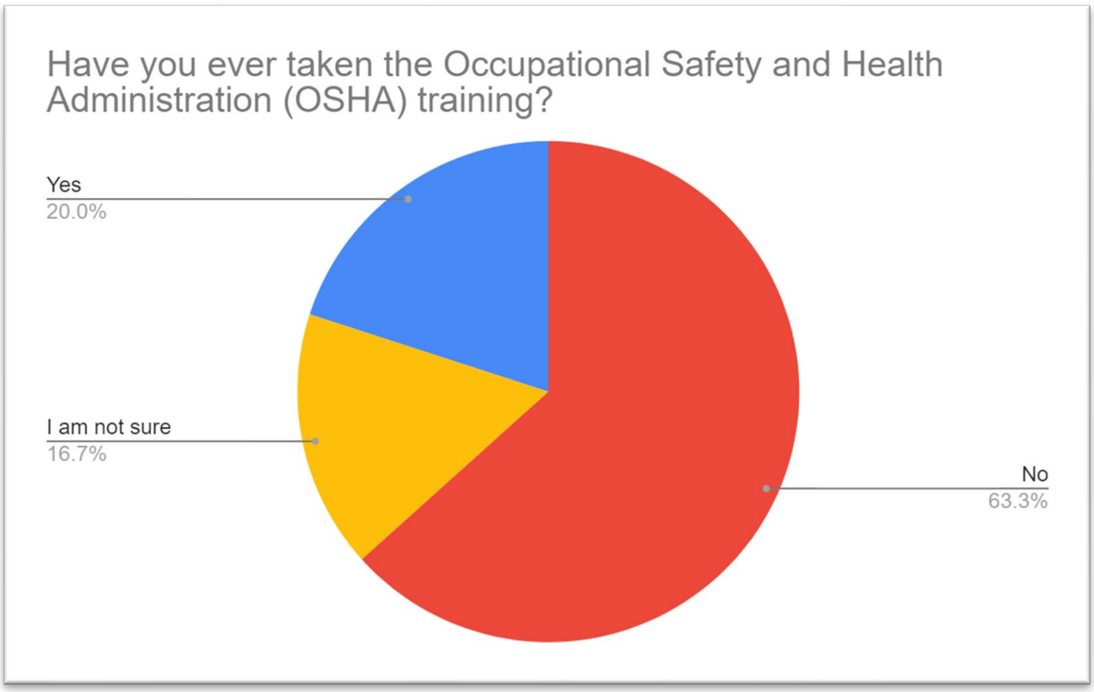

Figure 4. Participants' self-reported OSHA credentials

Students were recruited from a variety of subject majors and not just limited to students with construction as their study major. This was done to maintain a diversified population and to obtain results as accurate as possible with a mixed cohort. The following is the list of the departments and/or majors from which students were recruited:

- University Studies – Global Arts, Planning, Design and Construction (USAR)
- Construction
- Architecture
- Public Health

- Business
- Accounting
- Visualization
- Urban planning
- Neuroscience
- Psychology
- Economics
- English
- Marketing
- History

Figure 5 shows two sample questions taken from the actual pre-and post-test that were given to the participants. There were nine potential hazard categories from which participants were required to choose in the dropdown menu. The answer to the sample pre-test question in Figure 1 would be “guarding hazard” as there are no barricades or sufficient support for the worker to stop him or her from potentially falling. The answer to the sample post-test question would be “Trenching hazard” based on the surrounding of the worker’s environment from the picture in Figure 5. Participants were given nine options to select an appropriate hazard category. There were a total number of 18 questions in each quiz covering various categories of potential hazards across the pre-, post- and second post-test. The one-hour safety training video that participants watched comprised seven modules (e.g. General Work Rules, Process and Electrical, Trenching Excavation, Fire Protection, Vehicles and Equipment, Work at Elevations, and Other Safety Issues) covering various attributes related to construction safety.

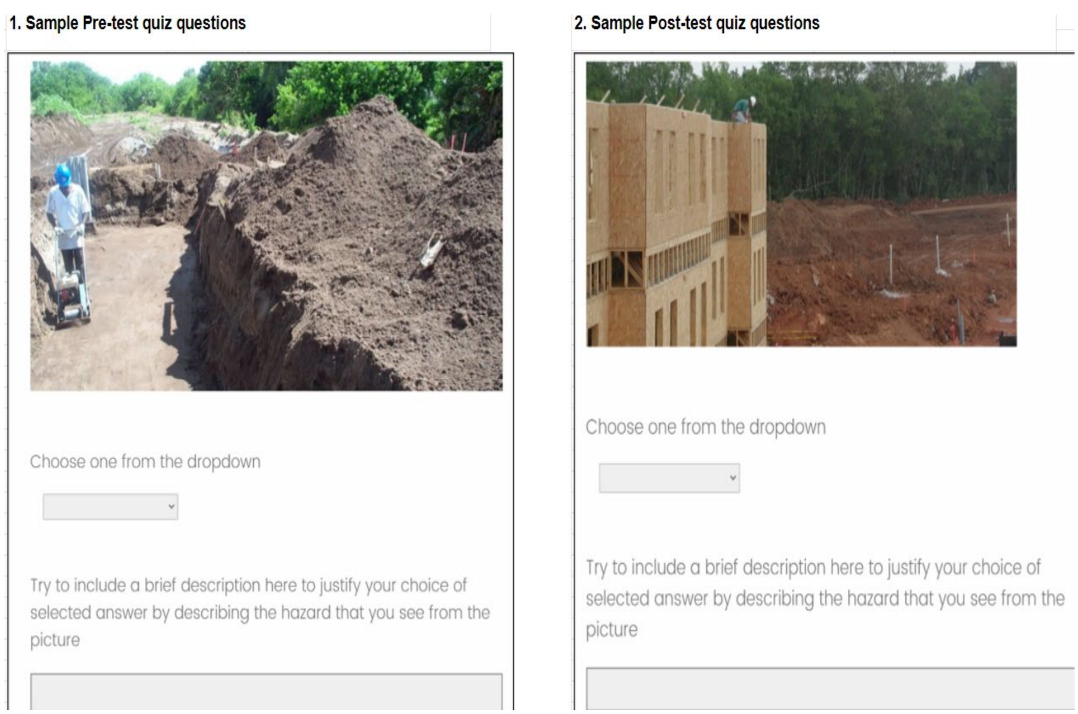

Figure 5. Sample pre-and post-test quiz questions

The one-hour safety training video that participants watched comprised seven modules covering various attributes related to construction safety (Figure 6). Images from a typical experience of participants during the experiments are also depicted (Figures 7, 8, and 9). A summary of participant responses during the post-completion survey is also shown (Figure 10).

Figure 6. Safety training video modules

Figure 7 shows a participant from the experimental group experiencing the VR safety training simulation video (approximately 15 minutes per participant) provided by The Haskell Company. The virtual simulation consisted of a jobsite exposed to several potential safety hazards which participants were asked to identify within 10 to 15 minutes.

Figure 7. Participant of the experimental group performing the VR simulation

Figure 8. Participant's performance evaluation after engaging in the VR simulation

Figure 9 depicts a control group participant watching a 360-degree recorded VR video simulation showing a construction jobsite tour which was provided by The Haskell Company.

Figure 9. Control group participant watching video

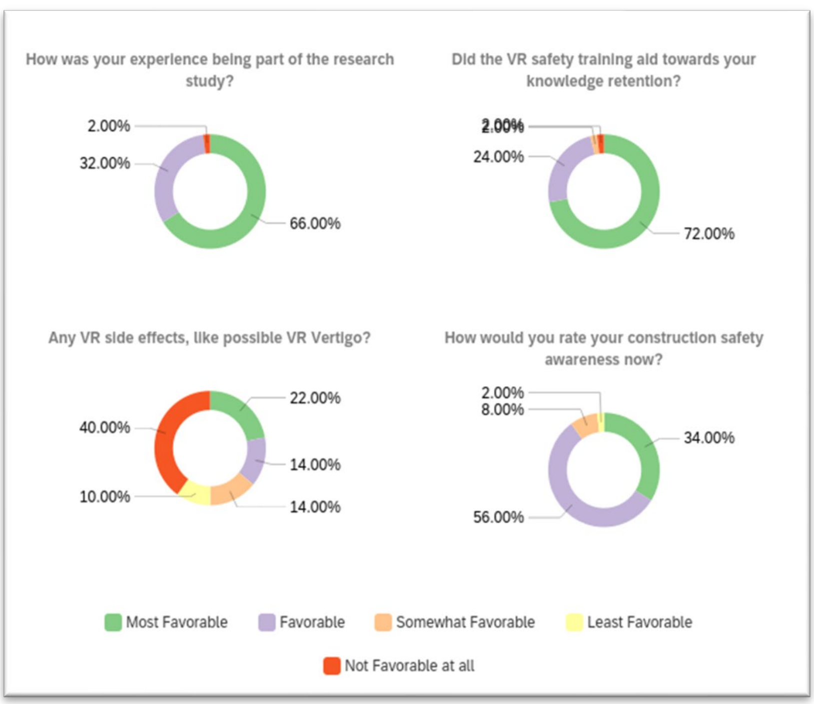

Figure 10. Summary of participant's responses from the post-completion survey

The results shown in Figure 11 were obtained using Minitab. There was a delta (improvement) of 17.83% between the pre- and post-test scores of the Experimental Group. Meanwhile, a delta of 11.89% was found between the pre- and post-test scores of the Control Group participants. In other words, participants of the experimental group performed better in terms of hazard recognition in the pre and post-test quiz when compared to the control group participants in this research study. Indeed, the data suggest that immersive, interactive, VR safety training to an individual can offer a be a more effective form of knowledge transfer rather than a static VR pre-recorded jobsite tour. While this appeared to generally be the case, four participants from the experimental group and two participants from the control group experienced some negative effects during their training (e.g., VR vertigo, motion sickness, etc.).

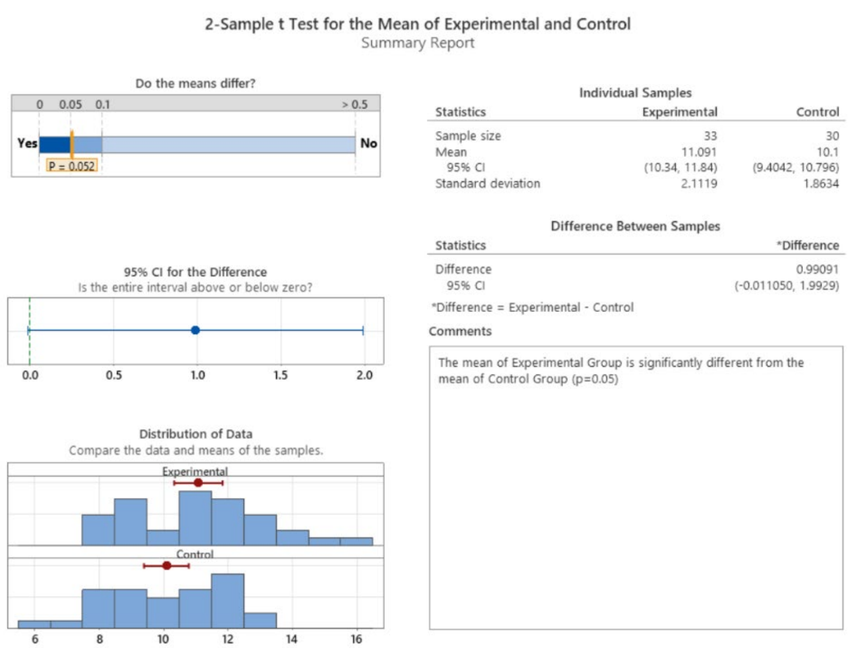

Figure 11. P-value and 2-sample t-test results

CONCLUSION

This research investigated the impact of VR training on construction worker safety and hazard awareness compared to more conventional methods of safety training. Of the total participants tested, 98% rated as “very favorable” their experience in partaking in this research study and strongly agreed that safety training using VR helped grow their knowledge about construction safety and hazard awareness. In total, 90% of the participants indicated that their construction safety awareness significantly improved after participating, compared to their past awareness. In fact, those trained using VR experienced a pre- and post-test score improvement of 17.83% compared to those who were trained using more conventional methods and who experienced a 11.89% score improvement. Although these data are preliminary and have some stated limitations, it is recommended that VR offers strong potential as a platform for safety training and further research should be pursued in this area. Providing background sound effects for the animated VR simulation may further increase hazard awareness retention.

ACKNOWLEDGEMENTS

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RESEARCH TIMELINE

The timeline for this research study was as follows:

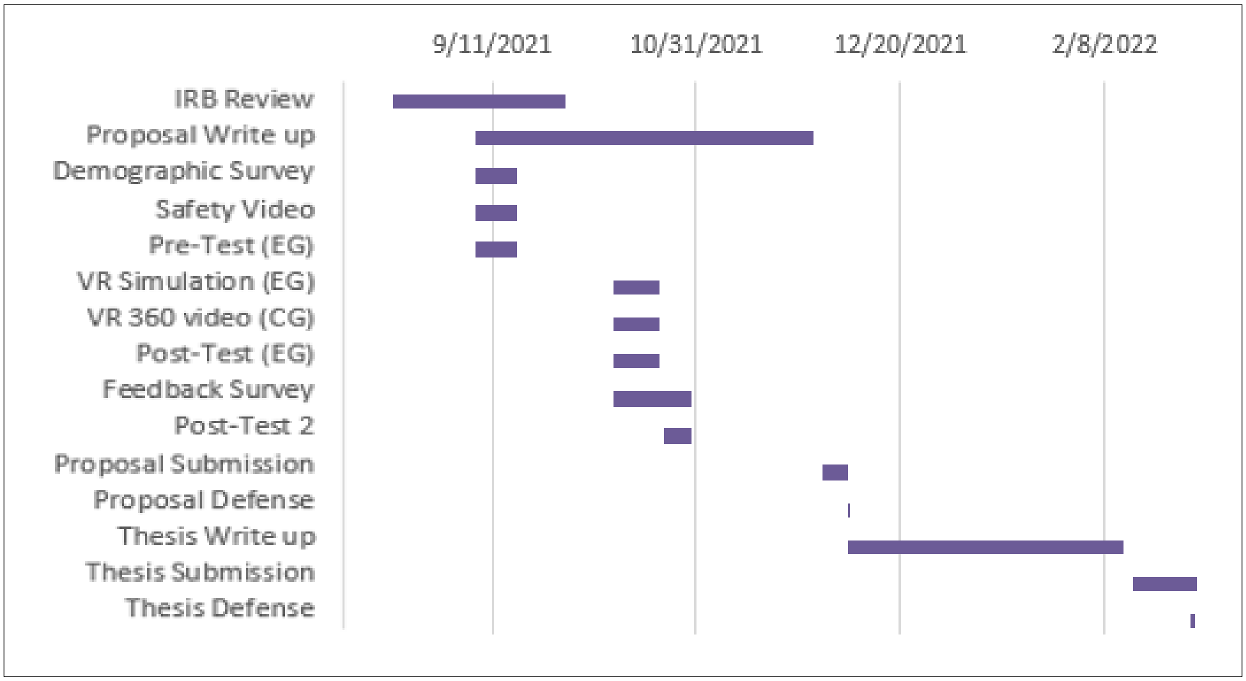

Figure 12. Research timeline

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APPENDIX A
CONTROL GROUP PARTICIPANTS' QUIZ DATA

Participant	Pre-test	Pre-test	Post-Test 1	Post-Test 1	Post-Test 2	Post-Test 2
Number	Score (out of 18)	Score in percentage	Score (out of 18)	Score in percentage	Score (out of 18)	Score in percentage
1	7	38.89%	8	44.44%	3	16.67%
2	6	33.33%	9	50%	7	38.89%
3	9	50%	11	61.11%	13	72.22%
4	6	33.33%	8	44.44%	8	44.44%
5	8	44.44%	10	55.56%	7	38.89%
6	5	27.78%	9	50%	12	66.67%
7	7	38.89%	8	44.44%	12	66.67%
8	9	50%	13	72.22%	8	44.44%
9	11	61.11%	12	66.67%	10	55.56%
10	7	38.89%	8	44.44%	6	33.33%
11	9	50%	10	55.56%	8	44.44%
12	9	50%	8	44.44%	9	50%
13	9	50%	12	66.67%	10	55.56%
14	8	44.44%	12	66.67%	11	61.11%
15	8	44.44%	9	50%	8	44.44%
16	6	33.33%	11	61.11%	11	61.11%
17	7	38.89%	9	50%	6	33.33%
18	6	33.33%	8	44.44%	6	33.33%
19	8	44.44%	10	55.56%	6	33.33%
20	7	38.89%	12	66.67%	11	61.11%
21	11	61.11%	13	72.22%	10	55.56%
22	9	50%	11	61.11%	10	55.56%
23	8	44.44%	11	61.11%	10	55.56%
24	11	61.11%	12	66.67%	10	55.56%
25	12	66.67%	11	61.11%	11	61.11%
26	10	55.56%	12	66.67%	10	55.56%
27	10	55.56%	10	55.56%	9	50%
28	10	55.56%	11	61.11%	11	61.11%
29	6	33.33%	7	38.89%	12	66.67%
30	4	22.22%	6	33.33%	10	55.56%
Average	8.1	45%	10	55.7%	9.17	50%

APPENDIX B
EXPERIMENTAL GROUP PARTICIPANTS' QUIZ DATA

Participant Number	Pre-test Score (out of 18)	Pre-test Score in percentage	Post-Test 1 Score (out of 18)	Post-Test 1 Score in percentage	Post-Test 2 Score (out of 18)	Post-Test 2 Score in percentage
31	11	61.11%	11	61.11%	9	50%
32	10	55.56%	12	66.67%	7	38.89%
33	7	38.89%	11	61.11%	6	33.33%
34	6	33.33%	9	50%	8	44.44%
35	4	22.22%	8	44.44%	8	44.44%
36	8	44.44%	7	38.89%	13	72.22%
37	8	44.44%	13	72.22%	11	61.11%
38	8	44.44%	11	61.11%	11	61.11%
39	10	55.56%	12	66.67%	9	50%
40	8	44.44%	9	50%	11	61.11%
41	9	50%	15	83.33%	12	66.67%
42	10	55.56%	10	55.56%	9	50%
43	6	33.33%	8	44.44%	6	33.33%
44	6	33.33%	13	72.22%	10	55.56%
45	7	38.89%	12	66.67%	8	44.44%
46	7	38.89%	11	61.11%	10	55.56%
47	9	50%	14	77.78%	10	55.56%
48	6	33.33%	13	72.22%	12	66.67%
49	11	61.11%	13	72.22%	12	66.67%
50	8	44.44%	11	61.11%	9	50%
51	9	50%	9	50%	7	38.89%
52	9	50%	12	66.67%	7	38.89%
53	8	44.44%	14	77.78%	13	72.22%
54	9	50%	8	44.44%	11	61.11%
55	10	55.56%	12	66.67%	12	66.67%
56	11	61.11%	10	55.56%	10	55.56%
57	10	55.56%	9	50%	13	72.22%
58	10	55.56%	16	88.89%	13	72.22%
59	7	38.89%	11	61.11%	12	66.67%
60	7	38.89%	10	55.56%	7	38.89%
61	6	33.33%	9	50%	6	33.33%
62	10	55.56%	12	66.67%	10	55.56%
63	8	44.44%	6	33.33%	5	27.78%
Average	8.27	45%	10.93	60%	9.6	53.3%

APPENDIX C
EXPERIMENTAL GROUP PARTICIPANTS' VR EVALUATION DATA

Participant	**VR Simulation data**		
Number	Time taken (In minutes)	Correct answers	Incorrect answers
1	13:03	6	7
2	10:54	4	7
3	14:20	5	8
4	8:50	2	2
5	15:04	1	3
6	15:02	4	6
7	7:28	2	3
8	13:59	5	6
9	13:12	1	7
10	12:39	5	6
11	10:46	3	5
12	17:21	3	3
13	14:58	5	3
14	11:51	5	5
15	8:49	4	5
16	5:34	4	2
17	11:44	7	7
18	15:50	2	5
19	14:54	7	5
20	12:14	2	8
21	16:41	5	4
22	15:20	5	5
23	14:09	6	7
24	8:40	8	3
25	9:03	5	3
26	15:13	5	8
27	10:08	6	5
28	15:14	11	2
29	10:13	5	6
30	17:52	3	2
31	9:56	2	4
32	14:54	9	4
33	11:58	4	4
Average	12:39	4.57	4.84

APPENDIX D
DELTA FOR EXPERIMENTAL AND CONTROL GROUP TEST SCORE

	Experimental Group				Control Group		
	Pre-Test Score	Post-Test Score	(out of 18)		Pre-Test Score	Post-Test Score(out of 18)	(out of 18)
	11	11			7	8	
	10	12			6	9	
	7	11			9	11	
	6	9			6	8	
	4	8			8	10	
	Data removed				5	9	
	8	13			7	8	
	8	11			9	13	
	10	12			11	12	
	8	9			7	8	
	9	15			9	10	
	10	10			Data removed		
	6	8			9	12	
	6	13			8	12	
	7	12			8	9	
	7	11			6	11	
	9	14			7	9	
	6	13			6	8	
	11	13			8	10	
	8	11			7	12	
	9	9			11	13	
	9	12			9	11	
	8	14			8	11	
	Data removed				11	12	
	10	12			Data removed		
	Data removed				10	12	
	10	9			10	10	
	10	16			10	11	
	7	11			6	7	
	7	10			4	6	
	6	9					
	10	12					
	Data removed						
Mean	8.172414	11.37931034			7.928571	10.07142857	
Delta		**3.21 (17.83%)**				**2.14 (11.89%)**	