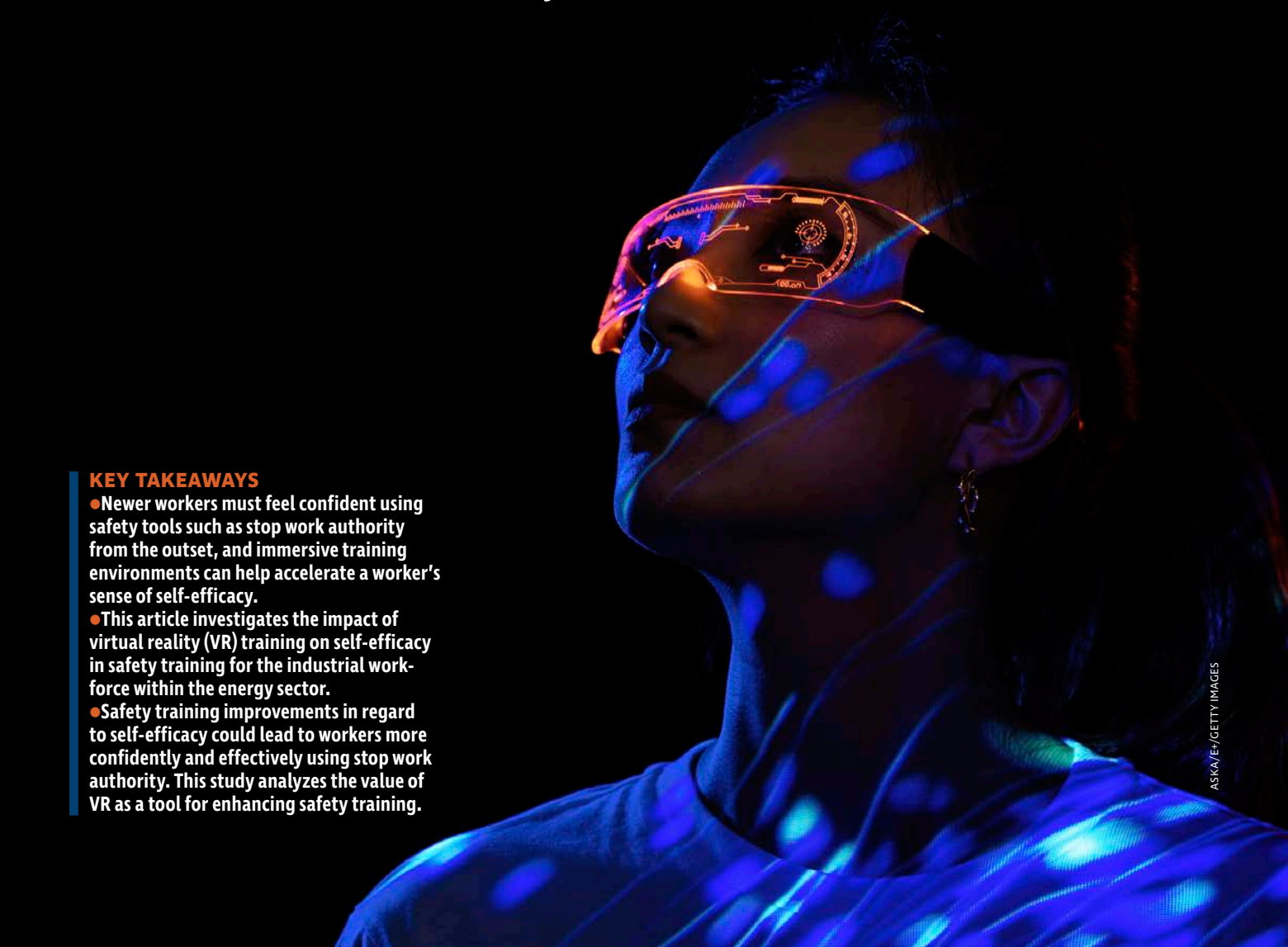
VR TRAINING & STOP WORK AUTHORITY

Strengthening Worker Confidence

By Richard Hannah



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KEY TAKEAWAYS

- Newer workers must feel confident using safety tools such as stop work authority from the outset, and immersive training environments can help accelerate a worker's sense of self-efficacy.
- This article investigates the impact of virtual reality (VR) training on self-efficacy in safety training for the industrial workforce within the energy sector.
- Safety training improvements in regard to self-efficacy could lead to workers more confidently and effectively using stop work authority. This study analyzes the value of VR as a tool for enhancing safety training.

IMMERSIVE TRAINING ENVIRONMENTS can accelerate a worker's sense of self-efficacy, which is particularly important for newer workers who must feel confident using safety tools such as stop work authority from the outset. Improvements to safety training in terms of self-efficacy could lead to workers using safety tools such as stop work authority with more confidence, more effectively, more quickly and with more frequency. Virtual reality (VR) has the potential to transform safety and skills training in the energy sector by enhancing worker engagement and learning retention (Exarheas, 2024; Colombo et al., 2014). Both energy production sites and contractors who are tasked with servicing these sites have started to see the benefit of VR training (AFPM, 2020; Hannah, 2021). These advantages include the ability to train workers to perform high-risk procedures in realistic environments and engage with hazards without endangering their health or well-being; the chance to practice, perform and replicate procedures and simulations in immersive environments; and the opportunity to develop robust, long-term memories by way of this practice.

This article investigates the impact of VR training on self-efficacy in safety training for the industrial workforce within the energy sector. Participants were contractor workers who took training on confined space safety at a safety council in the Gulf Coast region of the U.S. Each participant took one of three courses: either one without VR exercises or one of two with VR exercises. Self-efficacy was measured through quiz return rates following the course delivery. The results showed a statistically significant improvement in return rates among participants who completed VR courses, particularly for less experienced workers. Experienced workers also responded positively to VR training, though the effect was less pronounced. These findings suggest that VR training has the potential to significantly affect self-efficacy, especially for newer workers in high-risk industries. This study highlights the value of VR as a tool for enhancing safety training engagement and effectiveness.

Introduction

Despite improvements in safety and health training for the energy industry and construction trades that support the energy industry, key indicators used to gauge contractor safety have remained level since 2015 (Colombo et al., 2014; Gavish et al., 2015). According to the U.S. Bureau of Labor Statistics (BLS, 2022), significant violations in safe work practices and procedures that lead to injuries or fatalities continue to occur in the energy industry and construction trades that support it.

Energy jobsites can be hazardous, and incidents can result in injuries, fires, environmental damage or fatalities. New workers entering the industry must be trained and understand the dangers related to the work they perform and the hazards they may face on the jobsite, such as:

- electrical and mechanical failures,
- exposure to releases of hazardous substances such as hydrogen sulfide or flammable vapors,
- work at heights that pose fall risks,
- work in confined spaces where hazardous gases can accumulate, and
- work in areas with the potential for catastrophic explosions or fires.

With projections indicating that more than 600,000 new workers will be needed annually through 2033 to replace retirees and meet growing demand in construction-related trades (Lawhorn & Ilic-Godfrey, 2025), the industry's labor force is set to expand rapidly. This growth significantly increases the number of field workers exposed to high-risk environments. These same organizations often face seasonal surges, requiring swift onboarding of large numbers of temporary or short-term employees. High turnover and the constant influx of inexperienced workers elevate the risk of serious incidents, making it critical to implement robust, standardized safety training that is effective.

Literature Review

Stop Work Authority

The understanding and use of stop work authority is ubiquitous and fundamental to safe work activities in the energy sector (Gaddis, 2019; Havinga et al., 2021; Mlynek, 2021). Providing training that helps learners understand the benefits of stop work authority and promotes the use of this personal safety tool would benefit newer workers, other workers on the jobsites, and the industry as a whole. Abdelhamid and Everett (2000) identify three primary root causes that lead to incidents. Among these are a worker "deciding to proceed with a work activity after the worker identifies an existing unsafe condition" (p. 54). Stop work authority is a safety policy designed to stop any work an employee identifies as unsafe. According to Gaddis (2019), "the goal behind such a plan is to encourage workers to speak up without fear of retribution when they see a potential at-risk situation unfolding" (p. 2). When used correctly, stop work authority is a powerful tool for keeping workers safe.

Multiple studies have investigated how and why employees use or decide not to use stop work authority. In their qualitative study, Weber et al. (2018) identify 14 factors that might hamper a worker's ability to utilize stop work authority. Among those, six could be associated with worker self-efficacy, confidence and personal empowerment:

- the need to justify,
- being afraid of others,
- disagreements about the risk,
- their own credibility,
- the potential for negative repercussions, and
- ambiguous instructions.

Another issue regarding new employees' initiative to use stop work authority is the bystander effect. According to Furst (2015), the bystander effect "occurs when the presence of others hinders an individual from intervening in a situation that may cause injury to others or the environment" (p. 5). New employees might be less likely to stop work because they believe another, more experienced worker would stop the hazardous act if it were dangerous. Conversely, experienced workers may become complacent over time, and habits formed in the absence of incidents can lead to overlooked or skipped procedural steps.

Self-Efficacy

For contractors who support the energy industry, self-efficacy can be described as their belief in their abilities and capabilities in performing a task or procedure and their perceptions of themselves within the community (Bandura, 1977; Lopez-Garrido, 2025). Lopez-Garrido (2025) writes that self-efficacy "refers to an individual's belief in their capacity to execute behaviors necessary to produce specific performance

outcomes. It's the confidence in one's ability to influence events and control over one's environment" (para 1). As Lindley (2006) points out, Bandura believes that "self-efficacy is closely linked to individual human agency" (p. 144). Regarding stop work authority, summoning the confidence to speak up and stop a job, especially as a newer worker, is challenging. Greater agency, self-efficacy and confidence could help newer workers overcome the bystander effect sooner.

Citing several sources, Artistico et al. (2011) state that self-efficacy and self-worth are linked to a worker's abilities. They write that "the knowledge that one is succeeding or failing at a task has substantial implications for ongoing and future actions related to task performance and sense of mastery" (Artistico et al., 2011, p. 217). Additionally, Bandura (1997) writes that the "stronger the sense of self-regulatory efficacy, the greater the improvement in work involvement" (p. 189). So, this greater sense of self-efficacy can lead to greater worker involvement and an increase in the use of stop work authority.

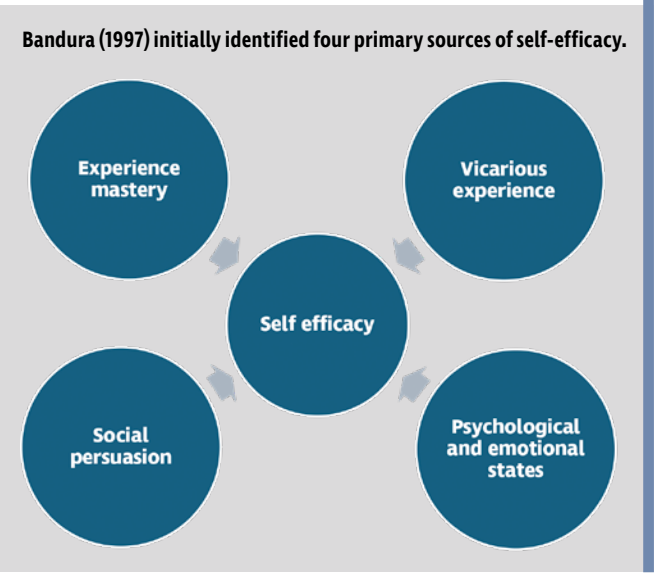
VR & Self-Efficacy

Many studies have explored the use of VR as a safety training tool for safety-related or hazardous industries (Bhoir & Esmaeili, 2015; Gallagher et al., 2013; Sankaranarayanan et al., 2018; Tanaka et al., 2015), in emergency action plan training in industrial plants (Longo et al., 2019), and for industrial maintenance tasks (Colombo et al., 2014; Gavish et al., 2015; Juricic et al., 2015; Patle et al., 2019). These studies support both the effectiveness and engagement of VR training. Mabry et al. (2020) found that VR-trained students "not only performed more effectively in simulations, but anecdotal observations of clinical educators were that students were better prepared for clinical practice" (p. 204). Pedram et al. (2021) and Perez et al. (2013), focusing on VR simulator training for the mining industry, concluded that VR not only helps learners overcome real-world training hazards and constraints but also better equips the learner for real-world situations. Multiple studies on immersive training have found that VR-trained learners outperform their non-VR-trained counterparts and are more likely to replicate their VR-acquired skills in real-world settings (Colombo et al., 2014; Katz & Halpern, 2015).

Many studies have found that VR training can improve industrial workers' self-efficacy (Colombo et al., 2014; Makransky & Klingenberg, 2022). These studies have shown that workers who underwent VR training had a higher likelihood of identifying and fixing problems they found on the jobsite and demonstrated higher levels of motivation and behavioral changes. Bandura (1977) initially identified four primary sources of self-efficacy, which include mastery of experiences, vicarious experiences, social persuasion, and physiological and emotional states (Figure 1). More recent findings support this and have found that experience mastery significantly contributes to individuals' self-efficacy (Gale et al., 2021).

Holbrook and Cennamon (2014) explain that one beneficial aspect of simulators is that "they provide a safe environment in which to learn and fail" (p. 40). Their study on emotion and self-efficacy in simulators for police officers found that learners in an immersive learning environment were more emotionally invested, found the training situations realistic and found the learning memorable and realistic. In a similar study, Nissim and Weissblueth (2017) found that when VR simulator training was provided to teachers, the participants' self-efficacy improved following the simulator training. Additionally, Shu et al. (2018) found that self-efficacy, learner motivation and enjoyment of the training course improved when high-definition immersive VR was used as the training tool. Studying nursing students' self-efficacy in performing tasks after VR training, both Chang et al. (2022) and Chiang et al. (2022) found that VR significantly enhanced participants' self-efficacy by increasing familiarity, improving confidence and reducing anxiety. All these results suggest that learners' self-efficacy is enhanced through training.

FIGURE 1
FOUR PRIMARY SOURCES OF SELF-EFFICACY



Objective

Given the potential benefits of VR for enhancing the self-efficacy of newer workers, this study explores the following research questions:

- How does VR training impact self-efficacy among contractor workers in the energy sector compared to traditional computer-based training (CBT) modalities?
- Does the experience level of workers (new vs. experienced) moderate the relationship between VR training and self-efficacy?

This study tested the following hypotheses based on the research questions:

- **Null hypothesis:** The provision of VR does not affect participants' potential for increased self-efficacy.
- **Alternative hypothesis:** The provision of VR does affect participants' potential for increased self-efficacy.

Methodology

This study was conducted as part of a larger research project examining the transfer of learning via VR-based training tools. The broader study explored how VR influences knowledge retention and the likelihood of transfer of learning (Hannah, 2024). During data analysis for the study, self-efficacy emerged

as a key factor influencing learner engagement and performance. The data used in this study were drawn from the larger project, but the original research was not initially designed with self-efficacy as the primary focus.

The sample for this study included contractors visiting a safety council in the Gulf Coast region of the U.S. who were registered for training by their contracting organizations. To ensure a random sample, participants were assigned to one of the three courses by the safety council learning management system at the time of their registration, utilizing a random registration application developed by the researcher for this study. An advantage of using this research design is that it allowed for a large, diverse sample to study from a homogenous community, which would yield generalizable results (Creswell, 2013; Williams et al., 2022). Learners at safety councils are all adult contractors who work in the energy industry. Although the learner population for this study had some previous experience with safety courses and concepts, the degree of that experience ranged from brief conceptual or theoretical understanding to deep experiential knowledge. Some participants were new to the industry, while others had years of experience. Demographic variables such as age, experience level, race or ethnicity, and gender were captured during the training delivery. The study was conducted over 3 months to ensure that the sample met the size requirements outlined in Creswell (2013).

Data collection did not begin until the study was approved by the safety council's executive leadership team as well as the university's Institutional Review Board, which partnered with the researcher for this study. There was no possibility for financial gain for either the safety council, the researcher, the contractor organizations to which the participants belonged or any of the study participants. Regardless of treatment, the study participants who took these courses fulfilled the compliance and regulatory training demands necessary for safe work in the field as mandated by their contracting organization, the jobsite and federal workplace safety standards. The randomization of the sample ensured that no one at the safety council, nor the contracting organizations, had a personal or professional relationship with any study participants that might have influenced the study or the participants' work. All participants in this study provided informed consent before their participation.

Each group in this study completed the same course content delivered in a similar manner. However, two of the courses included VR simulations. This provided participants a chance to practice procedures learned in the CBT course in an immersive virtual world using a VR headset. The CBT sections of the courses were developed using Articulate Storyline course development software. They included digital assets such as animations, explainer videos and interactive scenarios designed to help participants understand the information. The VR simulations were integrated into the CBT courses and provided to participants using tethered Oculus Rift S headsets. Seated modality, as opposed to room-scale, was used to fit established safety council procedures. Following concepts of temporal contiguity and essential processing, the course was organized so that the VR simulations occurred near the theoretical information they supported (Carmichael et al., 2018; Mayer, 2014). The VR simulations were integrated into the CBT course such that the learner would not have to leave the computer terminal to complete the VR exercises. Study participants who took the course with VR simulations were proctored and assisted in using the VR equipment by safety council proctors.

Regardless of group, all participants were sent a follow-up quiz three days after course completion. Scores from the quiz were collected and stored in the safety council learning management system. The quiz was limited to five questions as past internal studies performed by the safety council have found that a high respondent burden, which Leavy (2017) defines as asking learners to perform tasks that are too drawn-out or cumbersome, has led to fewer results from participants. Additionally, questions were limited to multiple-choice and true-or-false formats.

Since the safety council had no ability to mandate or require participants to complete the follow-up quiz, the results for this study used number of returned quizzes, not the content of the quizzes or quiz scores, as a measure of self-efficacy and continued learner engagement. Utilizing the return rate of these follow-up quizzes as a proxy for self-efficacy is supported by research indicating that individuals with higher self-efficacy are more likely to engage in voluntary tasks related to their learning (Elias & MacDonald, 2007). This behavior aligns with Bandura's (1977) theory of self-efficacy, which posits that individuals with higher confidence in performing well are more likely to take initiative, engage voluntarily and follow through with learning-related tasks, even without external incentives.

Results

The study data show that learners who took courses with VR exercises returned quizzes at a higher rate than learners who were part of the control group, as shown in Table 1. Both VR groups exhibited increased response rates, suggesting greater engagement or motivation to follow up. This indicated increased self-efficacy, confidence, and a desire to continue their learning.

A chi-square test of independence was conducted to examine whether quiz return rates differed significantly between learners who received traditional non-VR training and those

TABLE 1
FULL DATA ANALYSIS

Training type	Total course takers	Returned quizzes	Percentage of returned quizzes
Non-VR	237	50	21%
VR #1	201	60	30%
VR #2	196	71	36%

TABLE 2
DATA ANALYSIS FOR LESS EXPERIENCED WORKERS

Training type	Total course takers	Returned quizzes	Percentage of returned quizzes
Non-VR	166	27	16%
VR #1	137	43	31%
VR #2	139	44	32%

who received VR-based training (VR vs. non-VR). This test was selected because it is well-suited to examine relationships between two categorical variables and determine whether the distribution of results is due to chance or is statistically meaningful. The results revealed a statistically significant association between training method and quiz return rate, $\chi^2(1, N = 634) = 9.73$, $p = 0.0018$. This finding suggests that the likelihood of learners returning quizzes was not due to chance alone but was influenced by the type of training they received. Learners in the VR group returned quizzes at a higher rate (33%) compared to those in the non-VR group (21%), indicating that immersive training formats may enhance engagement and follow-through.

In addition to tracking quiz return rates, the study collected demographic and experience-level data from all participants. Participants were asked to provide information on key demographic factors, including race, age and gender, allowing for a more comprehensive understanding of the sample and potential influencing factors on training outcomes. Participants self-reported their industry experience using a Likert scale ranging from 1 (new to the industry) to 5 (very experienced). This measure provided insight into their familiarity with industry practices. The self-reported experience data allowed for a more targeted analysis, enabling an exploration of whether training type influenced self-efficacy and engagement differently based on participants' experience levels.

To assess the impact of experience level on quiz return rates, participants were grouped into two categories: those who self-identified as new or less experienced (Likert scores of 1 to 2) and those with some or significant experience (scores of 3 to 5). For less experienced workers, a chi-square test of independence revealed a statistically significant association between training type and quiz return rate, $\chi^2(1, N = 442) = 11.82$, $p = 0.0006$. As shown in Table 2 (p. 27), quiz return rates were markedly higher for VR group learners than for learners in the non-VR group. This suggests that immersive training had a more pronounced impact on quiz completion and, by extension, self-efficacy among those workers who were newer to the industry (Figure 2).

For more experienced participants (Likert scores of 3 to 5), the association between training type and quiz return rate was not statistically significant, $\chi^2(1, N = 196) = 0.22$, $p = 0.642$ (Table 3). While VR #2 still produced relatively high return rates, the differences across training types taken in total (VR vs. non-VR) were not large enough to rule out chance variation. This may suggest that workers with greater familiarity or confidence are less influenced by training format regarding follow-up engagement and self-efficacy.

These results indicate that experience level moderates the relationship between training type and learner behavior, as measured by quiz return rates. While VR-based training was associated with significantly higher quiz return rates overall, the effect was especially pronounced among less experienced workers. VR training nearly doubled return rates for this group compared to the control group, suggesting that immersive environments may enhance early engagement and reinforce learner self-efficacy during the initial stages of industry exposure. Among more experienced participants, however, differences across training types were not statistically significant, indicating that prior familiarity or confidence may diminish the influence of training format on follow-up behavior.

Based on these results, the author can reject the null hypothesis that VR training has no effect on learner follow-up behavior and self-efficacy. The statistically significant differences in quiz return rates, particularly among workers who are new to the industry, support the alternative hypothesis: VR training improves engagement and may serve as a catalyst for building confidence and reinforcing safety learning behaviors. While quiz return rate is an indirect measure of motivation and self-efficacy, in this case it serves as a behavioral proxy for these qualities, particularly when interpreted alongside learners' voluntary effort and follow-up behavior.

Discussion

The results of this study indicate that VR training has a significant impact on learners' self-efficacy, particularly in the context of their willingness to continue learning and to advance their learning goals. This finding could indicate a greater degree of self-efficacy in terms of self-confidence, task completion and a willingness to overcome the bystander effect in jobsite settings. Additionally, the higher response rates from the VR-trained participants in the voluntary follow-up quiz suggest that these individuals retained knowledge more effectively, demonstrated a higher level of engagement and were more motivated to continue learning. This is a strong indicator of enhanced self-efficacy, as individuals with higher self-efficacy tend to show more remarkable persistence in tasks, such as voluntarily completing follow-up assessments (Elias & MacDonald, 2007; Lucero & Moore, 2024).

FIGURE 2
MODERATING EFFECT OF EXPERIENCE ON SELF-EFFICACY

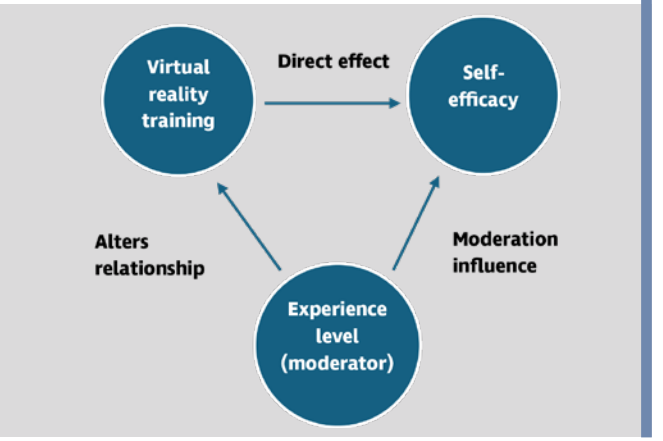


TABLE 3
DATA ANALYSIS FOR MORE EXPERIENCED WORKERS

Training type	Total course takers	Returned quizzes	Percentage of returned quizzes
Non-VR	71	23	32%
VR #1	64	17	27%
VR #2	57	17	47%

Enhanced self-efficacy directly correlates with workers' confidence in their ability to execute job-related tasks, including those related to safety. In the energy sector, where stop work authority can prevent potentially catastrophic incidents, workers' greater self-efficacy could translate into more decisive and confident actions or a lower likelihood of workers falling victim to the bystander effect. Individuals with a stronger sense of self-efficacy tend to trust their judgment and use their authority to stop unsafe work sooner, potentially mitigating hazards before they escalate (Burke et al., 2006; Furst, 2015; Gaddis, 2019).

The findings of this study reinforce the argument that immersive training environments such as VR enhance learner engagement and strengthen the connection between the trainee and the content. Simulating high-risk scenarios in a controlled virtual space allows learners to repeatedly practice decision-making and procedural tasks without real-world consequences. This exposure to vicarious learning experiences fosters confidence and a sense of mastery in performing job-specific tasks (Hernandez, 2023), which should yield greater self-efficacy. The higher quiz return rates observed among VR-trained participants provide empirical support for this effect, suggesting that these learners developed greater confidence, greater self-efficacy, and a desire to continue their development with a stronger belief in their ability to manage workplace challenges.

By fostering a more engaged and confident workforce, VR training has the potential to improve individual job performance and contribute to the broader safety culture of the organization and the industry.

Conclusion

The implications of these findings suggest that organizations in the energy sector could significantly benefit from integrating VR into their safety training programs. The increased self-efficacy observed in VR-trained learners could lead to more proactive safety behavior on the job, including a greater willingness to stop work in the face of potential hazards. Moreover, as newer workers are often hesitant to assert themselves or use stop work authority due to fear of retribution or lack of confidence, VR could accelerate their sense of self-efficacy and enable them to engage more confidently in critical safety procedures early in their careers.

By fostering a more engaged and confident workforce, VR training has the potential to improve individual job performance and contribute to the broader safety culture of the organization and the industry. As the energy industry continues to face high-risk challenges, innovative training solutions such as VR offer promising avenues for equipping workers with the self-efficacy they need to prevent incidents and ensure a safer workplace. **PSJ**

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