Determining Student Interest for a Virtual Reality Safety Training Course

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The purpose of Cal Poly's Construction Management Department is to provide students with the best education they can get so they can be prepared for the challenges they may encounter in their professional careers. This research paper analyzes students' prior knowledge of virtual reality (VR) and determines the interest in creating a Construction Management (CM) technical elective covering VR and safety training which can help educate and train students about safety, hazardous jobsite situations, and accident prevention measures. This paper also examines the advantages of a VR construction training course taught on campus compared to online training without VR. VR uses technology to create a computer-generated environment which gives the user the feeling that they are physically in the three-dimensional (3-D) environment. The use of VR for training gives an advantage to students by allowing them to interact with each other in a simulated 3-D jobsite environment, providing a higher retention rate for the training material. A survey was conducted to determine CM student interest in a VR and safety training technical elective. Based on these results confirming student interest in an additional course, the department may want to develop a VR course for students to take as a technical elective.

Key Words: Virtual Reality, Construction, Higher Education, 3-D Environment, Safety Training

Introduction

This course idea stemmed from another construction management (CM) elective introducing virtual reality (VR) which caused interest to further explore the topic. A safe jobsite is one of the most important responsibilities of a construction project manager (Lamar, 2021). There will be many graduating Cal Poly CM students, so proper safety training will better prepare them for the workforce. Improving safety conditions in construction projects continues to be an obstacle worldwide (Li, 2017). Despite several advances in construction safety equipment and technology, the construction industry continues to face high rates of injuries and accidents due to improper safety training (Li, 2017). Approximately 20% of worker deaths in the United States are in the construction industry, and construction workers make up only 6% of the U.S. labor force. Over 60% of construction accidents

occur within an employee's first year (Bureau of Labor Statistics, 2021), which may indicate that new entrants to the construction workforce need additional safety training.

A VR safety and training course could broaden students' knowledge of jobsite safety in a way they typically would never see prior to entering the workforce (Zhang, 2022). CM students are required to take 8 units of major-specific technical electives. These technical electives give students the only opportunity they have to choose classes on specific construction topics that interest them outside of the standard CM curriculum. Although safety is already implemented within many courses throughout the CM curriculum, it is often overlooked unless used in hands-on courses such as residential construction management and commercial construction management. In these two classes, students build structures and systems assemblies, which requires the use of personal protective equipment (PPE) and proper safety training. Students are trained on material handling by Cal Poly staff. During this training, students learn about and use the tools necessary when building the structures required in these courses. This is the only hands-on training students receive through their courses at Cal Poly and it is completed within a few short hours.

Today, aside from these two courses, the way students are trained about jobsite safety can be compared to going through any online training program, such as in the course jobsite construction (CM 413), where students complete OSHA 10. The most known safety training course for entry-level employees is OSHA 10, a fully online course since 2001 (Bartolomei, 2020). However, techniques used in these training programs are not set up to help learners engage with or retain the information provided (Bhandari, 2019). Therefore, employees trained with online safety courses are proven to be less likely to be able to identify and mitigate unsafe working conditions because it is not highly engaging, and therefore less retainable (Bhandari, 2019). In general, people remember 10% of what they hear, 20% of what they read, 30% of what they see, 50% of what they hear and see, 70% what they say, and 90% of what they do (Associate Constructor Exam Official Study Guide). If Cal Poly's CM curriculum were to introduce a VR and safety training technical elective , students would be engaged in the 3-D environment, therefore retaining more information through their real-life experience. This has the potential to improve the ability of recent graduates to succeed in the construction industry specifically relating to safety.

The primary objectives of this research are to: (1) identify whether Cal Poly CM students have any knowledge on the topic of VR and safety, (2) to determine whether these students would be interested in a technical elective on VR and safety, and (3) determine general subjects for the course's curriculum if it were to be implemented.

Literature Review

VR technology is a 3-dimensional (3-D) computer-aided approach to provide collaboration and visualization in a realistic 360-degree environment (Zhang, 2022). To use this technology, a person must wear special electronic equipment, such as a headset generating realistic images, sounds, and other sensations that replicate a real environment or create an imaginary setting (Oculus, 2021). In the construction industry, this type of device allows the user to visualize complex jobsite situations. The use of VR technology has gained popularity as an efficient tool to enhance learning in the fields of architecture, engineering, and construction (Li, 2017). Many construction-related accidents are because of the lack of preventive measures in workforce training, risk source identification, safety awareness, and education (Li, 2017). The ability to recognize dangerous situations is a learned trait, which is much more effectively cultivated on a jobsite through hands-on experience, rather than in low engagement courses (Zhang, 2022). Onsite training, however, is time-intensive, expensive, and

potentially hazardous depending on actual site situations (Li, 2017). In addition, construction employees may not be engaged by traditional safety training methods, resulting in a lack of knowledge transfer during the training process. VR can aid against all these obstacles. Multiple studies have argued that virtual reality can provide effective alternatives to traditional training methods in construction safety due to its realistic simulation capabilities with fewer hazards, and a higher level of alertness and cognition (Li, 2017; Zhang, 2022).

VR allows students to practice identifying hazardous conditions in an engaging environment where there are no life-threatening consequences. By being immersed in this environment, students are more likely to be fully engaged. In 2013, a study done was on 66 subjects, where half received traditional classroom training with visual aids, and the other half were trained using a 3-D immersive VR. VR training was found to be more effective than traditional methods in maintaining trainees' attention and concentration. Trainees in the virtual reality training environment maintained a higher level of alertness for the entire period while trainees in the normal training environment were unable to maintain concentration past the first hour (Barak, 2013). Maintaining concentration during safety training is extremely important to retain the necessary knowledge needed to create a safe jobsite for not only yourself, but your company, and surrounding bystanders. According to the U.S. Department of Labor (2020), "Businesses spend $170 billion a year on costs associated with occupational injuries and illnesses — expenditures that come straight out of company profits. But workplaces that establish safety and health management systems can reduce their injury and illness costs by 20 to 40 percent." When being part of a company, it is savings like these that can keep a business running (Lamar, 2021).

To achieve a fully immersive safety course, the course material should include a 3-D VR training module. The $300 Meta Quest 2 VR headset would be efficient for this type of course (Oculus, 2021). This headset includes a charging cable, power adapter, two touch controllers, AA batteries, and a glasses spacer. Other VR devices by Oculus are slowly being replaced by this rebranded headset. There are several training programs that can effectively provide the safety knowledge a class like this would need. Oculus Quest, now rebranded as Meta Quest 2, gives training options in the virtual world, including how to identify common Occupational Safety and Health Administration (OSHA) violations through a VR app. In this lesson, the wearer learns in detail about violations that occur within a warehouse environment (Oculus, 2021). A separate company called PIXO Apex connects businesses of all sizes with standard VR training content. Pixo Groups' self-guided training scenarios enable anyone to learn a procedure at their own pace and in a safer, more efficient way. Voiceovers and visual aids guide the learner through procedures and explain the step-by-step process. Construction training lessons that they provide include hazard recognition, fall protection, fire prevention measures, housekeeping, and confined spaces. They have headset options of Oculus Quest, Oculus Rift, and HP Reverb, being a great fit for this course (What is VR training, 2022).

Methodology

Using a quantitative research design, an anonymous online survey was distributed via email to all current students within Cal Poly's CM department in both the winter and spring 2022 quarters. The objectives of the survey were to (1) identify CM students' prior knowledge of VR, (2) assess the interest CM students had on a VR and safety training course, and (3) determine the usefulness of a virtual reality and safety training technical elective for the Cal Poly Curriculum.

To answer each of these objectives, a 16-question survey was comprised of multiple-choice, short answer, and rating scale questions on a scale of 0-10. The survey consisted of three sections with two

demographic questions to identify their year in school and internship experience. Free response questions gave students the opportunity to provide their input on the topic and a question to leave any other thoughts at the end of the survey. A copy of the survey questions is included in Appendix A.

Survey Response and Analysis

Of the approximately 530 students in the CM program, a total of 34 responses were received, which is a response rate of 6.4%. Since students' acceptance has not been analyzed for using VR technology in construction safety training on campus, this survey established new information and the data has been compiled into the figures shown below. As seen in Figure 1, 68% of the students responding to this survey were either 3rd or 4th-year construction students. This is important because these are the students who will or have been enrolled in technical electives. Of the 34 responses in Figure 2, 13 of these students have had 1 internship, 15 students have had 2 or more internships, and 6 have had no internships.

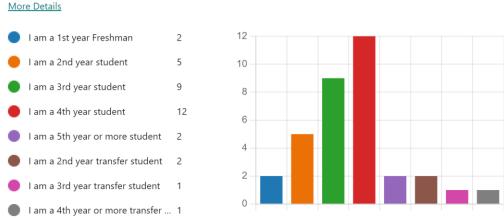1. How many years have you been a student at Cal Poly? (0 point)

More Details

● I am a 1st year Freshman	2
● I am a 2nd year student	5
● I am a 3rd year student	9
● I am a 4th year student	12
● I am a 5th year or more student	2
● I am a 2nd year transfer student	2
● I am a 3rd year transfer student	1
● I am a 4th year or more transfer ...	1

Figure 1: Students' Year of Enrollment at Cal Poly

2. Have you had an internship? (0 point)

More Details

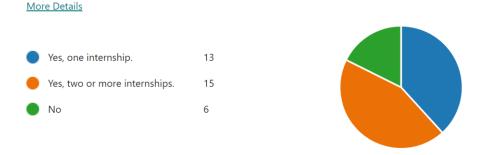| ● Yes, one internship. | 13 |
| ● Yes, two or more internships. | 15 |
| ● No | 6 |

Figure 2: Students' Number of Internships Completed

6. Rate your level of familiarity with virtual reality safety training. (0 point)

More Details

Promoters	1
Passives	2
Detractors	31

0

-88

-100   +100

NPS®

Figure 3: Students' Familiarity with VR Safety Training

Figure 3 used a Net Promoter Score (NPS) scale with ratings one through ten to determine how familiar students are with VR regarding safety training. On this scale, 10 represents being extremely familiar, and 0 represents not being familiar at all. Results show that nearly every student is not familiar with this type of safety training, demonstrating a lack of knowledge on the subject.

8. If you have used a VR device, what was the purpose of application? (0 point)

More Details

● Entertainment	24
● Education	4
● Business	3
● Other	1

Figure 4: Students' Purpose of VR Application

When asked is respondents had used a VR device, results showed that 74% (25) of the thirty-four respondents had previously used a VR device. Figure 4 determines why these students used a VR device by assessing the purpose of application. Respondents could select multiple responses, which can be seen through the results. Some of the respondents chose all three options that they used VR for education, business, and entertainment. Results show that most students have used VR for entertainment.

There were 13 responses from students to the question, "if known, what model VR device was used"? These students' responses concluded that they all used the VR device Oculus Quest 2. The Oculus Quest 2 VR headset would be the best for this course, due to the familiarity students have with this device.

10. Do you believe our department should create a class implementing a Virtual Reality safety course?

More Details   Insights

🔵	Yes	16
🟠	No	2
🟢	Maybe	15

Figure 5: Student Opinion on Implementation of a VR and Safety Training Course

Figure 5 shows student's opinion of whether Cal Poly should implement a technical elective on VR and safety training in the curriculum. Results indicated that students were interested in the implementation of a technical elective course. About 48% of respondents said yes, while 45% said maybe.

11. What type of material would you like to see in a Virtual Reality (VR) course? Choose all that apply.   (0 point)

More Details

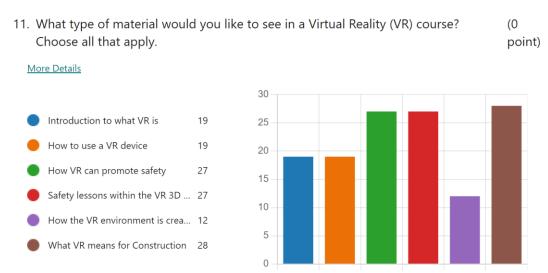|		
🔵	Introduction to what VR is	19
🟠	How to use a VR device	19
🟢	How VR can promote safety	27
🔴	Safety lessons within the VR 3D ...	27
🟣	How the VR environment is crea...	12
🟤	What VR means for Construction	28

Figure 6: Students' Interest in Course Material

Figure 6 sought to understand students' perspectives on what type of content should be included in a course on VR safety. Included are the topics, "Introduction to VR, how to use a VR device, how VR can promote safety, safety lessons within the VR 3D environment, how the VR environment is created, and what VR means for construction". This question shows a color code of student interests for the recommended topics, and each student can choose as many topics as they want. Introduction to VR and how to use a VR device received 19 votes, meaning that 19 students of the 34 voted for these topics. Only 12 students were interested in how the VR environment is created. 27 students would like

to see how VR can promote safety and safety lessons within the VR 3D environment, and 28 wanted to learn about what VR means for construction.

The follow up free response question asks, "What other type of material would you like to see in a Virtual Reality (VR) course? Describe it below". Several modules outside of physically acting in the 3D training will provide more insight towards the topic when implementing a 10-week course. Students suggested, "integration with non-VR programs, all applicable uses in construction not just VR but AR [augmented reality], other uses of VR besides safety such as virtual walkthroughs, how to create building models in VR, hands on learning with equipment, and how VR can be implemented beyond the safety aspect of construction". These are all great suggestions from students which could help expand the proposed course.

13. Would you want to enroll in a Virtual Reality Safety Training Course? (0 point)

More Details   💡 Insights

- Yes   16
- No   2
- Maybe   16

Figure 6: Students' Opinion on Enrollment

Figure 6 determines the students' interest in enrolling if there were to be a virtual reality and safety training topic course in the curriculum. The results were heavily in favor of being interested in the implementation of a virtual reality and safety training topics course. 47.5% of students answered they would be interested, 47.5% said they may be interested, and only 5% said they would not be interested in this course.

14. How effective do you believe a Virtual Reality course would be to train students about safety before entering the workforce?

More Details   💡 Insights

Promoters   3
Passives   20
Detractors   11

0

-23
NPS®

-100   +100

Figure 7: Students' Opinion on Effectiveness of Course

Figure 7 shows whether students believe a virtual reality and safety training topics course would be effective in training students about jobsite safety before starting their career. Many students were passive about this question and were not sure about how this course would help for their future career. This demonstrates that there is a lack of knowledge in this area of the survey.

At the end of the survey, the free response question asking "If there is anything else you would like to add, describe it below" received 4 responses, providing additional student feedback on VR and the potential for a VR safety training course. One student commented, "COVID makes using the equipment not the safest." When using any equipment in a classroom it is important to wipe it down before and after use. With COVID restrictions lifting and significantly less case numbers arising, there are precautions that can be taken to almost diminish any risk of COVID contraction completely through this equipment. Interacting within a 3-D environment can even help fight against COVID contraction due to its ability to project wherever the user feels comfortable. Another student says, "I think this is a useful concept, but probably more as a module in an existing course as opposed to a full course on its own. How do you fill 10 weeks of content?" This could be analyzed in future research. A course as such will need to be analyzed more deeply to determine what students believe would best fill a 10-week course. However, based on the results of question 11 in the survey, students have established a potential broad course material outline based on their interests. Several weeks will need to be dedicated to separate VR training lessons, such as hazard recognition, fall protection, fire prevention measures, housekeeping, and confined spaces.

Conclusions and Future Research

For a project to succeed, workers need to receive proper safety training before entering a jobsite. Online safety courses such as OSHA-10 and OSHA-30 are affordable and effortless ways for companies to train their employees, but the effectiveness of these online safety courses is not high (Bartolomei, 2020). Many construction training programs are expensive to fund but VR applications reduce the need for costly equipment and improve training accessibility (Zielinski, 2021). According to the U.S. Department of Labor, "Businesses spend $170 billion a year on costs associated with occupational injuries and illnesses", but with virtual reality, construction safety training becomes less costly, less risky, and more efficient (Lamar, 2021).

This project focused on determining student interest in a VR technical elective course for the Cal Poly curriculum through a survey approach. The purpose of my research was to identify whether Cal Poly CM students have prior knowledge of VR and safety, whether these students would be interested in a technical elective on VR and safety, and to determine general subjects for the course's curriculum if it would be implemented. One promising component of the survey was that many students showed interest in the course. With these results, it would be possible to create a functional course curriculum using the results of this survey. Future research could include interviewing potential teachers and industry members to determine the relevant lecture material for successful CM VR and safety training technical elective.

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Appendix A

Survey Questions:
1. How many years have you been a student at Cal Poly?
2. Have you had an internship?
3. What safety technology have you used during your internship? Choose all that apply.
4. Describe any other safety technology you have used below.
5. How important do you believe safety training is on a jobsite to prevent injuries?
6. Rate your level of familiarity with virtual reality safety training.
7. Have you ever used a Virtual Reality device?
8. If you have used a VR device, what was the purpose of application?
9. If known, what model VR device was used?

10. Do you believe our department should create a class implementing a Virtual Reality safety course?
11. What type of material would you like to see in a Virtual Reality (VR) course? Choose all that apply.
12. What other type of material would you like to see in a Virtual Reality (VR) course? Describe it below.
13. Would you want to enroll in a Virtual Reality Safety Training Course?
14. How effective do you believe a Virtual Reality course would be to train students about safety before entering the workforce?
15. Due to the current COVID 19 pandemic, how beneficial do you believe a Virtual Reality Safety course would be?
16. If there is anything else you would like to add, describe it below.