Research Data Camp – Final Project

By: Jazmin Lopez

*Note to audience: the following information pertains to data gathered through my research project. I am currently working on the journal papers; thus, data set and relevant work have not been made publicly available.

Research Question

Within the construction industry, VR has been extensively used as an assessment tool to measure individuals' hazard recognition skills (Jeon & Park, 2005; Perlman et al., 2014). Very few studies have evaluated the efficacy of using VR as a *learning* platform. The few studies that have tested the efficacy of VR as a learning intervention (e.g., for knowledge acquisition, task performance, self-efficacy, hazard identification, risk assessment, and safety behavior; Eiris et al., 2020; Jeelani et al., 2020; Osti et al., 2021; Sacks et al., 2013; Shi et al., 2019) have studied its efficacy in isolation. This body of evidence, while seminal, lacks ecological validity since VR will not be used as a standalone training platform in the foreseeable future, but as a supplement to existing safety training frameworks in the construction industry. Additionally, some of the aforementioned studies also lack requisite external validity, as most of the evidence is gathered from limited data sets sometimes consisting of college students (i.e., not adult learners; Adami et al., 2023). It is essential to conduct research on the targeted populations that VR affects because, as Adami et al. (2023) found, the effectiveness of VR-based safety training for the acquisition of knowledge on students may not necessarily associate with its effectiveness on construction workers. To address this knowledge gap, the authors of this study adopted a quantitative quasi-experimental design to answer the question: *to what extent, if at all, does VR-based based safety training enhance hazard recognition of construction workers when paired with traditional training modalities*? This foundational inquiry seeks to provide much-needed evidence on the potential value-proposition of using VR technology in the construction industry for safety training before individual organizations make significant investments.

Methods

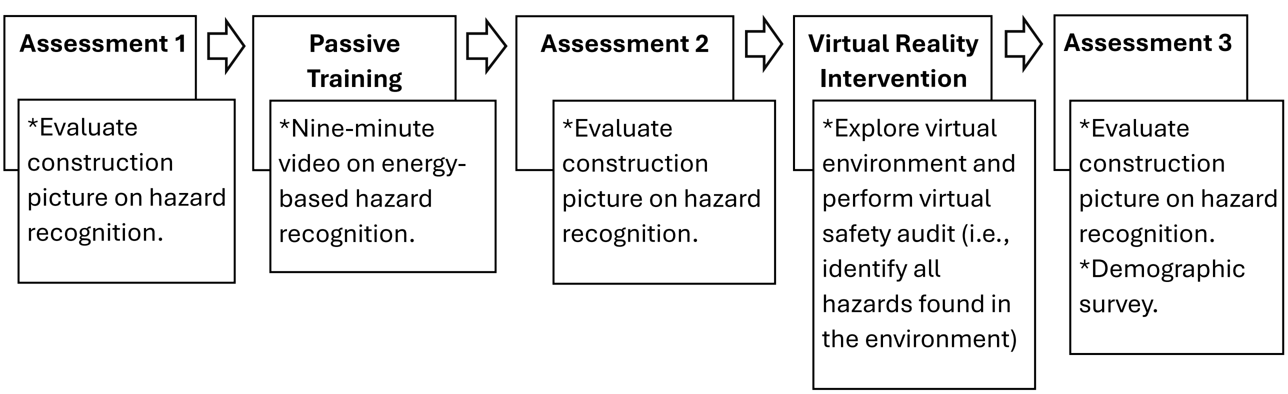

Figure 1 - *Experimental Protocol*

Figure 1 illustrates the experimental protocol implemented in this study, which consisted of two interventions: one introducing participants to a traditional passive training module via nine-minute video, and another intervention consisting of a VR simulation. To evaluate the changes in hazard recognition skill due to the interventions, participants were asked to complete a hazard recognition questionnaire at three assessment phases: at baseline (i.e., prior to any interventions) –which corresponds to variable *HR.Skill.B* on the data set—, after the traditional passive training intervention –variable *HR.Skill.T* on the data set—, and after the VR intervention –variable *HR.Skill.VR* on the data set. These assessments consisted of evaluating the hazards found in three construction-related pictures (one for each assessment phase with mixed ordering for all participants). The picture identity (i.e., either picture #1, #2, or #3) evaluated at baseline is characterized by variable *Picture.B* on the data set, *Picture.T* refers to the specific picture evaluated at Assessment 2, whereas *Picture.VR* pertains to the picture evaluated at Assessment 3.

Results

A total of 221 participants (consisting of both field workers and leadership personnel within the construction industry) took part in the study. For all tests performed in this study, results were deemed significant at a confidence level above 95% (i.e., p-value < 0.05).

Table 1 - *Means for Hazard Recognition Skill (*indicates statistically significant)*

Assessment Phase	Mean	Change in Performance
Assessment 1 (Baseline)	15.0%	-
Assessment 2 (Post-Passive Training)	23.3%	8.3%*
Assessment 3 (Post-VR Training)	19.1%	- 4.2%*

Table 1 shows the grand means for the hazard recognition performance at every assessment phase of the protocol. As shown by this table, baseline hazard recognition performance was 15.0% across the entire sample, which increased to 23.3% after passive training but declined to 19.1% after VR intervention. Differences in the means were analyzed using paired-sample t-tests, which revealed a statistically significant increase in performance post-passive training and a statistically significant decrease in performance post-VR training.

Table 2 demonstrates the effect of picture identity (i.e., picture 1, 2, or 3) at every assessment phase of the protocol. The difference in performance suggests the order in which participants see the different pictures may moderate their hazard recognition performance.

Table 2 - *Means of Hazard Recognition Skill accounting for picture identity and assessment phase.*

Assessment Phase	Picture 1	Picture 2	Picture 3
Assessment 1 (Baseline)	12.99%	17.06%	13.85%
Assessment 2 (Post-Passive Training)	22.57%	19.77%	25.95%
Assessment 3 (Post-VR Training)	17.34%	18.48%	22.42%

To explore the effect of pictures on hazard recognition, the research team performed a linear regression analysis for picture identity at every assessment phase. Table 3 shows that the perceived decline in hazard recognition skills following the VR intervention is not a uniform effect but is moderated by the identity of the pictures used in the assessment phases. The findings suggest that VR interventions may yield differential outcomes based on the specific assessment content or context presented to participants. That is, this moderation indicates that the content depicted in these pictures— whether it is the type of hazards, the context of the risk, the ordering of the pictures at every assessment phase, and/or the visual presentation—plays a crucial role in how hazards are identified and assessed. Based on these results, it is not possible to conclusively determine whether VR (as designed and tested in this study) has a positive or negative effect on participants' hazard recognition performance.

Table 1 - *Linear regression of picture identity at every assessment phase on Hazard Recognition Skill.*

Assessment Phase	**Picture 1**	**p-value**	**Picture 2**	**p-value**	**Picture 3**	**p-value**
Assessment 1 (Baseline)	12.99%	<0.001	17.06%	<0.001	13.85%	<0.001
Assessment 2 (Post-Passive Training)	22.57%	<0.001	19.77%	<0.001	25.95%	<0.001
Assessment 3 (Post-VR Training)	17.34%	<0.001	18.48%	<0.001	22.42%	<0.001

Data set Evaluation: A brief (250-500 words) that evaluates a data set with respect to one of the FAIR principles, and best practices for data publishing more generally. In the write-up, you might reflect on the challenges that a user of the data set might encounter, or suggest changes to the data set's documentation or metadata with a view towards enhancing its reusability for future users.

Data Set Evaluation

The dataset derived from the study provides a unique perspective on the use of VR technology within the construction industry. This study aimed to assess the impact of VR-based safety training on hazard recognition among construction workers, when adopted alongside traditional training methods. Through a quantitative quasi-experimental approach, significant insights were garnered, as evidenced by the structured assessment across three phases and the inclusion of various control variables such as picture identity.

Reflecting on the FAIR principles, particularly Reusability, this dataset exhibits a strong foundation yet offers room for enhancement to maximize its potential for future research endeavors. The inclusion of variables that take into consideration the type of assessment used in the study (i.e, *Picture.B*, *Picture.T*, and *Picture.VR*) alongside detailed assessments of hazard recognition performance (i.e., *HR.Skill.B*, *HR.Skill.T*, and *HR.Skill.VR*), lays a groundwork for replicability and secondary analysis. However, enhancing its reusability requires addressing certain elements more comprehensively, which include:

- *Detailed Documentation:* While the dataset provides a basic structure of the experimental design and results, a more detailed documentation could further enrich its utility. Including a comprehensive data dictionary (or ReadMe file) that explicates each variable extensively, the methodology behind picture selection, and the rationale for the specific VR content used could mitigate ambiguity and facilitate more nuanced secondary analyses.
- *Standardization and Metadata:* Aligning the dataset with widely recognized metadata standards would bolster its interoperability with other datasets, thereby enhancing its reusability. Adopting

standards such as the Dublin Core schema for metadata can make the dataset more accessible and easier to integrate with existing databases, enabling broader comparative studies.

- *Open Licensing:* Clearly specifying the licensing terms under which the dataset is released can remove barriers to use. Adopting open licenses, when possible, encourages wider dissemination and reuse of the data, provided that ethical and privacy considerations are meticulously observed.
- *Long-term Accessibility*: Ensuring the dataset's accessibility over time is crucial. Depositing the data in a reputable, subject-specific repository can safeguard against data loss and maintain accessibility for future researchers.
- *Expand Data Context:* Incorporating qualitative feedback from participants or additional context about the VR environments could offer deeper insights into the variability in hazard recognition performance. This qualitative dimension could illuminate how different factors influence the efficacy of VR training, providing a richer dataset for analysis.

In summary, to enhance the reusability of the dataset from the study a targeted plan will be executed, focusing on comprehensive documentation, standardization of metadata, open licensing, ensuring long-term accessibility, and enriching the dataset with qualitative insights. By creating a detailed data dictionary and adopting the Dublin Core schema, the dataset's clarity and interoperability will improve, facilitating broader comparative studies. Clear open licensing terms will encourage wider use, while depositing the data in a reputable repository ensures its future availability. Additionally, incorporating qualitative feedback will offer deeper insights into the dataset, making it a richer resource for analysis. These steps aim to closely align the dataset with FAIR principles, particularly reusability, ensuring it remains a valuable asset for ongoing and future research in VR and safety training within the construction sector.