

Effectiveness of Virtual Reality Technology to teach Gen Z students about Construction Safety: A Pilot Study

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Abstract

This pilot study was conducted to investigate the effectiveness of using Virtual Reality (VR) technologies to teach the "Generation Z" (GenZ) students about construction safety as part of the Construction Science and Management (CSM) program at Tuskegee University.

Research shows that the "Technology Generation" or GenZ students are not satisfied with the traditional pedagogical methodology; rather they demand for hands-on, tech-heavy immersive learning experience. Virtual Reality (VR) is propelling similar pedagogical approach with technological renovation for Architecture, Engineering, and Construction (A/E/C) education. In this approach, students learn from a 3Dimensional (3D) interactive environment, instead of traditional 2Dimensional (2D) visual aids. This approach has been proven to positively influence construction education in many ways, including enhanced awareness and improved understanding, in general. At Tuskegee University, VR had been used in similar manner, in particular, to learn about Construction Safety, instead of going to the potentially dangerous construction sites for its effectiveness to teach GenZ students enrolled at the CSM program. For this study, GenZ students were first exposed to the traditional 2D teaching aids, demonstrating construction hazards, and then to multiple Virtual Reality serious games. Their responses were recorded through written reports, oral interviews followed by a survey incorporating comparative analysis between 2D visual aid and VR technologies. The results indicated that the GenZ students greatly welcomed VR Construction Safety exercises over the traditional 2D visual aids and were interested in exploring more.

Keywords: Virtual Reality Serious Games, Construction Safety, GenerationZ students, Higher Education

1. Introduction

The Construction Science & Management (CSM) program at Tuskegee University is committed to provide GenerationZ students with the most current technology to assist them become "project ready" construction personals. This pilot study was done to investigate if teaching construction safety using Virtual Reality (VR) technologies will be beneficial to incorporate into the CSM program curriculum.

GenerationZs (GenZ) are also known as "Digital Natives" are born between 1995–2005 and are very "tech savvy" and extremely comfortable using technology and social media [1]. They tend to embrace social learning environments rather than traditional learning approaches. Research shows that, they are more interested to be fully engaged in immersive education experience and be a part of the learning process [2]. It was also observed that this generation thrives within a realm that must connect

their academic experience to the real-life experiences through hands-on exercise [3]. This makes Virtual Reality (VR) the perfect platform to teach construction related subjects.

At Tuskegee University, construction safety has been traditionally taught using 2D visual aids such as drawings, pictures, video or infrequent construction site visits. Visiting construction sites is often the best means of learning about construction hazards and their mitigation methods. However, construction site visits could be dangerous, limited or unfeasible because of accessibility issues or potential liability. Therefore, this new approach will explore the effectiveness of VR technology in lieu of site visits. The hypothesis is that, this approach will provide a similar learning experience in identifying and assessing construction

safety hazards as site visits, without exposing the students to the potential dangers.

It is a well-known fact that the construction industry is one of the deadliest industries globally. Introduction of the Occupational Safety and Health Act (OSHA) in 1970 has resulted in a reduced number of injuries, yet statistics prove that it is still a severe threat. As a result, safer construction sites remain a big challenge and priority in every construction project. The goal to enhance construction safety education has led to research involving safety management along with on-site safety policies to better regulate construction activities and control risks. However, it requires involvement from all stakeholders, including workers, construction companies, owners, designers, regulators and educators [4]. Research has shown that a lack of proactive and preventive measures such as workforce training, risk source identification and control, safety awareness and education have considerable influence in controlling risk and safety on site [5]. Given all these facts, teaching safety to experienced workers remains a challenge, which magnifies when it comes to teaching GenerationZ (GenZ) students about

3. Literature Study

The pilot study began with an extensive literature review related to GenZ education in the construction science and management related fields. It was apparent that there are not many scientific publications realting GenZ education, VR and construction safety. However, several associated

4. Research Methodology

This research study was conducted as part of the current Construction Safety course at Tuskegee University as an entirely new approach to learn identify construction hazards. The involved students were all between the ages of 18 to 23 representing the tech-savvy GenZ generation. The study was strategically divided into three phases to promote data collection based on the literature study.

4.1 Part I – First, students were introduced to traditional teaching materials such as 2D images, PowerPoint presentation and related articles, etc. during regular lectures hours. These lectures were designed to teach students how to identify construction hazards based on OSHA's rules and regulations. For hazards assessments, students were given multiple real-life construction site pictures or videos to identify

2. Background: History and Connection to Gen Z Students

construction safety, as most of them lack the vital experience of working in a construction site. For example, they have little idea how it is to walk on a steel beam 300ft above ground. Most students are interested in looking over the class materials to pass the course or making better grades, than a life-saving tool. This demands for a new pedagogical approach incorporating more than just common training methods with low engagement (such as lectures, videos or demonstrations) that consistently had less impact compared to the more engaging forms of instruction [6] and this research seeks the answer if Virtual Reality is one of these engaging technologies.

GenZ students are also famous for learning by doing [2] or by a hands-on approach. Therefore, virtual environment, also known as Virtual Reality (VR) serious games seem to be a natural enhancement to traditional 2D visual aid that allows them to experience the real world from the safety of the classroom, bolstering their independent and self-reliant decision-making persona, both in the classroom and beyond.

topics such as appropriate pedagogical method for GenZ students [1], [2], [3] and [7] or impact of VR serious games to construction safety and education [8], [9], [10], [11], [12] were found. These articles helped formulate the research methodology.

and analyze the construction safety hazards. Their knowledge about the subject was tested for eight weeks using multiple quizzes along with toolbox presentations and safety observation reports. Once students were comfortable in identifying the hazards, they were exposed to the next phase of the experiment.

4.2 Part II - During this phase, students were exposed to five different Virtual Reality serious games, incorporating major risks related to construction work. Post VR experiments, data was collected as reports, via oral discussion and a 30-questions survey to gather maximum information possible. The survey mainly focused on a comparative analysis between 2D teaching aids vs. VR environments. The VR serious games used for this experiment were the ones available

for free and short enough to be used during class time as listed below.

4.2.1 *Texas Mutual's Safety in a box*: This is a simple and free app that can be downloaded from the Texas Mutual's website to a smartphone and used in a Google Cardboard viewer. Once installed, students were able to experience custom VR simulations of accident scenarios that could be a real threat on the job site and followed by a short quiz to reinforce the message. These exercises had demonstration listing the fatal four with examples by a real person,

which was extremely popular among students. Some students reported that this experience felt "real." However, they were immersive 360degree images with limited to no interaction or movement within the virtual environment. Most students felt this approach was limited as they could only turn their heads and look around instead of walking back and forth. Another recorded shortcoming was lack of emphasis on the use of Personal Protection Equipments (PPEs) which is vital for safe job site. Few scenes from this exercise are presented in Figure 1.

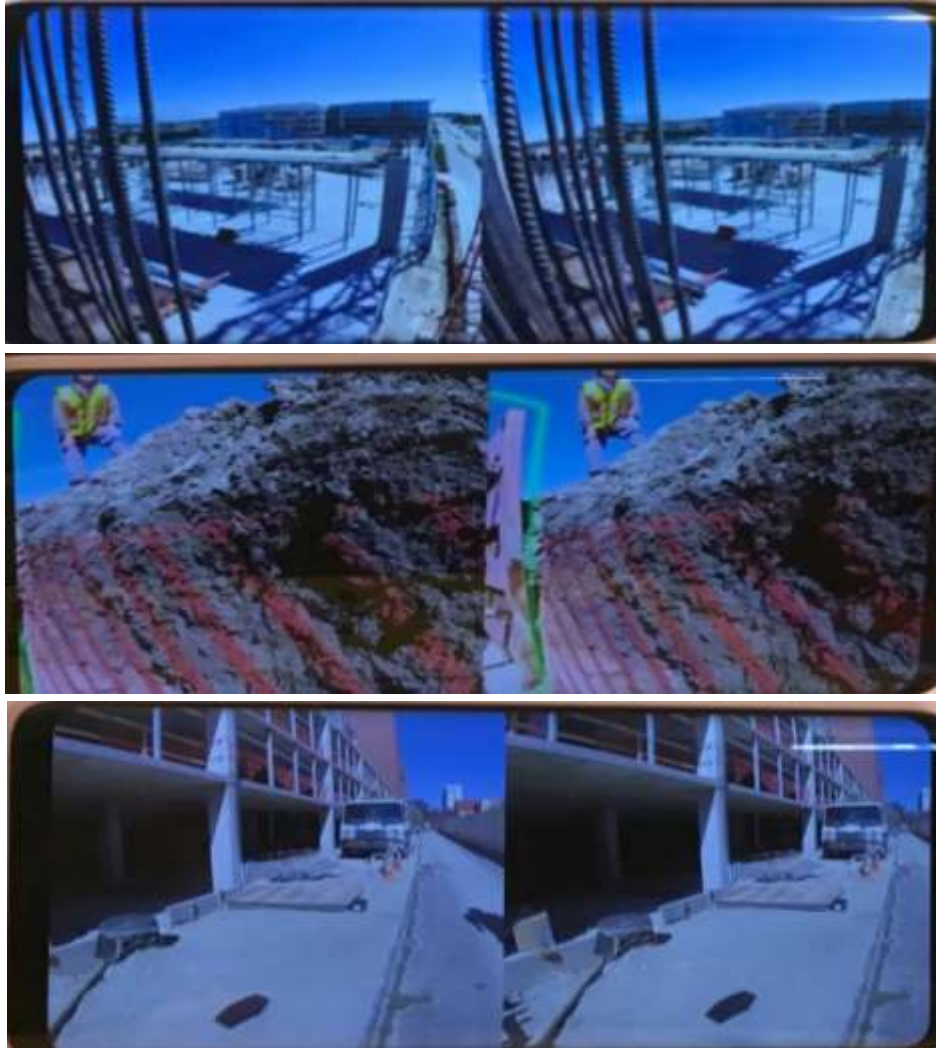


Figure 1: Texas Mutual's Safety in a box

4.2.2 *Harness Hero*: Similar to the Safety in a box, this free App can also be downloaded to a smartphone. It can be played on a screen instead of a head-mounted display. Harness Hero was developed in partnership with the Master Builders Association of Western Pennsylvania (MBA) and Constructors Association of Western Pennsylvania (CAWP) to help students make critical decision about picking the right Fall

arrest systems, i.e. a full body harness, in a safe and fun way. In this game, the students were exposed to several options and asked to choose the right anchor point, anchorage, and connection device, set up of the harness and more for an avatar worker. After that, the games continued to inspection for equipment-defects. The games ended with the avatar worker encountering a fall which could be fatal depending on the decisions made by the

students. The game can be repeated until the right decisions were learned. Images from this game are shown in Figure 2.

Most students liked this “engaging and challenging” yet fun game and admitted that they gained new knowledge about anchor points. The students were also moved by the acknowledgment of how their decisions can make a life-changing impact on someone

else. Most admitted that at that point, this game, and its content presented huge potential, bigger than just passing the course; instead something to carry in mind for their future career. They also acknowledged that this hands-on approach gave them a new viewpoint better than the 2D visual aids presented during the first phase of the experiment.

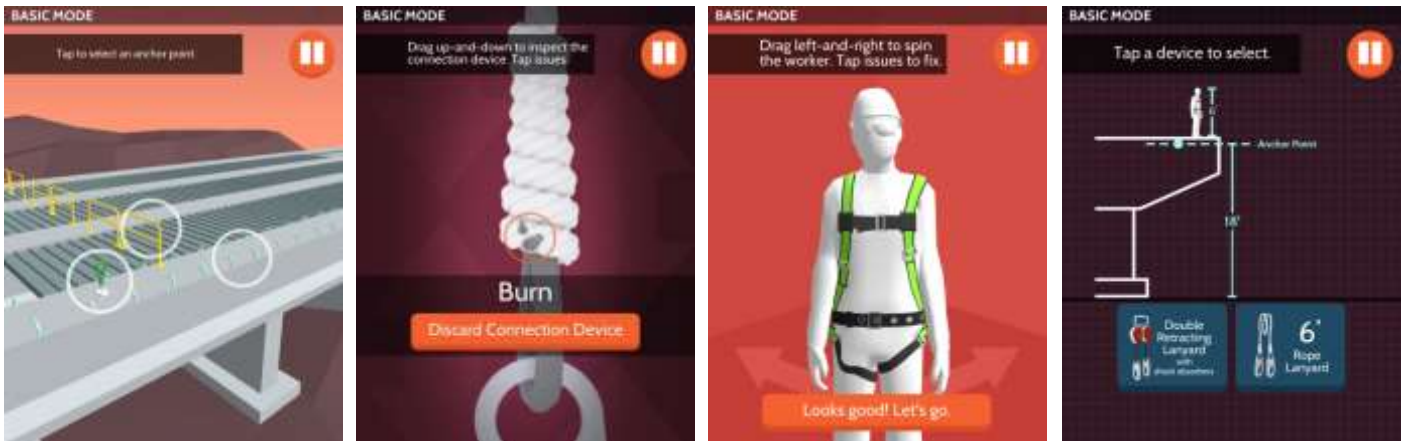


Figure 2: Harness Hero

4.2.3. *Safety VR by Kraus-Anderson Construction Company:* Developed by Kraus-Anderson Construction Company Safety VR is a Virtual Reality simulator to improve safety on the job site. This game can be downloaded on an iPhone or iPad device that are typical in a construction site for two Virtual construction safety exercises. In the first exercise, students had to collect three heavy items (a barrel, a crate and a roller) and drop them off to a designated place while

crossing over a narrow bridge between two high-rise platforms. The second exercise involved 360degree narration of PPE for Fall protection, Electrical, Excavation, Gas welding, Demolition, Fire protection added with KA’s alcohol and drug policy. However, the students had difficulty to operative within this simulated environment and we had limited experience with this exercise. Figure 3 shows few scenes from this game.



Figure 3: Safety VR by Kraus-Anderson Construction Company

4.2.4 *3M Virtual reality training for harness inspection and Fall protection:* Developed by the 3M company, the first step of the Fall protection game took the students to a typical locker room to inspect and wear a full body harness system. This exercise was simulated on a head-mounted display (HMD) named Oculus Go. With the controller, students could rotate the harness to inspect and learn about it. They also learned about proper working order, including buckles, straps, and how to visually inspect webbing, for frays, cuts, tears, burns, holes and any other damage that can compromise the

harness's integrity and ability to serve its purpose. After this exercise, students were placed in a simulated environment, where they needed to connect to a life-line and walk over a narrow bridge between two tall structures. Students reported this experience as a "real high up" feeling and being very careful not to engage their life support system by falling off the bridge as they walked between the structures. This exercise was ranked number 1 by most of the students. Figure 4 shows a GenZ student during this exercise and Figure 5 shows few images from the game.



Figure 4: Student during the 3M VR Fall protection exercise

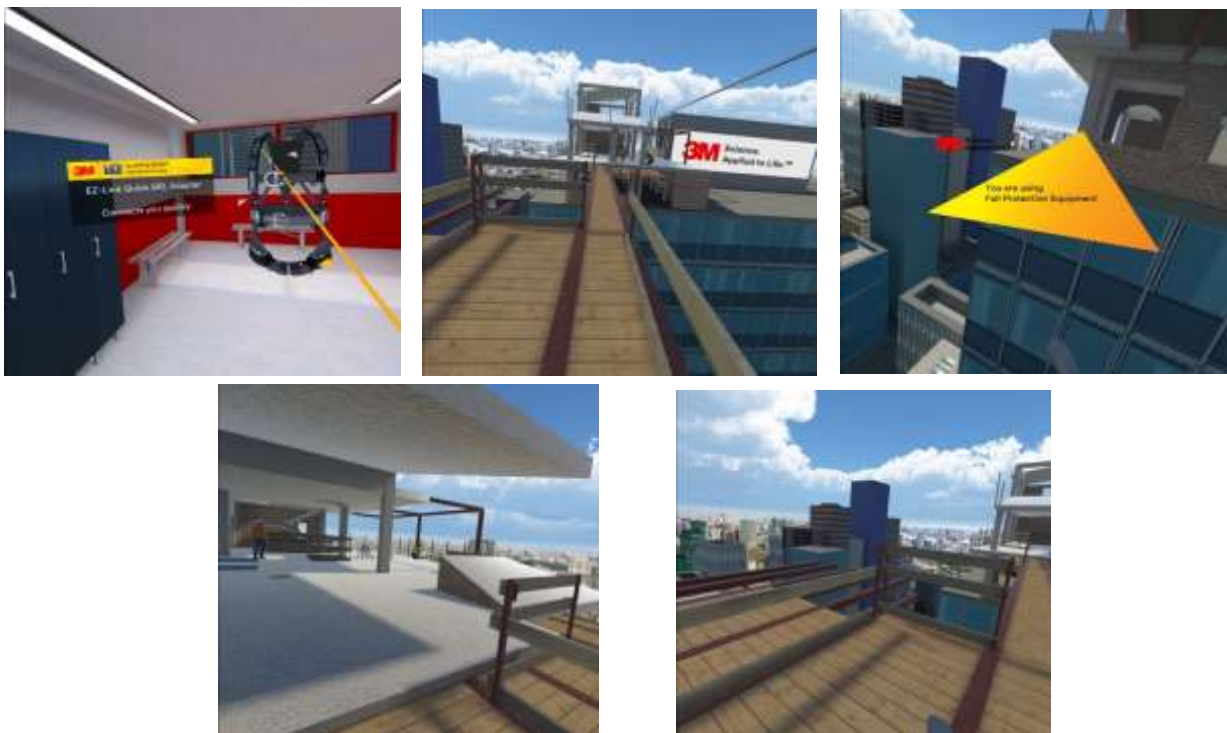


Figure 5: Images from 3M VR fall protection exercise

4.2.5 *3M Virtual reality training welding inspection:* 3M's VR welding training module used with HMD, Oculus Go was the final exercise. Figure 6 contains few images from the welding game. In this exercise, students learned the differences between

passive filter helmet and auto-darkening helmet. They needed to wear the helmet and complete a welding job within a given period using the controller. They passed or failed depending on welding technique used and the time taken to do the job. Most students

needed more than one attempt to complete this exercise as they ran out of time for their first attempt.

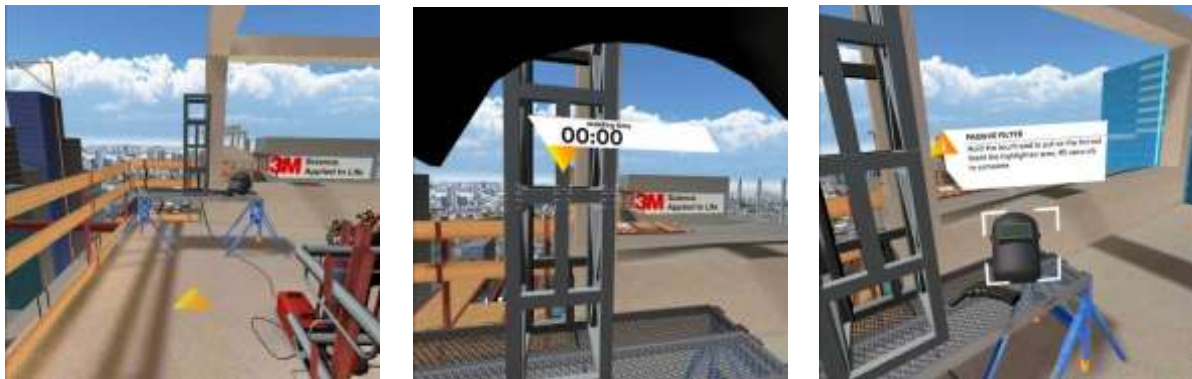
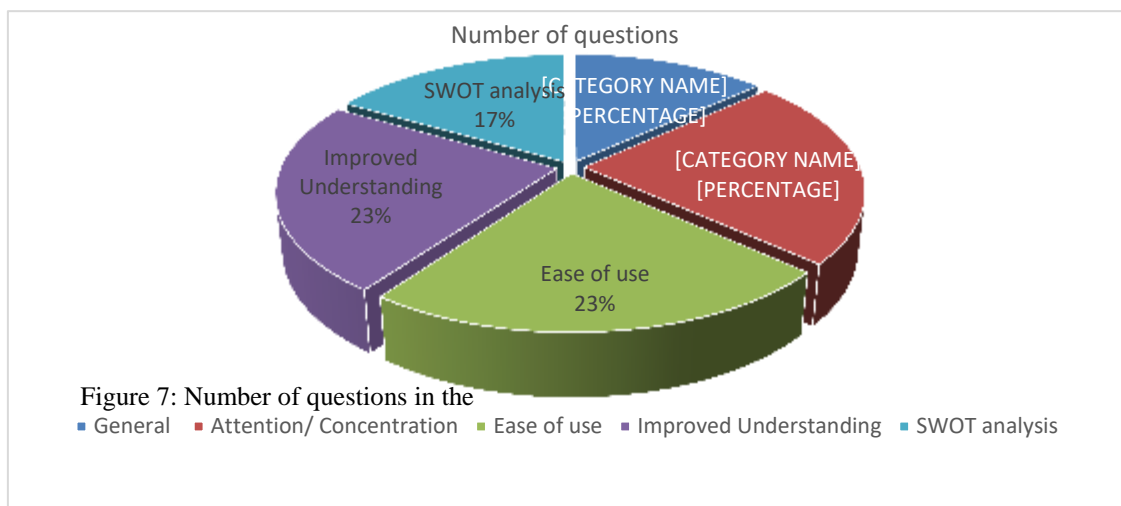


Figure 6: 3M Welding Exercise

4.3 Part III - As the final part of the study, students completed reports, oral discussion and a 30 questions survey focusing on a comparative analysis between 2D traditional teaching aids used during the first phase of the experiment vs. the VR games. The survey questions were

categorized into five different groups, namely General, Attention/Concentration, Ease of use, Improved understanding and SWOT analysis as depicted in Figure 7. Students' responses were analyzed and displayed below.



4.3.1

General Section:

In this section, questioned focused on students' background and knowledge of construction safety. All students indicated that this was their first construction safety

course. However, they had some prior knowledge about the subject as part of training or work experience.

4.3.2 Attention/Concentration:

The next section contained questions about their engagement with the VR exercise vs. 2D traditional visual aid as described in Figure 8. All students responded that 'they paid more attention', 'felt more engaged' and

experienced 'better personal learning experience' during the VR exercises than 2D teaching methods. However, few were undecided about losing concentration during the VR exercise vs. 2D teaching aids.

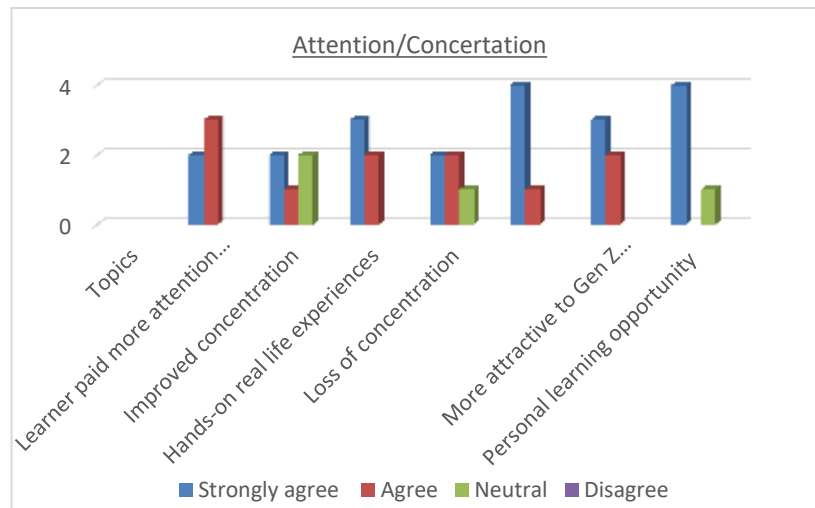


Figure 8: Attention/Concentration Category

4.3.3 Ease of use:

The third section was about the learning curve for the VR technology. Here, most students mentioned that it was not difficult to adopt and understand the VR technologies and demonstrate it to their

peers. Results depicted in Figure 9. This comes as no surprise, as GenZ students are very comfortable in handling electronic gadgets and new technology [1]. They also found them as “Fun” activities.

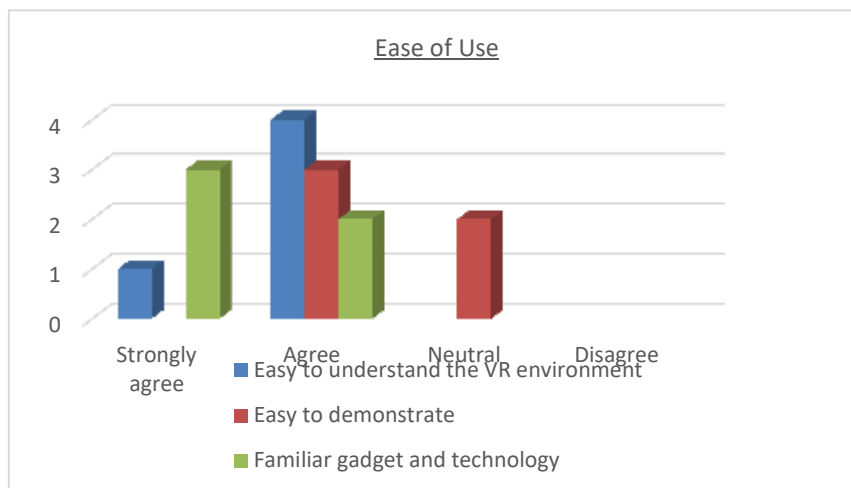


Figure 9: Ease of use

4.3.4 Improved Understanding:

The fourth section focused on a comparison between the improved understanding of the subject matter taught using VR technologies. All students agreed that it was lot easier to

understand the subject using this 'hands-on' approach compared to traditional 2D visual aids. This directly relates to right teaching methodology for GenZ students as they always prefer to "learn by doing" [2].

4.3.5 SWOT analysis:

Questions in the final section focused on challenges faced and future potentials. One big challenge identified as lack of variance in the VR safety games because this research included only free and readily available VR safety games. Currently available games

mostly focus on Fall protection, and there is hardly anything available in other fatal three categories. Also, many students were interested to see more detailed and critical decision-making games. Therefore, the need to develop customized games was evident.

Additionally, it was recognized that the success of using VR tools in classroom teaching depends

on the technology infrastructure. Although many games can be downloaded as a smartphone app

and therefore are readily available to all the students, more serious games that rely on a head-mounted display (HMD) require superior



Figure 10: Tuskegee University student engaged in the VR exercise

5 Conclusions

Based on the positive feedback received during this pilot study, it is safe to conclude that Virtual Reality (VR) technologies have huge potentials as alternative teaching methodology for GenZ students. The most significant advantage of this exercise was real-life experience without exposing the students to the danger of the job site. It was acknowledged that, VR technology has a long way to go before it reaches its full potential to real-life decision making, however the small gaming exercises proved to be beneficial to teach GenZ students about construction safety compared to traditional 2D visual aids. Positive results

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computing ability, therefore, demands significant investment on equipment and technology. Also, it was realized that careful course design is vital to engage the students who are not wearing a HMD while others are going through the exercise. It was evident that students who were waiting to wear the HMD or google glasses were getting restless, and therefore one must ensure that there are enough devices available for all students to experiment with at the same time. Figure 10 shows a Tuskegee University student using google glass device for the "Safety in a box" exercise.

recorded as improved understating of the subject with a small learning curve and, most importantly, with a tool that GenZ students feel comfortable in using. Following this pilot study, students showed interest in using more VR exercises, thus indicating that more research is needed to formulate a new pedagogical language. However, at this point, Construction Safety course at Tuskegee University will include VR exercises for better understanding and every effort will be made to invest in this technology to incorporate more topics and environments.

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