Emotionally resonant videos with virtual reality exercises in contractor safety training

Richard Hannah, PhD

"Integrating VR into CBTs and optimizing VR training using emotion has the potential to improve transfer of learning."

EXECUTIVE SUMMARY

This 2023 study on recall and long-term memory for energy industry contractors examined the effects of integrating short virtual reality (VR) exercises and emotionally resonant videos in computer-based training (CBT) courses. Traditionally, energy contractors are trained using CBT courses so developing new techniques to improve the transfer of learning would be beneficial for worker safety, not just within the energy industry but in other industries with similar training models who face the same hazards. The courses used in this study presented information on working safely in confined spaces, a hazardous job type in energy and construction industries that can lead to fatalities for workers. The quantitative research design included two experimental groups, both of which were exposed to CBTs with integrated VR exercises, however one experimental group took the CBT with integrated VR exercises and a video designed to inspire an emotional response. The control group received the CBT course without VR exercises and without videos. All of the participants, regardless of group, received a quiz three days after completion of their course to determine if the information in the course was retained. This design allowed the researchers to determine to what degree the potential for transfer of learning was affected by the different training techniques. Although the results found a non-statistically significant relationship between the groups, there was evidence that the experimental groups benefitted in terms of knowledge retention. Additionally, when different segments of the sample were analyzed, statistically significant results were found which could be explained by learner expertise and cognitive load theory.

INTRODUCTION

Jobsite accidents in the energy industry can lead to injuries, fires, explosions, damage to equipment, toxic environmental releases, and fatalities. Jobsites that require entering or performing work in and around confined spaces can lead to injury or fatalities due to: (a) the challenges of entering and exiting the space, (b) the potential for these spaces to include hazardous atmospheres, or (c) sloping sides that could collapse and engulf the worker. Between 2011 and 2018, there were 1,030 confined space fatalities in the United States according to the United States Bureau of Labor Statistics (BLS) (BLS, 2022a). Exposure to harmful substances or environments, a classification for permit-required confined space work and hazards led to more worker fatalities in 2021 than in 2020 and the highest number of fatalities in this category for the past ten years (BLS, 2022b). Confined space awareness training is not just a regulatory compliance requirement that contractor organizations must fulfill, but it is routinely taken each year as a refresher to ensure that workers are constantly aware of, and educated on, the dangers that these jobsites pose.

Safety skills training and safety compliance training for contractors who work in the energy industry have traditionally been provided using CBTs. CBTs are beneficial because they are: (a) scalable to large organizations with many workers, (b) ensure consistency and compliance, and (c) can be quickly developed, updated, and disseminated. For training to be effective, however, it must help the learner remember procedures at the worksite. Transfer of learning in this context is defined as the ability of the worker to use the skills and knowledge learned in training in a work enviornment

(Bossard et al., 2008). Integrating VR into CBTs and optimizing VR training using emotion has the potential to improve transfer of learning.

Studies have shown that providing training through simulations that allow learners the opportunity to practice, reflect, and test out real-world-seeming experiences are more engaging and more memorable for learners. Why is this? Training via simulation leverages cognitive constructivist learning theories (McHaney et al., 2018). VR exercises that act as simulations have been shown by other studies to lead to more durable memory development (Boller et al., 2021; Bossard et al., 2008; Knörzer et al., 2016). VR simulations, especially immersive VR simulations, provide multiple representations of reality in realistic digital environments and can help evoke emotion during learning sessions. Immersiveness, or the feeling of being present in an online or virtual environment as brought about by sensory fidelity and a sense of realism has the ability to enhance emotion for learners (Basu, 2019, Marín-Morales et al. 2019). When emotion is inspired, particularly emotion that is enhanced by an immersive learning environment, the learning moment can be magnified through the creation of more diverse memory cues that can aid retrieval at a later date (Brown, 2014).

Although VR training has been used in the energy industry for many years (Benedict, 2019; Taylor, 2022), it has not been widely used to train contractors. Determining not just how it can be integrated into traditional training methods, but if VR exercises can be optimized using emotionally resonant videos, could be extremely helpful in improving training for this learning community and in helping contractor workers mitigate jobsite hazards.

METHODS

This study followed a research design that included randomized multiple treatments and a control group with a post-test design. The sample for this study included contractors working in the energy industry who took a confined space CBT course during the timeframe of this study. Although all participants took an exam when completing the CBT section of the course, they were also provided with a follow-up quiz that was delivered directly to their smartphones three days following the completion of their course. This follow-up quiz asked a series of questions designed to determine if VR exercises alone or VR exercises with emotional videos provided a better chance for knowledge retention than CBT alone. This follow-up quiz which measured recall after three days was the primary resource used to answer this study's research question:

- Do differences exist in knowledge retention for contractors from the following three groups: (a) those who completed confined space courses with VR and emotionally resonant videos, (b) those who took confined space courses with VR, and (c) those who completed confined space courses without VR and without emotionally resonant videos?

During the time frame of the study, June 2023 to August 2023, 1,131 learners were registered and randomly assigned to one of the three study groups. Of these potential participants, 634, or 56% completed the courses and consented to be included in the study. Of these, 181, or 29% completed the follow-up quiz. These 181 participants provided the data necessary to complete a quantitative analysis of the data as it yielded a sample of at least 30 per group, the minimum number of participants needed for a strong statistical analysis (Wilson Van Voorhis & Morgan, 2007). Additionally, there was an approximately even distribution of results among the three groups such that there were 50 participants in the control group, 60 participants in the CBT with VR-only group, and 71 in the CBT with VR and emotionally resonant video group.

The analysis of the data showed that VR exercises increased the chance for transfer of learning to occur, but the results were not statistically significant. Overall, the application of VR, regardless of whether the VR exercises included an emotionally resonant video, enhanced recall three days or more after the course completion. Additionally, the results

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showed that participants in the VR with emotionally resonant videos group had marginally higher scores on the follow-up quiz than participants who were provided CBTs with VR alone.

Although the exams taken as a part of the CBT were not the primary resource used to determine the recall opportunities, they were used as a part of the overall analysis. Mean scores on this CBT exam were approximately equal across all groups, suggesting that neither the VR exercises nor the VR exercises that included emotionally resonant videos increased overall learning for the participants in the short term. However, the means on the follow-up quizzes showed that there was a difference in mean scores three days following the completion of the courses. These results show that the VR only group and VR with emotional video group had greater recall than the participants who did not have the advantage of using these tools and techniques. This suggests that VR and emotional videos encourage no greater immediate learning benefits, but that they help with recall in the longterm.

This study's null hypothesis stated: that there is no difference in knowledge retention for contractors who completed confined space courses with VR and emotionally resonant videos, or confined space courses with VR, compared to those who took confined space courses without VR and without emotionally resonant videos. Although the analysis of the data show a lack of statistical significance there was a difference in recall quiz means that favored the participants in the VR only and VR with emotionally resonant video groups. When the data were analyzed further, a statistically significant relationship was found that favored both the VR only group and VR with emotionally resonant video group when either: (a) the youngest participants, those who were 18-24 years old, and (b) when the least experienced participants, less than five years of experience, were removed from the sample. In both of these cases, the VR only group and VR with emotionally resonant video group participants' means on the follow-up quiz were significantly higher than the mean scores on follow-up quiz scores for participants who took the CBT alone.

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CONCLUSIONS

What does it indicate that when the youngest and least experienced participants are removed, a statistically significant relationship is found that favored both the VR only and VR with video groups? Do younger learners or less experienced workers not find the same benefit from CBTs with VR exercises and emotionally resonant videos as those learners with more experience? Part of the reason for this difference might be found in memory schema theory and cognitive load theory.

Cognitive load theory has been addressed in many studies of multimedia instructional design (Mayer, 2020) as well as in VR simulations (Albus et al., 2021; Breves & Stein, 2023; Makransky & Petersen, 2021). Studies like these and others have found that learners' mental resources become more limited when VR is included in memory-making (Fisher et al., 2019; Parong & Mayer, 2018). When there is too much information presented to learners at one time, learners must limit the information that is processed and stored. When examining cognitive load researchers generally consider three different types: (a) intrinsic cognitive load, (b) extraneous cognitive load, and (c) germane cognitive load. Intrinsic cognitive load is characterized by the difficulty and complexity of the learning material. Extraneous cognitive load is usually expressed as the processes that are not directly involved in learning but might distract or pull the learner's attention away from the learning. Germane cognitive load is the effort needed by the learner to create and develop memories of the learning (Sweller et al., 1998).

When considering these theories in the aspect of this study, learners with less experience would be required to use more resources in terms of intrinsic cognitive load to understand and make sense of the new procedures, terms, and process that they are confronted with. The VR exercise and emotionally resonant videos would work to increase the germane

cognitive load and extraneous cognitive load that the participants felt and could also limit working memory that otherwise might be allocated to deal with intrinsic cognitive load. Along these lines, other studies that have a focus on memory schema, expertise, and prior experience have found that learners with more prior knowledge and experience build on already developed complex schema based on prior experience. Older and more experienced learners naturally have had more opportunities to train on and work in confined spaces, which leads to more prior experience and more complex memory schema. This expertise and previous experience would lead to more well-developed and complex memory schema and free up working memory resources (Sweller et al., 1998). Inexperienced learners on the other hand would not have the benefit of previous experience and well-developed expertise so that their ability to learn could have been hindered by a potential over-taxing of memory-making resources when taking the training.

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To learn more about this research brief and other research endeavors in the College of Education at Kansas State University, please reach out to the Office of External Funding and Research at: coeresearch@k-state.edu

Major Professor: Dr. Haijun Kang

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