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Using 360-VR Narrative Communication to Boost Small Employers' Safety Practices

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May 2025

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 CPWR is the research and training arm of NABTU. Production of this document was supported by cooperative agreement OH 009762 from the National Institute for Occupational Safety and Health (NIOSH). The contents are solely the responsibility of the authors and do not necessarily represent the official views of NIOSH.

Report #23-5-PS

Abstract

This study explores the use of VR-Employer4Safety, a 360-degree virtual reality narrative, to increase small employers' awareness of free safety resources—from organizations like NIOSH and CPWR—and their motivation to implement them. To understand the motivational challenges of implementing safety measures for small employers (1-19 employees) and create a believable and plausible narrative, the researchers conducted semi-structured interviews with 14 small employers. Then, a pre-and-post intervention design was used, complemented by YouTube Analytics, to assess the impact of the VR-Employer4Safety narrative. Results revealed notable improvements in safety motivation from multiple aspects. Participants also reported increased awareness and appreciation of free safety resources. The study demonstrated the effectiveness of VR narratives in fostering safety culture among small employers, highlighting the potential of innovative communication tools for addressing critical safety issues in the construction industry.

Key Findings:

The results of the program the researchers developed included:

- Improved Motivation: The VR-Employer4Safety intervention reduced amotivation (-0.15) and slightly increased identified (+0.10) and intrinsic safety motivations (+0.05), fostering stronger autonomous safety motivations among small employers.
- Enhanced Awareness: Participants reported greater awareness of free safety resources, which played a critical role in strengthening their safety motivation.
- High Engagement: The VR-Employer4Safety video achieved 406 views, with a retention rate exceeding 28% for most of the content, demonstrating its ability to motivate and engage the target audience effectively.
- Positive Feedback: Participants indicated the intervention positively influenced their perceptions of safety culture and proactive engagement in safety practices.
- Better understanding of contractor knowledge: Most interviewees and study participants had a general lack of awareness regarding the free safety resources provided by government agencies for small contractors.

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Introduction

Construction is one of the central pillars of the American economy—and one of the most hazardous. According to the Bureau of Labor Statistics (BLS) (2022), the number of fatal work injuries in the U.S. was 5190 in 2021, and 951 of these were recorded in construction. Given the high proportion of fatal injuries occurring in the industry, construction researchers and practitioners continually strive to implement innovative and diverse strategies to mitigate work-related incidents.

While fatality rates at construction companies with more than 20 workers declined almost 30% between 2008 and 2016, fatal injuries rate among workers at smaller contractors (less than 20 employees) increased 57% (Dong et al., 2018). In 2016, small construction contractors employed 37% of the workforce but accounted for more than two-thirds (67.2%) of fatalities. For example, in the residential building subsector, nearly 78% of fatal injuries occurred among small contractors. Similarly, in the subsectors of siding, framing, painting and wall covering, and roofing, the proportion of fatal injuries among small contractors was 75.7%, 75%, 72.9%, and 70.7%, respectively (Dong et al., 2018). The high rate among small contractors is a key reason the number of fatal occupational injuries in construction has remained steady for the last five years (BLS, 2022b).

In general, small businesses face significant challenges. According to the National Institute for Occupational Safety and Health (NIOSH) (2023), they struggle to exist in a risky economic environment, and market factors, structural changes, and social and business climate can threaten resources available for their safety and health initiatives.

Experiences around the world have identified a series of factors that lead to a higher rate of occupational accidents for small employers, including less adequate management skills, less ability to implement health and safety works, insufficient worker safety awareness, failure in labor safety laws and regulations compliance, and insufficient safety protection measures and facilities (Cheng et al., 2010). To respond to these challenges, many free resources, such as the Occupational Safety and Health Administration (OSHA)'s compliance assistance and NIOSH's construction program and research products, have been developed. Unfortunately, many small construction employers lack awareness of these resources or have misperceptions about them (e.g., asking for assistance will result in an OSHA inspection) (Schneider, 2013). After analyzing safety and health practices in the U.S., Ringen et al., (2018) proposed approaches to improve occupational safety and health, including building a safety culture for all.

Creating a strong safety culture requires self-motivation and engagement of all stakeholders. Recognizing the pivotal role of motivation in attaining safety excellence, this project designed and developed VR-Employer4Safety. By harnessing the power of 360-degree virtual reality technology, VR-Employer4Safety creates a narrative communication experience in the form of a video that can bolster the safety practices of small employers. Our goals are twofold:

a) motivate small employers to proactively implement robust safety measures.
b) increase their awareness of the wealth of resources provided by NIOSH/OSHA that are specifically applicable to their needs and requirements.

Through these efforts, we seek to empower small employers with the knowledge, tools, and motivation to strengthen safety culture within their organizations.

This study also interviewed small employers to expand our understanding of the challenges they encounter in implementing safety measures. These interviews were central to creating success stories of small employers who faced struggles yet became aware of the long-term benefit of safety programs and eventually implemented applicable resources. These story narratives functioned as motivators and sources of encouragement to small

employers who have similar challenges and helped them increase their awareness of safety-related resources and ways to implement them.

Objectives

This project investigated the effects of a narrative communication tool, VR-Employer4Safety, in boosting small employers' motivation to implement safety measures and increase their awareness of existing safety resources.

Achieving this goal has multiple degrees of complexity and led to the following research objectives:

Objective 1: Understand the motivational challenges of implementing safety measures for small employers and assess their awareness about the availability of related safety resources.

Objective 2: Develop a new tool, VR-Employer4Safety, to increase small employers' motivation to create safe jobsites and improve awareness of safety resources using 360-VR success stories.

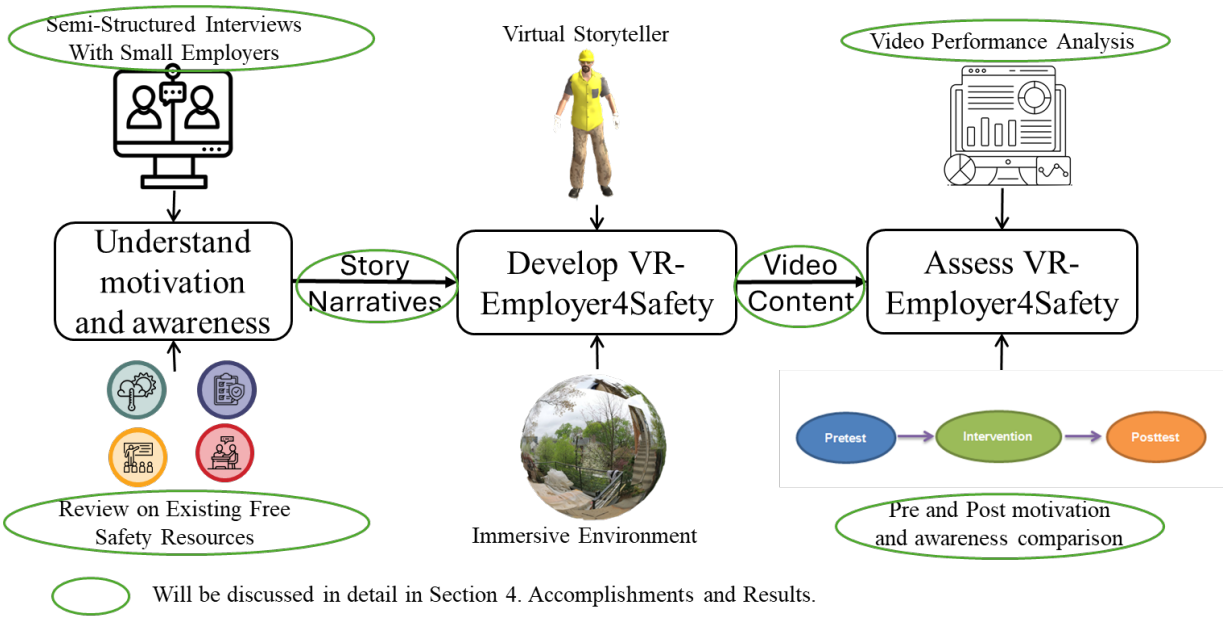
Objective 3: Assess the influence of VR-Employer4Safety on small employers' motivation and awareness.

VR-Employer4Safety is a 360-degree omnidirectional video, available on popular social media platforms, that offers a narrative designed to educate and motivate small employers toward better safety practices. To maximize the practical benefit of VR-Employer4Safety, this story narrative includes discussions and links to many useful and free safety resources (such as OSHA compliance assistance, the Safety Climate Assessment Tool for Small Contractors from CPWR, and NIOSH construction program and research products). Once small employers are motivated and interested, they immediately have fast, straightforward, and convenient access to relevant material.

Methods

This project was carried out in three steps (Figure 1), which were aligned with three objectives.

Figure 1. Research Steps



In the first step, the research team conducted interviews with 14 small contractors over a four-month period. The interviews covered the following topics: current safety practices, observed or perceived challenges to implementing safety practices, and attitude towards the free resources. The researchers comprehensively reviewed existing free resources beforehand so they were properly covered and discussed in the interviews. The review results will be discussed in Section 4. Accomplishments and Results.

The interviewees were all men at small employers (five general contractors and nine sub-contractors), whose working experiences range from 10 to 40 years. The research team categorized them into small general contractors and small subcontractors depending on the nature of their work. Amongst the five general contractors, four worked in the residential sector (three did remodeling and construction of townhouses and one did design-build of townhouses) and only one worked in both the residential and commercial sectors (townhouses, gym, and restaurants). Out of the nine subcontractors, two worked on roofing, one on metal framing and drywall construction, and six on structural and industrial wastewater work. The story narrative was created after the interviews and the review of existing resources, and its details will be discussed in Section 4. Accomplishments and Results.

In the second step, the research team developed the VR-Employer4Safety story narrative. It integrated (1) the 360-degree locations of the work environment and (2) the storyteller who leads the stories. The 360-degree environment was generated through authoring, visualization, and augmentation. Authoring entails the creation of a flat representation of a full 360-degree environment.

In this project, these scenes were panoramas captured from a residential reconstruction site in Atlanta, Georgia. The research team chose a single construction site for the story for two key reasons. First, the selected site aligned with the story's narrative, eliminating the need to film at multiple sites. For example, a ladder was already present, matching the narrative's focus on ladder safety resources. Additionally, the site provided safe roof access, enabling the panorama to support discussions about safety resources for roofing tasks. Second, using a single site ensured consistency in the panorama, helping the audience to become familiar with the setting. This approach minimized distractions, enhancing the audience's engagement with and focus on the narratives.

Generating the panorama involved using Unity, the game development platform, to render the 360-degree jobsite environment by projecting the equirectangular scenes into a sphere. In the augmentation process, visual aids, such as 2D images (e.g., diagrams of ladder instructions in Figure 2 left), highlight elements (e.g., the ladder and toolbox talks in Figure 2 left), and 3D objects (Figure 2 right), were superimposed on the 360-VR environment.

Figure 2. Screenshots of the story scenes where 2D images (left), highlight elements (left) and 3D objects (right) were superimposed

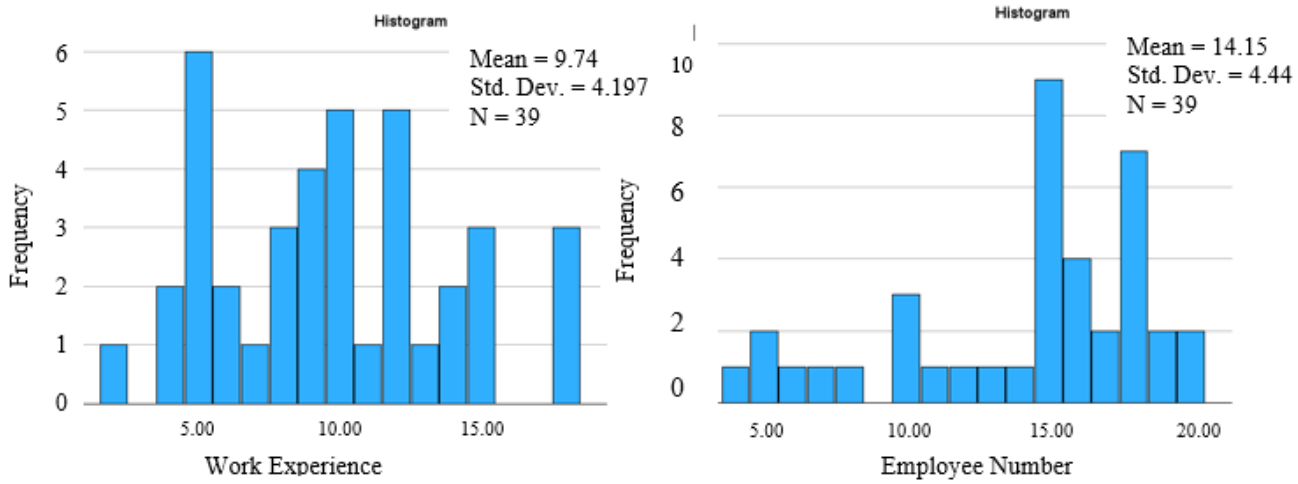
Two virtual storytellers were then generated and integrated into the game development platform. Finally, the integrated VR-Employer4Safety content was exported into 360-degree omnidirectional video format compatible with a variety of tools (e.g., smartphones, laptops, regular computers) and popular social media platforms (e.g., YouTube, Facebook). YouTube was selected as the platform for hosting the VR-Employer4Safety video due to its wide audience reach and detailed analytics, which allowed the research team to track website traffic data and visitors' behavior-related data in depth. A usability study was conducted with a middle-aged population of 19 people who had little experience with 360-degree videos, resulting in a score of 72.5, which is above the average usability score of 68 (Sauro & Lewis, 2016). This suggested that the video was easy to comprehend and interact with, and the audience would be likely to feel comfortable watching it.

While the storytellers are virtual and fictional characters, audiences also develop relationships with them and perceive social support from such characters (Kreuter et al., 2007). A previous study has also found that fictional narratives and characters did not affect audiences' absorption into the story (Green & Brock, 2000).

In the third step, pre- and post-intervention survey questionnaires were used to determine the impact of VR-Employer4Safety. The video was available to participants through a YouTube 360-degree omnidirectional video (https://youtu.be/phIzgXJ4B7k), a link to which was embedded on the Qualtrics online surveying platform. During the data collection process, participants first responded to a pre-story survey that showed their current safety management practices from five aspects (i.e., management commitment, safety training, workers' involvement, safety communication and feedback, safety rules, and procedures) (Vinodkumar & Bhasi, 2010). Safety resource awareness, safety knowledge and safety motivation were assessed before and after the intervention, and the Wilcoxon Signed Rank Test was applied for the paired ordinal dataset of the pre- and post-narrative scores (Mann & Whitney, 1947). In addition, website traffic and audience behavior were analyzed using YouTube Analytics to further evaluate how VR-Employer4Safety had affected engagement and motivation.

In the assessment step, 39 small employers in residential building, siding, framing, painting and wall covering, and roofing subsectors were recruited. On average, they have nine years of work experience and have 15 employees in their companies. Detailed demographics distribution can be found in Figure 3.

Figure 3. Detailed distribution of participants by years of working experience (left) and number of employees (right)



Accomplishments and results

Results from interviews with fourteen small employers

Current safety practices: Small general contractors often lack dedicated safety personnel. Only one of the five general contractors in this study employed a safety superintendent, who periodically visits sites to provide training and recommendations for safety improvements. These contractors prioritize trust and long-term relationships with seasoned subcontractors, which helps enforce safety standards and improve worker protection. However, one contractor includes a list of safety practices in subcontractor agreements but then does not strictly enforce them to avoid losing valuable subcontractors or incurring higher costs.

While general contractors don't interfere with subcontractors' safety programs, they actively encourage workers to wear safety gear and use safe equipment, such as ladders and scaffolding. One contractor employs daily checks for safety gear and bi-weekly equipment inspections to enhance jobsite safety. Another contractor, who specializes in home remodeling, abstains from investing in safety equipment, citing minimal risk in their work. However, they hire subcontractors with strong safety protocols for specialized tasks like roofing, making it highly likely that proper safety equipment will be available.

Pre-qualifying subcontractors based on liability, workers' compensation, and insurance documents is a common practice among four of the general contractors to protect workers without taking direct responsibility. Maintaining transparency at project start and discussing safety material bills with subcontractors for special equipment requirements, such as special shoes for roofers and framers, helps to improve trust and collaboration with the subcontractors. Three contractors enhance jobsite safety by providing additional equipment, such as fire extinguishers and first aid kits, and prominently displaying OSHA safety rules in English and Spanish.

Subcontractors also play a crucial role in safety management. All nine interviewed subcontractors embraced the ethos of "You are your brother's keeper," emphasizing collective safety. They provide proper documentation, invest in safety gear, and implement specific measures for their trades, such as anti-slip shoes and fall protection equipment for roofing. Regular safety training and toolbox talks were standard. Some subcontractors employ dedicated safety superintendents, while others trained all employees equally, fostering shared responsibility.

Roofing subcontractors prioritized safety, with one leveraging financial support from a general contractor to provide extensive training and stricter guidelines than the OSHA standards. This subcontractor also developed site-specific safety plans, pre-task planning, and proactive compliance checks, creating a niche as a minority-owned business with a robust safety culture.

Industrial subcontractors relied on general contractors for initial safety planning, adapting checklists and formats to specific sites. Repetition of consistent safety plans across projects helped workers internalize protocols. Drywall subcontractors managed smaller teams for easier safety oversight and hired additional pre-qualified subcontractors as needed to maintain compliance.

In summary, small general contractors and subcontractors collaborate to ensure safety through trust-based relationships, pre-qualification processes, shared responsibility, and tailored safety measures. While contractors depend heavily on subcontractors for safety implementation, subcontractors invest in training, equipment, and partnerships with general contractors to maintain safety standards across diverse job sites.

Observed or perceived challenges: The main challenge for small contractors and subcontractors is limited financial resources to invest in safety programs, equipment, and training. Tight budgets and high costs, particularly in trades like roofing, led contractors to decide that safety investments were impractical. A "machismo" culture in residential projects further complicates efforts, as workers often resist safety measures, viewing them as unnecessary or undermining their masculinity. Contractors fear losing subcontractors by

enforcing strict safety rules, leading them to rely on advice rather than enforcement. Misconceptions about accidents being "unavoidable" and the absence of OSHA inspections also make safety less of a priority.

Attitude towards free resources: Most interviewees showed a general lack of awareness regarding the free safety resources government agencies offer for small contractors yet expressed a positive attitude towards them once they had seen them. They recognized the potential benefits of these resources could offer, with some optimism about leveraging them to circumvent the expenses associated with company-specific training programs.

However, two interviewees expressed reservations about utilizing the OSHA free consultation program due to concerns about triggering inspections and appearing on their radar. They suggested that if similar resources were offered by third-party non-government agencies, subcontractors and general contractors might be more inclined to use them. Overall, despite varying concerns, all interviewees conveyed positive sentiments regarding the accessibility of free resources for safety training.

Reviews of existing free safety resources and development of a centralized guide to free safety resources for small employers

To identify free safety resources for the construction industry, the research team first explored safety and health-related materials from government and regulatory agencies, including OSHA and NIOSH. Then, the team leveraged industry associations and searched resources from Associated Builders and Contractors (ABC), National Association of Home Builders (NAHB), and Associated General Contractors (AGC). In addition, the team explored nonprofit platforms like CPWR–The Center for Construction Research and Training. Finally, the team identified 14 free safety resources from OSHA (43%), CPWR (29%), ABC (14%), NIOSH (7%), and NAHB (7%) and categorized them into four main types: safety climate assessment, safety checklists, safety consultation, and safety training.

1. **Safety climate assessment:** Safety climate refers to the shared perceptions, attitudes, and beliefs that employees hold regarding safety within an organization. It represents the prevailing organizational culture surrounding safety, encompassing the policies, practices, and behaviors related to ensuring a safe work environment. This type of resource helps small employers to track, evaluate and improve the safety climate across all their jobsites.

   Specifically, resources falling within this category include safety training assessment and recognition program of the American Association of Concrete Contractors; safety training evaluation process by ABC, and S-CAT for small contractors from CPWR.

2. **Safety checklists**: These tools list easy steps to check safety on sites prior to work beginning. They come in simple digital/paper formats.

   Specifically, resources falling within this category include Pre-task planning (PTP) assessment checklist from CPWR, Safety Program Toolkit of NAHB, and OSHA's safety and health program.

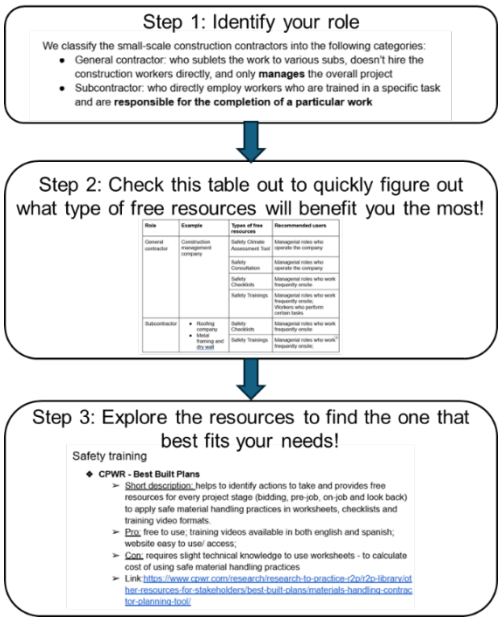
3. **Safety trainings**: This tool explains potential job-site hazards, and steps to be followed to prevent accidents. Normally in video formats, they are extremely helpful in overcoming language barriers present within the construction sector.

   Specifically, resources falling within this category include two tools from CPWR, the Contractor Planning Tool (manual material handling) the Foundations for Safety Leadership (FSL); Hazard Identification Training Tool from OSHA; and Falls in the Workplace: Ladder Safety Mobile App from NIOSH.

4. **Safety Consultation**: This tool provides free safety consultation from an approved/ certified safety consultant who helps small business owners develop site specific safety plans to improve overall safety.

   Resources falling within this category are OSHA - On-site consultation program and OSHA - Compliance Assistance Specialists.

Figure 4. Three steps to locate the free safety resources in the centralized guide document (https://docs.google.com/document/d/15Y0ONazSRo-AifzE-yVYPkY_p3jw0qk5-BGP1fTiJks/edit?tab=t.0).)



To make these kinds of resources more accessible, the research team also developed a guide to free safety resources for small employers, published as an online shared document that anyone has access to. This document helps small employers identify the most suitable free safety resources for them in three simple steps (Figure 4). First, the user reads the description and examples of the roles of general contractors and subcontractors and classifies themselves. Then, based on that identification, they explore a table that details the four resource categories. The table also recommends users for each category (e.g., safety climate assessment tools are more applicable for managerial employees). Finally, based on the resource category selected in step 2, the user can explore available free resources within that category. Each resource includes a description, a list of pros and cons, and a link for easy access.

A motivational safety story narrative of a small employer

The story narrative was based on the interviews and knowledge of the existing safety resources. The research team first defined the topics of narrative and then developed the narrative based on these topics:

(1) Introduction of the storyteller
(2) Career background and initial safety misconceptions
(3) Post-safety training realizations
(4) Initial challenge as a small employer
(5) Free resources for small general contractors
(6) Free safety resources for small subcontractors
(7) Small personal initiatives gathered from interviews

The storyteller was created as a residential general contractor with 14 years of experience. He first worked for a general contractor and then opened his own company. He shares his career path stories, the safety practices he has observed on different projects, the challenges he encountered when he first started his company, and how he coped with them. He also introduces some free resources he has found and shares his experiences using them. The story narrative was validated with seven small construction contractors and safety experts.

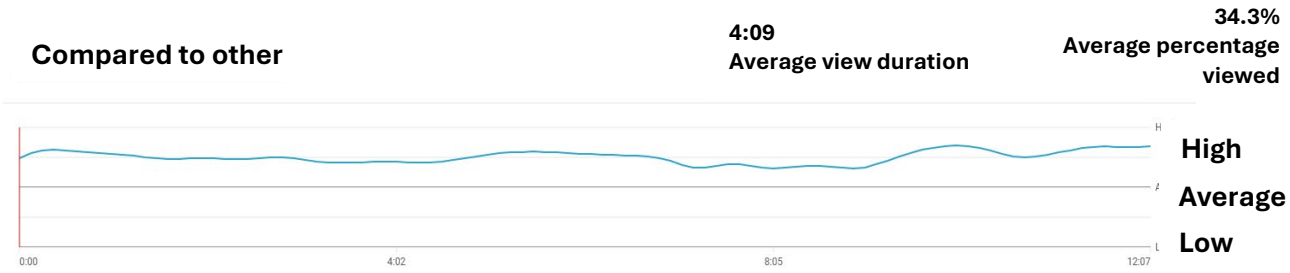
Evaluation results of VR-Employer4Safety Based on Video Performance

This project analyzed website traffic and viewers' behavior to assess the effectiveness of VR-Employer4Safety in motivation and engagement. Website traffic refers to the number of viewers over time (Stephan, 2023). Video viewers' behavior indicators include the actions they take on the website; specifically, how long they interact with the site, where they click, and how they scroll down a page (Hotjart, 2024; TermsFeed, 2024). In this project, watch time, audience retention, returning viewer count, and subscribers count were used to directly measure the effectiveness of VR-Employer4Safety.

View count measures the total number of times a video has been watched for at least 30 seconds (YouTube Community 2023). A higher view count suggests the audience found the topic relevant or compelling enough to watch the video. According to YouTube analytics, the VR-Employer4Safety received a total of 406 views since it was uploaded on May 10, 2024, with 165 views (40.6%) coming from direct URL entries and 224 views (55.2%) originating from external sources. Direct entries were generated by the video's shareable QR code and URL link that were incorporated within dissemination materials such as posts and flyers, while external sources typically originated from Qualtrics.com, DuckDuckGo.com, Google, and WhatsApp. The variety of sources indicates that VR-Employer4Safety is being effectively promoted across multiple platforms and resonates with the target audience, driving them to engage with the content.

Watch time refers to the amount of time that viewers have watched a video for the date range (Bello-Bravo et al., 2021). The 12-minute length of VR-Employer4Safety had an average view duration of 4 minutes and 9 seconds. The length of the average view duration demonstrates significant audience retention compared to other, similar YouTube videos, which typically retain viewers for 1 minute and 31 seconds (Faisal, 2023). It should be noted that a longer view duration does not necessarily imply active engagement, as audiences might leave videos playing in the background without truly watching them (YouTube Help, 2024a). To address this, **audience retention** was also analyzed. Audience retention data highlights how specific moments in the video capture viewers' attention, represented as a percentage of total views (YouTube Help, 2024a). VR-Employer4Safety had a retention rate of 71% at the 30-second mark, which is considered good performance, and consistently exceeded 28% retention from the second minute onward (Clark, n.d.). Notably, between 4 and 8 minutes, the retention rates were 30% to 40%, suggesting 120-160 viewers were still actively engaging with the video. This performance significantly outperformed other videos of similar length (Figure 5), demonstrating the effectiveness of the VR-Employer4Safety video in motivating viewers to continue watching and actively engaged with the contents.

Figure 5. Comparing the audience retention rate of this video with other videos of similar duration from YouTube Analytics



Returning viewers are those who have previously engaged with the video and chose to return for additional content (YouTube Help, 2024c). A videos with strong, positive impression will make viewers want to revisit the material (Brame & Perez, 2017). In this project, there were 33 returning viewers among the 406 views overall, about 8% of the total views. Although this proportion seems small, it is significant, especially as five

viewers subscribed to the channel after watching VR-Employer4Safety (YouTube Help, 2024b). **Subscribers count** is the number of viewers who have subscribed to the resource channel (YouTube Help, n.d.). The metric serves as an additional indicator of VR-Employer4Safety's capacity to effectively captivate viewers. The combination of high view counts, returning viewers, and subscribers highlights the effectiveness of VR-Employer4Safety in not only attracting a fresh audience but also in retaining those likely to rewatch the content.

In conclusion, these metrics illustrate that the video successfully motivated small employers to explore safety practices and kept them engaged long enough to absorb key messages. Feedback and engagement behaviors (e.g., subscribing or revisiting) further validate that the video influenced their attitudes and potentially their safety behaviors.

Evaluation results of VR-Employer4Safety as a Motivational Tool

This project applied Self-Determination Theory (SDT) to evaluate small employers' safety motivation from multiple dimensions. SDT explains human motivation as a continuum that ranges from extrinsic to intrinsic, emphasizing the role of autonomy, competence, and relatedness in fostering motivation. In the context of safety, SDT categorizes safety motivation into the following five factors, and they were evaluated by 16 5-point scales to indicate their levels of agreement to related statements (Fleming, 2012).

Amotivation represents a lack of motivation to engage in safety behaviors. Individuals may feel that their actions are not connected to meaningful outcomes or that they lack the ability to influence safety (Deci & Ryan, 1985). Four statements were used to assess this factor, such as "I don't (put effort into working safely), because it doesn't make a difference whether I work safely or not." A higher score indicates a high lack of motivation for working safely.

External Safety Motivation is driven by external pressures, such as avoiding punishment or receiving rewards (Deci & Ryan, 2000), with behavior performed to comply with external demands or achieve tangible outcomes. Three statements were used to assess this factor, including "I put effort into working safely in order to avoid being criticized by others (e.g., supervisors, colleagues, family, clients…)." A higher score indicates a higher contingency-based motivation influenced by others in the environment.

Introjected Safety Motivation is influenced by internalized external pressures, such as guilt, shame, or obligation (Deci & Ryan, 2000). Individuals comply with safety standards to maintain self-esteem or avoid self-imposed guilt. Three statements were used to assess this factor, and one example was "I put effort into working safely because otherwise I will feel guilty." A higher score indicates a higher internal pressure to work safely.

Identified Safety Motivation is where individuals recognize and accept the personal value of safety behaviors, integrating them into their goals (Deci & Ryan, 2000). Behavior is performed because it is seen as personally important. Three statements were used to assess this factor, with one example being "I put effort into working safely because I believe it is important." A higher score indicates higher personal value-based motivation.

Intrinsic Safety Motivation is driven by inherent interest, enjoyment, or satisfaction in performing safety behaviors (Deci & Ryan, 1985). Individuals engage in safety activities for the intrinsic pleasure or interest they derive from them. Three statements were used to assess this factor, and one example was "I put effort into working safely because I enjoy working safely." A higher score indicates a higher personal interest and enjoyment in safety activities.

The results showed that the 12-minute intervention positively influenced four of these dimensions (Table 1). The intervention appears to have positively influenced safety motivation, with notable reductions in amotivation (Pre-video: 1.94 vs. Post-video: 1.79) and slight improvements in identified motivation (Pre-video: 4.35 vs. Post-video: 4.45) and intrinsic motivation (Pre-video: 4.10 vs. Post-video: 4.15), both of which are more autonomous forms of motivation. Participants' comments confirmed the impact of the video, such as the

employee who said that the overall experience shared by the virtual employer "*makes me love and value safety at work more than before"* and *"made me feel the power of safety culture, which prompted me to become more actively involved in safety activities and training*." Participants specifically mentioned their introduction to free resources from CPWR and OSHA, with one noting that such material *"motivates me to take a more proactive approach to safety rather than simply maintaining the status quo.*" This highlights an increased awareness of these resources and underscores the essential role this awareness plays in strengthening small employers' safety motivation. Moreover, one participant highlighted the value of the emphasized information on free resources available in multiple languages, stating that "*it would greatly sensitize my workers and educate them on the importance of workplace safety*," particularly noting that "*most of my workers are immigrants.*" However, the changes in external and introjected motivation were minimal or nonexistent, indicating that the intervention primarily impacted more autonomous motivational factors. These results suggest that the VR-Employer4Safety intervention is effective in fostering meaningful and sustainable safety motivation, particularly by reducing disengagement and enhancing personal value recognition.

However, no statistically significant differences were observed in the motivational factors before and after the intervention. A possible explanation for this outcome is that participants who volunteered to participate in a safety motivation-related study may already have had relatively strong safety motivation and a heightened emphasis on workplace safety. As a result, while the video had a positive impact, the overall change was not significant due to their high baseline level of safety motivation.

Table 1. Descriptive analysis for five safety motivation factors

	Pre-video score Mean (SD)	Post-video score Mean (SD)	Difference (Post minus Pre)
Amotivation	1.94 (0.93)	1.79 (0.86)	-0.15
External Safety Motivation	2.86 (1.05)	2.90 (1.13)	0.04
Introjected Safety Motivation	3.8 (0.97)	3.8 (1.00)	0
Identified Safety Motivation	4.35 (0.70)	4.45 (0.54)	0.10
Intrinsic Safety Motivation	4.10 (0.87)	4.15 (0.80)	0.05

Changes/problems that resulted in deviation from the methods

It proved difficult to recruit small construction contractors, primarily due to their limited availability and reluctance to participate. As a result, the study's sample deviated slightly from the original plan of recruiting 50 participants to assess the video's impact. Moreover, the voluntary nature of participation suggests that these participants likely had a higher baseline level of motivation before watching the video, limiting the observed positive impact to a level that was not statistically significant. A similar pattern emerged in another study we conducted, which aimed to enhance high school students' motivation toward construction careers. Since participants were already aware of and interested in construction—leading them to voluntarily join the study—the intervention's impact, while present, did not reach statistical significance.

This presents a dilemma: those who lack motivation and could benefit the most from such motivational interventions are also the least likely to participate the study voluntarily. A key lesson learned is the importance of implementing incentives, such as monetary compensation or extra credit, to encourage broader participation. In this study, we offered a $30 incentive per participant, but this amount appeared insufficient to attract professionals working in a highly competitive and fast-paced industry. Future studies may need to explore alternative or more substantial incentives to ensure a more diverse and representative sample.

In addition, while all interviewees worked at a firm with fewer than 20 employees (team sizes ranged from 1 to 18), due to recruitment difficulties, six subcontractors from the wastewater industrial sector were included to

ensure a sufficient sample size for analysis. While it is acknowledged that these firms operate in different contexts from residential construction contractors, the research team observed shared motivational challenges and attitudes toward free resources. Therefore, the findings of this study are considered applicable to the target population within the scope of the interviews conducted.

List of presentations/publications

Jingyuan Shen, Jing Wen, Masoud Gheisari. (2025); Using 360-degree virtual reality narrative video to boost small construction contractors' safety motivation and awareness. 2025 International Conference on Computing in Civil Engineering. In preparation.

Varuni Jindal, Jingyuan Shen, Jing Wen, Masoud Gheisari. (2025); Safety perceptions among small construction contractors in the US. Safety Science. In preparation.

Jingyuan Shen, Jing Wen, Masoud Gheisari. (2025); Enhancing Small Construction Contractors' Safety Motivation and Awareness: Evaluating the Impact of 360-Degree Virtual Reality Narrative Video. Journal of Construction Engineering and Management. In preparation.

Dissemination plan

- Academic Publications: Submit findings to peer-reviewed journals such as *Safety Science* and *Journal of Construction Engineering and Management* to share insights with the academic and professional communities.
- Conference Presentations: Share the study's methodology and results at academic gatherings, including the American Society of Civil Engineers (ASCE) Construction Research Congress and International Conference on Computing in Civil Engineering conference.
- YouTube: Continue hosting the VR-Employer4Safety video on YouTube to ensure accessibility and track viewer engagement through analytics.
- Social Media: Leverage platforms like LinkedIn, Facebook, and Twitter to share updates and promote video and resources.
- Integration into Safety Programs: Integrate the VR-Employer4Safety video into safety training program (i.e., Professional Mater in Occupational Safety and Health) for small employers offered by the School of Building Construction at Georgia Tech.

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