Labour Safety & Skill Training Using Virtual Reality, A Case Study- Of Higher Altitude Work.

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***Abstract*—As the construction industry has boomed, urban migration has surged, triggering an increase in demand for housing in crowded urban spaces, which leaves us with only one option besides high-rises.**
With a background in high-rise construction, labor safety is one of the foremost concerns. This type of construction has a relatively high accident rate. Researchers and professionals have been motivated by this scenario to find innovative ways to solve the problem. To address this issue, after a given period of time, regular safety training should be implemented. Effective training may refresh the comprehension of existing employees as well as convey critical safety knowledge to new personnel. Virtual reality using hardware meta oculus has enabled us to better understand work fatalities without putting our lives at risk. This paper is based on a case study of planning and creating a VR module for high-altitude safety training. Using an experimental methodology, several features of the VR module were investigated. The results showed that the VR module positively improves high-altitude professionals' perceptions of VR applications as additional training tools.

Keywords—Virtual Reality, Training, Technology, Project Management, Construction, Meta-Oculus.

I. INTRODUCTION

According to the Occupational Safety and Health Administration [OSHA], the construction sector has one of the worst rates of work deaths, and the best way to improve the industry's safety performance is to prevent accidents from occurring in the first place. One approach to achieve this goal is to raise construction workers' awareness. Previously, various tactics such as video recordings, handouts, and hands-on training were utilized to instruct construction workers on safety. Each of these strategies has benefits and drawbacks. Virtual reality and other forms of mixed reality technologies have completely changed several facets of the building sector. It provides a distinctive and efficient training technique for personnel in the construction industry, reducing the need to expose them to hazardous site situations. In the context of safety instruction, this immersive and realistic technology outperforms more conventional training choices like movies and handouts. The capacity of this technology to recreate high-risk scenarios is one of the main goals of using it. There are several potential advantages of new technologies for construction training, including cost-effectiveness, accessibility, repeatability, and user customization. They do, however, have certain shortcomings. High upfront expenditures, protracted development times, difficulties with customization, and restrictions on hardware and software are a few of these. However, efforts are still being made to improve VR technology, eliminate these drawbacks, and increase the number of applications for VR-based solutions.

II. AIM

Analyzing the safety issues associated with high-altitude construction work and developing an effective solution utilizing Virtual Reality (VR).

III. OBJECTIVE

1. To study the concept of Virtual reality in labor safety programs working at high altitudes.
2. To analyze problems associated with high-altitude construction work.
3. To find the issues regarding the existing safety training model for high-altitude work.
4. To propose a safety training module for high-altitude construction work using virtual reality.
5. To study the impact of Virtual reality training for high altitude on user groups through survey forms.
6. To suggest Preventive measures for the high-altitude safety training model.

IV. HYPOTHESIS

The construction industry should adopt to VR-based training to overcome accidents & fatalities on-site.

V. SCOPE

The research work is undertaken at Pune locations for the use of VR in the safety training of high-altitude construction work.

VI. LIMITATION

The paper is limited to higher altitude construction work for the Pune region.

VII. LITERATURE REVIEW

Extensive research conducted in recent years has focused on the utilization of VR technology in construction training. Numerous studies have demonstrated that training programs based on VR can lead to significant enhancements in both safety and skill levels among workers.

Similar to this, research by Gok et al. (2018) discovered that VR-based training was successful in enhancing employees' abilities to carry out electrical activities. The study concluded that workers' knowledge, abilities, and confidence in carrying out risky activities may all be improved with the use of VR-based training programmes. Another research by [Rajan et al., 2019] looked at the efficiency of VR-based training in enhancing construction workers' safety and productivity. According to the study, VR-based training programmes increased worker productivity and safety more than conventional training techniques.

When it came to monitoring site activity in the past, safety managers in the construction sector depended on their professional expertise and visual observations. Virtual reality (VR), on the other hand, has become a potent method for visualising digital information as a result of the rapid improvements in information technology (IT). Users may fully immerse themselves in computer-generated models thanks to VR technology, which allows for the construction of immersive and realistic settings. Highly responsive and dynamic computers that can react fast to human interactions, choices, and manipulations underpin this technology. Different inputs, including speech, movement, sound, and location, can be included in VR models. The discipline of advanced construction management has benefited greatly from VR as a result. Virtual reality (VR) technology has been successfully applied in numerous facets of construction management in recent years. They are useful resources for worker training, safety management, quality and defect control, and visualization. VR technologies help to lower the number of accidents on building sites by offering platforms for monitoring, regulating, and teaching projects. [Ahmed, 2018]. The use of VR in safety management was explored by Li et al. in 2018, and they emphasized the technology's potential in a number of safety-related fields, including hazard risk detection, workforce education, skills transfer, ergonomics, and more. By simulating building operations with VR technology in 2020, Getulietal also enhanced the traditional planning procedure on construction sites. Li et al. divided the uses of VR methods in construction safety into three primary areas in a review study published in 2018: safety planning, safety inspection, and safety training. A minimum level of acceptability for VR in safety training, which attempts to improve danger awareness skills, was typically seen among safety professionals, who frequently favored hands-on activities.

To sum up, VR technologies have demonstrated a great deal of promise in the management of construction safety, delivering prospective advantages in a number of domains while acknowledging the desire for hands-on training among safety experts.

VIII. METHODOLOGY

This project's primary goal was to determine whether VR technology might be used for safety instruction.

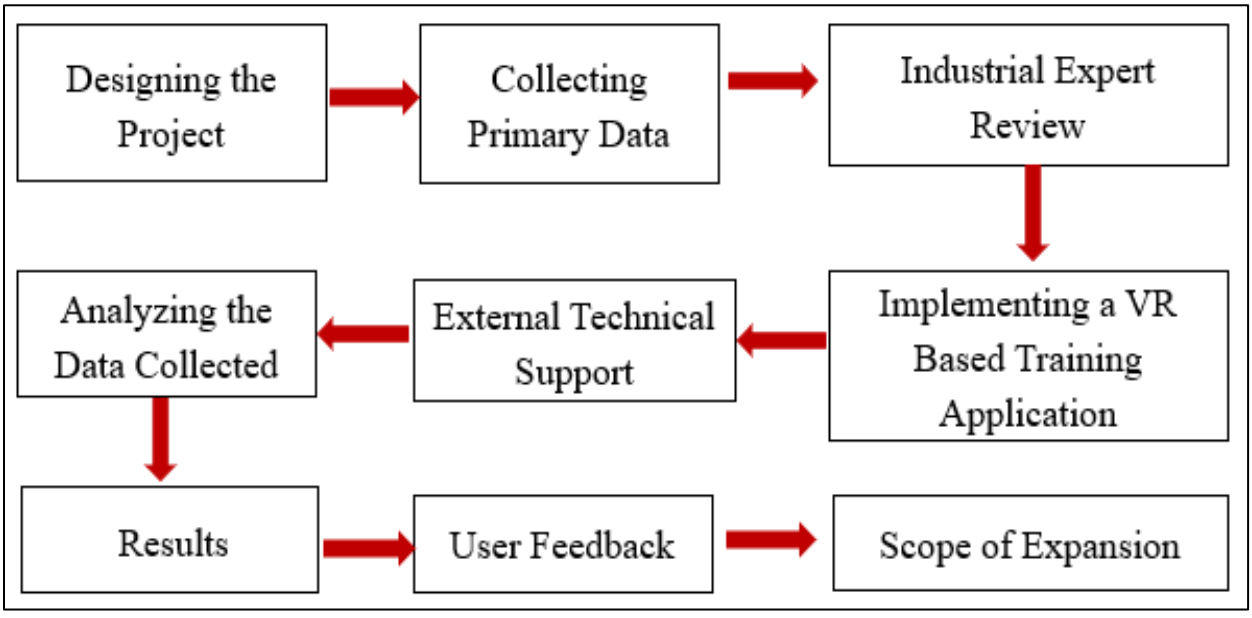


FIG. 1. RESEARCH METHODOLOGY FLOW-CHART.

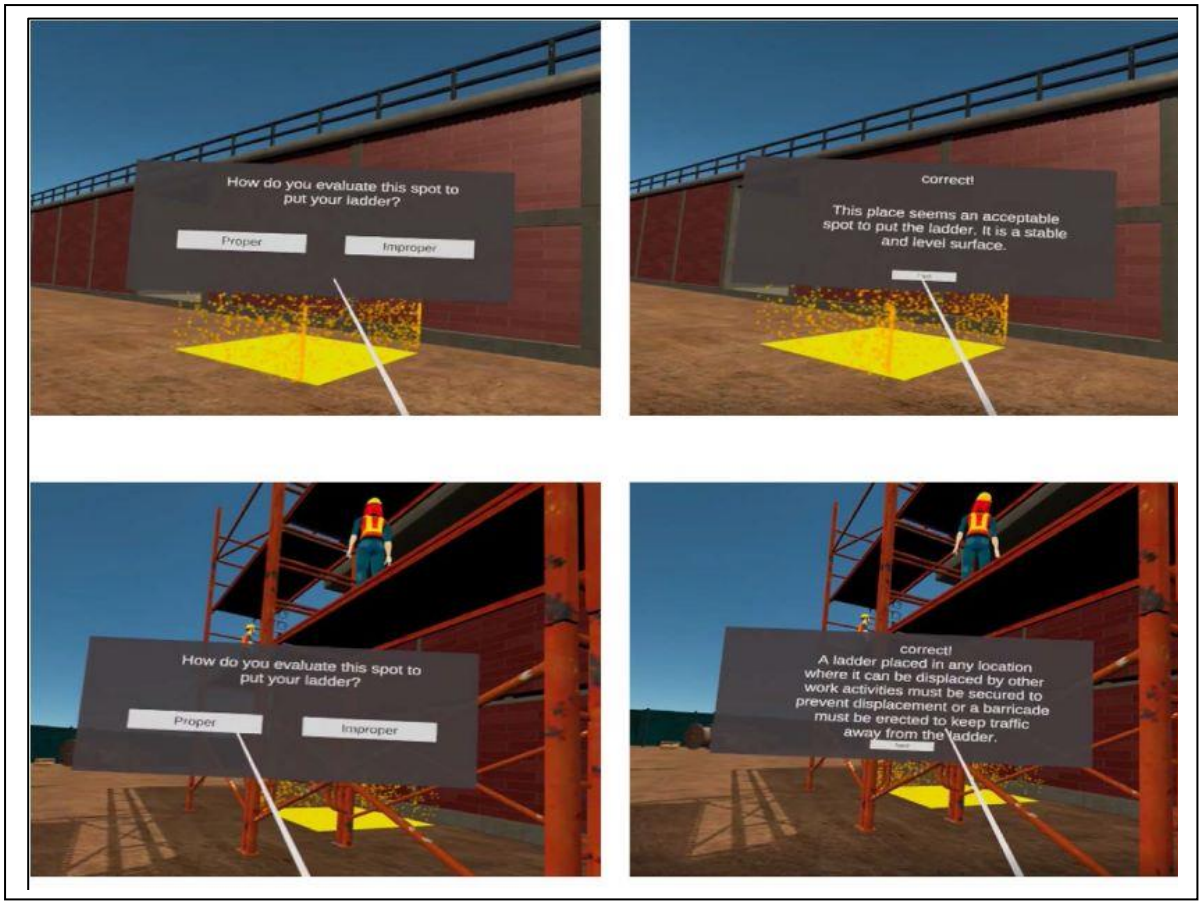


FIG. 2. VR INTERACTION SNAP SHOTS (SOURCE: SAEED ROKOOEI ET-AL (2022)

In addition to user impressions. As the primary users of the module, high-altitude working professionals were given priority in the study's approach. After reviewing the ten distinct parts made utilizing the software programs 3D Sketchup and Unity to do ladder-related duties, a scenario was presumptively created.

Participants in the Saeed Rokooei et al. 2022 research were immersed in a pre-designed 3D model utilizing virtual reality technology called Oculus or online meetings. The participants completed a standardized questionnaire, which was given to the researchers via an Internet platform. After a section on demographics, a five-point Likert scale was used to gauge participants' degrees of agreement or their perceptions of the significance of various impacts. Participants were asked to respond, and the researchers collected their replies. After analyzing the data, the researchers found that 30 responses were appropriate for further examination. Using software like Microsoft Excel or Word for descriptive analysis, the replies were collated, processed to remove any mistakes and inconsistencies, and suitably categorized to assure accuracy.

IX. ACTION PLAN

After reviewing the 10 distinct portions that were created using the 3D Sketchup studio and unity, software, and duties linked to ladders. Action plans included safety guidelines and directives for the corresponding circumstances.
The area's primary topics include:
1) determining the optimal placement for the ladder on the job site.
2) Choosing the ladder to use depending on the weight rating and height of the structure,
3) Examining the ladder for mud, grease, structural damage, and missing parts; 4) erecting the ladder; 5) securing the ladder; 6) maintaining secure contact with the ladder; 7) using the ladder to transport materials; 8) dismounting the ladder at the roof; 9) un-securing and descending the ladder and lowering the ladder to the ground; 10) safe roof work inspection; and 11) loading the ladder on the truck for safe transport. The study's approach Every part made the premise that the user was a freshly hired high-altitude worker who was responsible for assessing the hazards and safety issues associated with various ladder-related jobs. The primary topics of traditional safety training and the viability of VR technology as supplemental aids were covered by the survey's questions.

The VR interaction window shows where a ladder should be placed and underlines the important details to consider while utilizing it at a high height.

The VR training program educates workers on potential risks and dangers through a variety of situations.

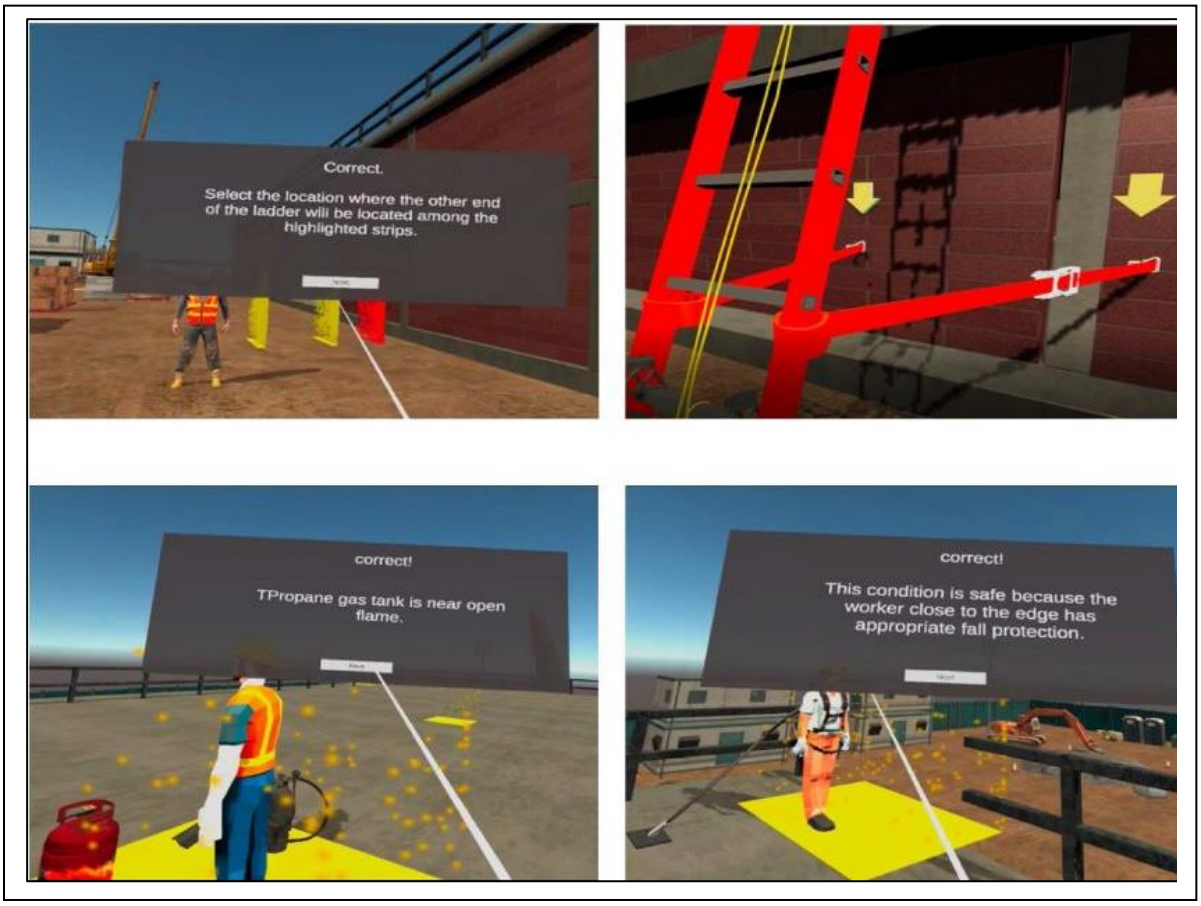


Fig. 3. VR Interaction Snap shots (Source: Saeed Rokooei et-al (2022)

safety precautions necessary for working at heights, enabling them to make decisions with knowledge in the worst-case situation.

X. DATA ANALYSIS

The demographic information of the participants In [Table 1]. Shows that the majority of Participants were male, above 51 years old, and with experience above 25 plus years. Also, the participants were mostly high-level executives from companies. The next questionnaire was safety-related.

hours of training that must be mentioned for new hires As shown in Table 1, forty-five percent of participants said that new

More than 16 hours are spent on staff training. Moreover, 85% of interviewees said that their present workers must

Gender	**Male (%)**	**Female (%)**			
	68	32			
Age	**21-30 (%)**	**31-40 (%)**	**41-50 (%)**	**51-60 (%)**	**61+ (%)**
	28	9	20	39	4
Experience	**1 to 3 (%)**	**4 to 7 (%)**	**8 to 15 (%)**	**16 to 25 (%)**	**25+ (%)**
	12	40	24	10	14
Position	**CEO (%)**	**Project Manager (%)**	**Sales Manager (%)**	**Office Engineers (%)**	**Labors (%)**
	9.5	48	14	19	10
New Hires Experience years	**1 to 3 (%)**	**4 to 7 (%)**	**8 to 15 (%)**	**16 to 25 (%)**	**25+ (%)**
	51	39	4	2	4
Training Hours	**0 to 4 (%)**	**5 to 8 (%)**	**9 to 15 (%)**	**16+ (%)**	
	20	22	13	45	
Training Interval	**Within 3 mo. (%)**	**Within 6 mo. (%)**	**Within 1 year (%)**	**At will (%)**	
	56	18	21	5	

TABLE 1. DEMOGRAPHIC PROFILE

attend training programs on safety to update their expertise. Participants were also questioned on the frequency of ongoing safety training that their staff members must attend. [Table 1] displays the proportion of time intervals.

The following inquiry asked participants to identify the primary cause of accidents in the high-altitude industry. Although a substantial majority of workers showed a reckless attitude, 51% of participants said that accidents were caused by a lack of information or insufficient training. [Fig. 4].

Using a Likert scale with a maximum score of 5, participants also judged how much they think various factors have an influence on high-altitude industry accidents [Very Low: 1; Very High: 5]. [Fig. 5.] displays each level's percentage.

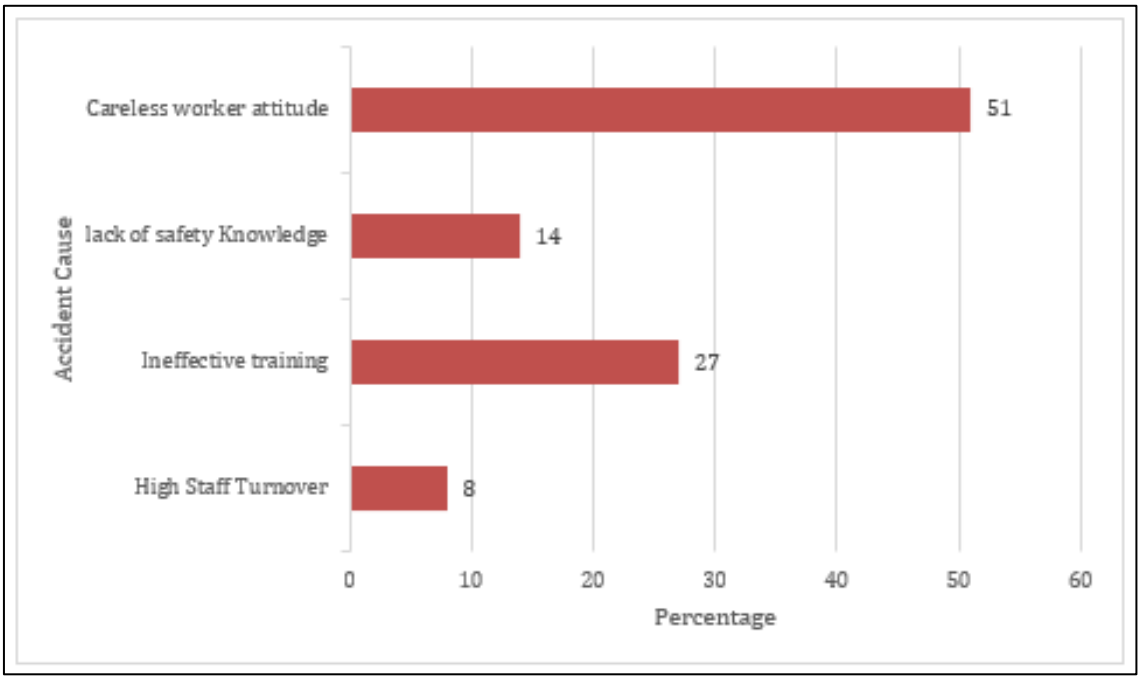


FIG. 4. MAIN CAUSE OF ACCIDENTS

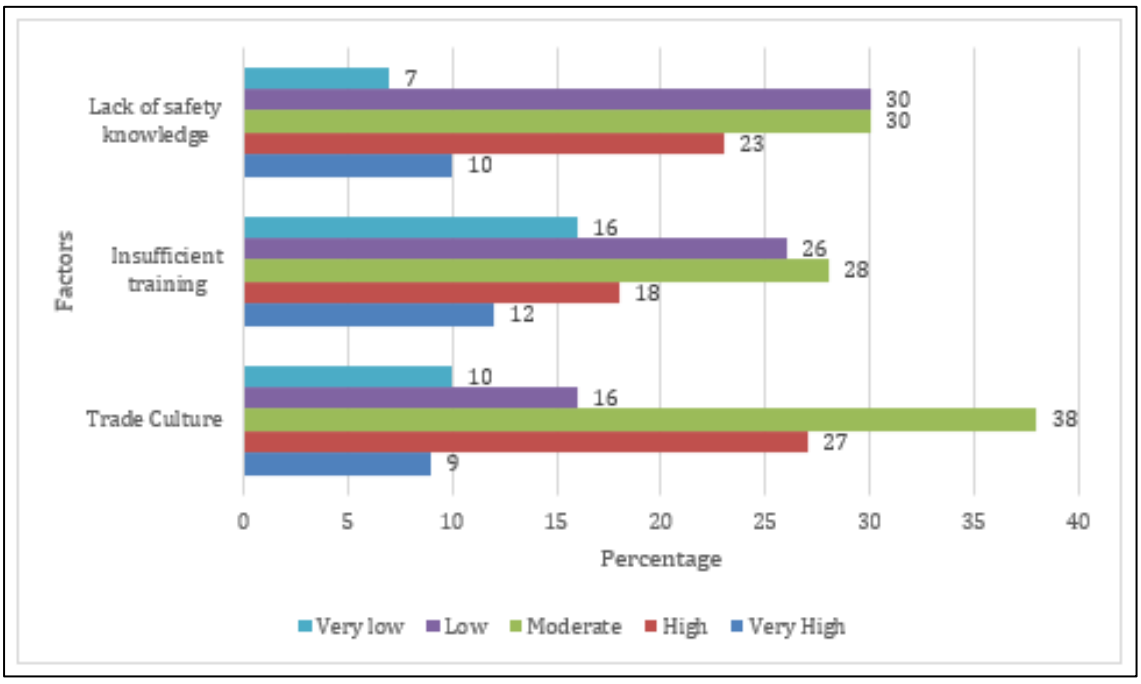


FIG. 5. FACTORS IMPACTING ACCIDENTS

The survey's next portion included inquiries about virtual reality and its use in safety instruction. First, using a five-stage Likert scale, participants were asked to assess how familiar they were with VR in general. [Fig. 6.] displays each level's percentage.

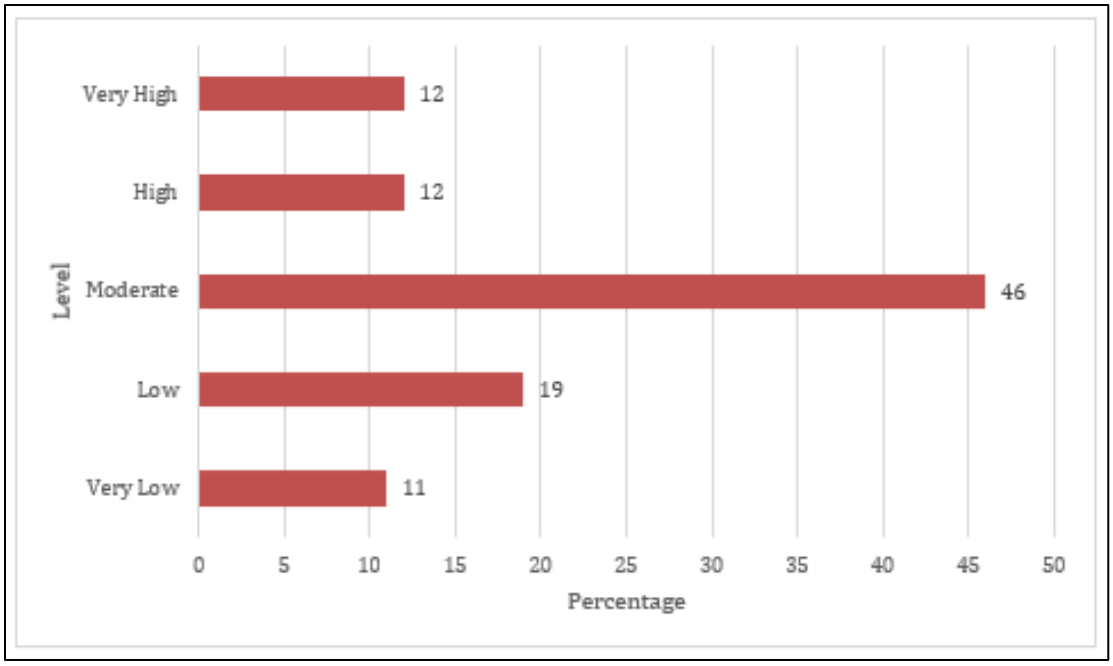


FIG. 6. VR FAMILIARITY.

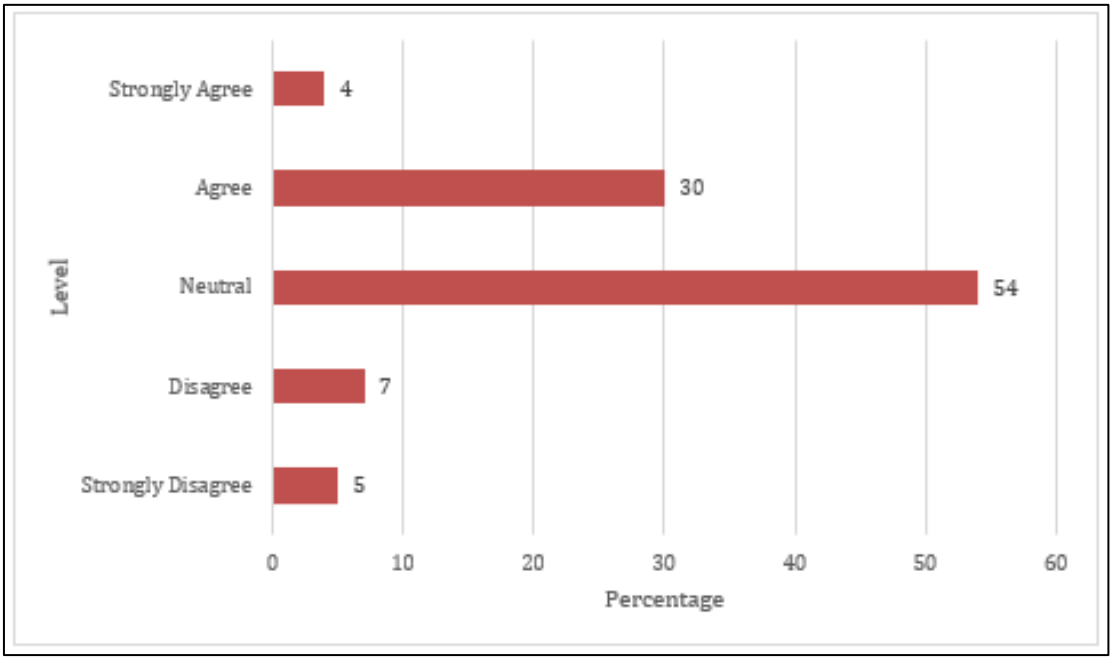
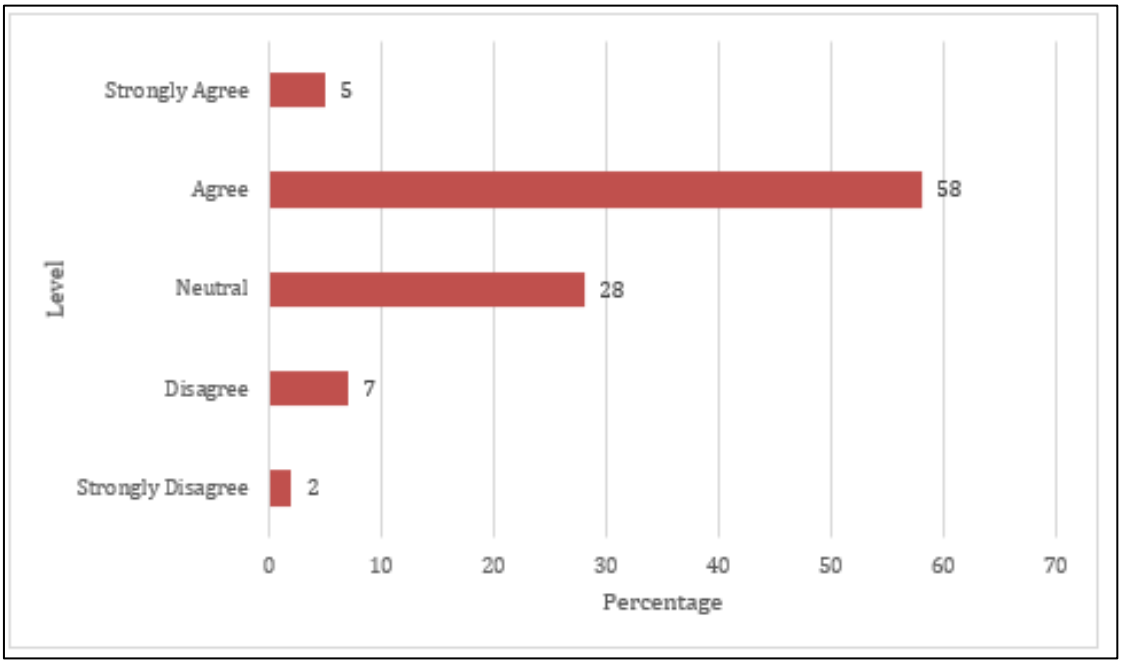


FIG. 7. VR APPLICABILITY

The answer to the following question's statement, "Virtual reality is highly appropriate for workforce development in the high-altitude industry," showed the contributors' level of settlement. Only 5% of participants disagreed with the statement, while 30% agreed and the rest 54% were neutral [Fig. 7].

In a similar vein, participants were questioned about whether they thought virtual reality may assist the next generation of workers in learning the necessary safety guidelines while still

enjoying the surroundings. The majority of participants (63 percent agreed, 28 percent were indifferent, and 9 percent disagreed) had favorable opinions about VR's suitability for modern training. In [Fig. 8], the proportion of each level is displayed. Participants also stated that they intended to look for chances to implement virtual reality programs for safety training in their organizations. Only 9% of participants disagreed with the strategy, while 55% were indifferent and 36% of participants said that they were in favour of using VR for training.



Only 9% of participants disagreed with the strategy, while 55% were indifferent and 36% of participants said that they were in favor of using VR for training.

The proportion of each agreement level is displayed in [Fig. 9]. After taking part in the safety lesson, participants also responded favorably to the VR application. On a five-stage Likert scale, participants were asked if their confidence in the usage and application of digital reality increased after they gave it a try.

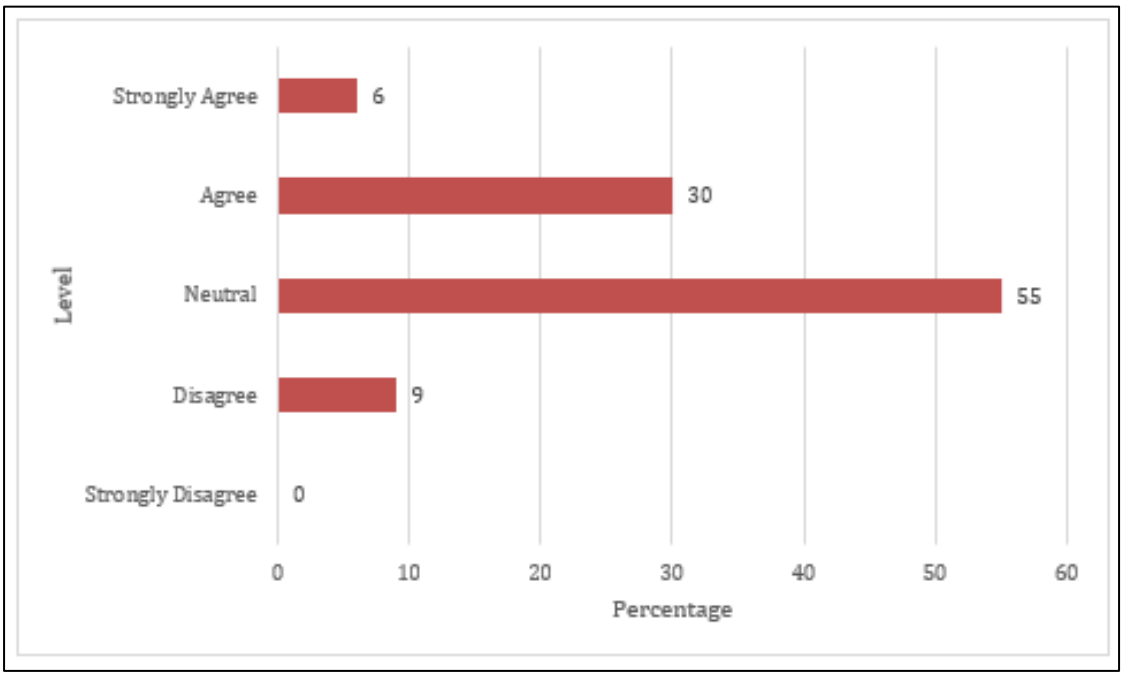


FIG. 9. VR AGREEMENT FOR TRAINING PURPOSE

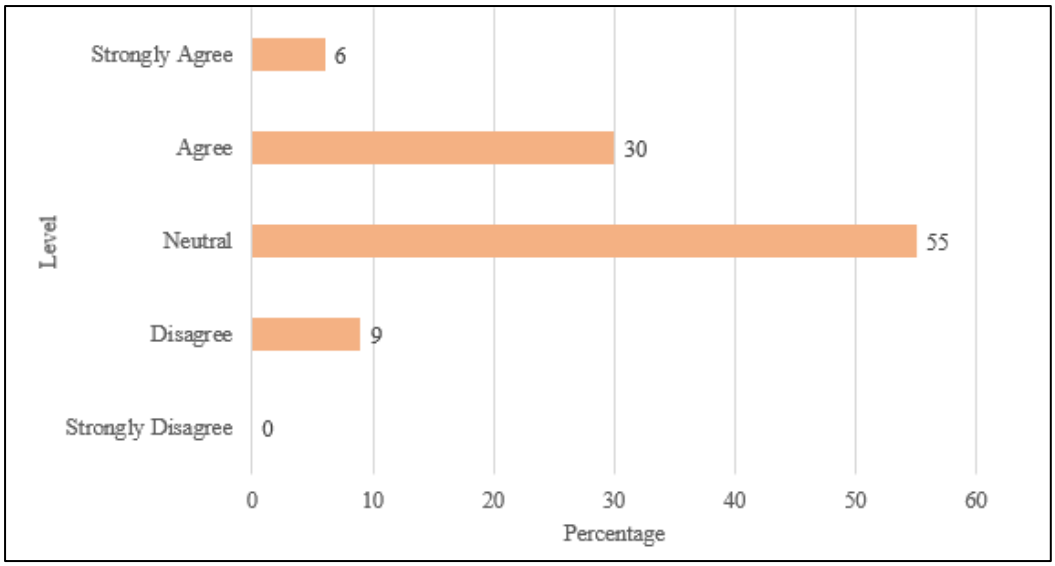


FIG. 10. VR AGREEMENT FOR ENGAGEMENT

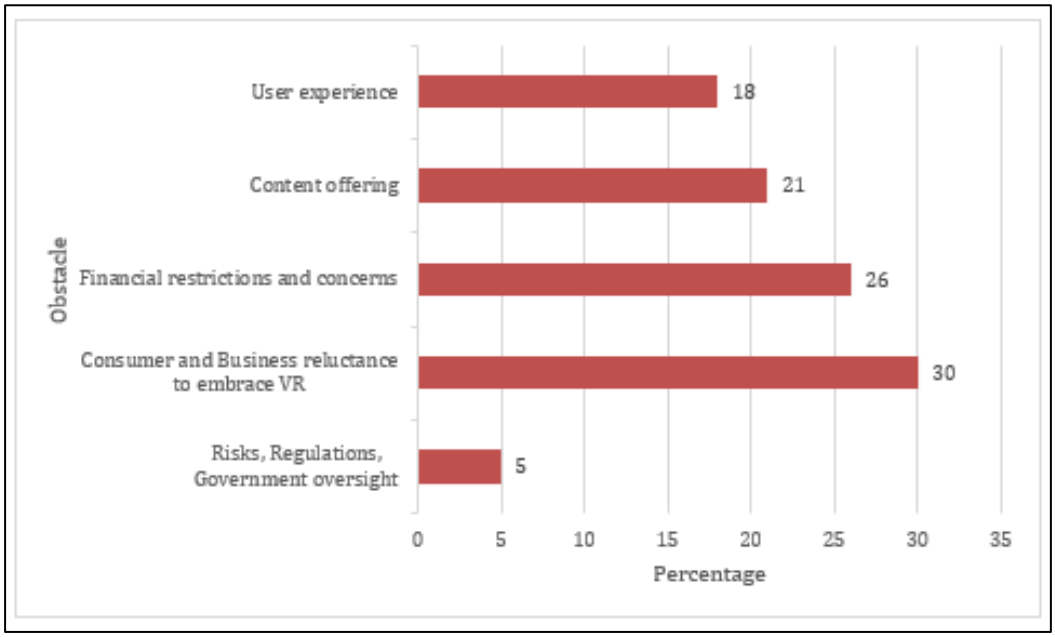


FIG 11 MASS ADOPTION PERCENTAGE OBSTACLE

On a five-stage Likert scale, participants were asked if their confidence in the usage and application of digital reality increased after they gave it a try.

The proportion of each agreement level is displayed in [Fig. 10]. Participants were also given a variety of VR characteristics to score on a Likert scale with a total of five stages. the average of all factors, weighted. The three qualities of "ease of use," "detailed and complete instructions," and "engaging audio/visual components" were among the most sought-after features, despite the fact that all elements were judged as being of interest (above mid-point). The top five well-known hurdles were conditioned to be chosen when participants were asked to identify the largest barrier to the widespread use of virtual reality technology in the high-altitude working sector. [Fig. 11] displays each obstacle's proportion. As shown,

XI. DISCUSSION

VR has created a new platform for immersive learning. It is especially useful for simulating potentially hazardous locations, like construction sites. Construction employees may receive safe training there without having to worry about failing or suffering any negative consequences. The findings of the safety-related section questions revealed that most businesses require new hires to undergo more than 16 hours of training, with breaks typically occurring every three months. This demonstrates the value of safety training for employees who work for the questioned organizations. On the other side, some businesses mandate shorter training sessions and don't mandate breaks. This demonstrates that some businesses still do not prioritize safety. Nearly half of the participants had some VR experience, however the majority of the relaxation had little to very low VR experience. Contrary to interior design, this fact is supported by statistics from more established crafts in the building

sector, such as concrete, structural, and cladding. Therefore, raising public knowledge of VR applications in safety training needs to be a top focus.

XII. CONCLUSION

The results of this study point to the potential of VR-based training programs to improve worker safety and skill development for those doing higher-altitude construction work. The study's findings suggest that by offering accurate simulations of hazardous circumstances that workers may come across when working at high altitudes, VR-based training programs can dramatically increase workers' safety and skill levels.

Given the enormous advantages of VR-based training programmes, it is advised that construction organisations use these initiatives to raise the safety and competence levels of their workforce.

Additionally, construction firms want to keep spending money on creating tailored VR-based training courses that address the individual requirements of their employees. In conclusion, VR-based training initiatives have the power to fundamentally alter how employees are prepared for dangerous professions like high-altitude construction.

These training programmes may greatly increase employees' safety and skill levels by giving them accurate simulations of dangerous circumstances, thereby lowering the likelihood of accidents and fatalities in the construction sector.

The few negatives of VR training include eye irritations, high investment costs, the need for ongoing site-specific adjustments, and the inability to use it in crowded areas.

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