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Efficacies of Different Modes of Disseminating Construction Safety Training

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The construction industry continues to be plagued by a high rate of injuries and fatalities. The Occupational Safety and Health Administration requires that employers provide training for their employees on a regular basis to improve safety. Researchers for this study used a pretest-posttest evaluation method to investigate the effectiveness of different forms of construction safety training. The topics include warning lines, preferred fall protection systems, and harness inspection using videos, texts, and slides as training modes. The findings suggest that the training topic affects the training outcome. A more complex training topic like the preferred fall training topic will result in greater change in participants' posttest after the intervention while a simple topic like harness inspection will register minimal change in scores. The preliminary conclusion is that training was effective for all topics and all modes of instruction, but some are more effective.

Key Words: Construction safety, Safety training, Safety training videos, Fall protection, Training assessment

Introduction

The construction industry is hazardous globally, regardless of efforts that have been made by stakeholders in terms of policies, safety research and innovations (Loosemore, & Malouf, 2019). The Occupational Safety and Health Administration (OSHA) only has1850 inspectors for all worksites and so a low percentage of sites get inspected. As such, punishment as deterrent for safety infractions may have little effect on preventing accidents (Taylor, 2015). Education and training have been found to be more effective alternatives for accident prevention (Taylor, 2015).

Ideally, workers trained and educated in OSHA regulations significantly reduce their likelihood of injury. However, challenges exist in communicating the safety rules to the workers. Some challenges are literacy barriers (Loosemore & Andonakis 2007) and ethnic diversity (Brunette, 2005) which are notable given the culturally diverse workforce in the construction industry.

With various modes of disseminating safety training in use, the purpose of this study is to examine the efficacies of some common modes of construction safety training. Specifically, this study examines three different modes: text only, slides with text and graphics, and short videos. To examine the efficacies of each mode, this study was delimited to safety trainings for falls-from-height. The reason for selecting fall-from-height as the focus of the study is that it remains the leading cause of injuries and fatalities in the construction industry in the US accounting for 17% of fatalities in all industries in the US and 37% of fatalities in construction in 2020 (Bureau of Labor Statistics, 2020). Therefore, it is essential to train workers on safe methods of working at heights.

Literature Review

Efforts by constructions stakeholders and government agencies towards improving safety on construction sites have only yielded marginal improvements (Kaskutas, Dale, Lipscomb, & Evanoff, 2013). Effective training is essential to improving this situation and workers must be equipped with the technical skills and knowledge that will help them in performing their jobs in a safe and healthy manner (Goldenhar, Moran, & Colligan, 2001).

Construction Safety Training

Different training techniques have been developed over time to help increase worker safety awareness and improve overall safety performance in the construction sites. To improve safety performance, employers invest in developing safety training programs. Despite large investments in training, there is still a gap in workers' ability to recognize hazards (Albert, Hallowell, & Kleiner, 2014). There are several reasons for this, among them are faulty training delivery, methods, and materials (Wilkins, 2011). Additionally, language barriers, poor worker attitudes, and unqualified trainers present problems in effective training (Wang, Goodrum, Haas, & Glover, 2008). Nevertheless, training is still as important as ever to improve the poor safety performance of the construction workers.

Construction safety trainers need to focus on knowledge transfer to ensure a depth of learning from the training that is then practiced in the field (Blume, Ford, Baldwin, & Huang, 2009). Traditional classroom training is the most common mode of safety training, but its effectiveness is unclear.

Training Methods

Traditional training methods are not always effective for construction workers. Common instructor-led training techniques for adult learners are more fitting for standard classroom settings. To improve on this common pedagogical approach, learner-centric andragogic principles should be integrated into safety training programs (Tixier, Albert, & Hallowell, 2013). The Bureau of Labor Statistics (2020) estimates the median age of construction workers to be 43; the teaching principles usually used to teach much younger university students are applied in construction safety training when training adult learners (Bhandari et al., 2019).

Adult learner theory places the focus on self-directed learning in which the adult learner is in control of his/her own learning (Mitchell & Courtney, 2005) and offers guidance on ways to improve the effectiveness of safety training. Incorporating adult learning theories into health and safety training programs will produce better results and employees are more likely to retain what they learned (Wilkins, 2011). There is a need for safety training built on these principles for effective construction safety training (Fairchild, 2003; Kazis et al., 2007; Lundberg, 2003).

Research Method

For this study, one group pretest-posttest evaluation method was used to study the efficacies of the three different modes of construction safety training: text only in the form of electronic handouts, texts with graphics in the form of slides, and short videos. This one-group pretest-posttest design has been used for decades and is still being used today (Knapp, 2016). The study focused on three specific fall protection related trainings: preferred fall protection (such as guardrails and other basics), warning lines, and harness inspection. Data was collected using the online platform Qualtrics. Training was developed for each topic using all three training modes. Thus, each topic had three surveys giving nine unique surveys in total. The sample consisted of students at different levels and construction professionals. The trainings were connected so that when a participant received the link to one training, they would be redirected to the second training upon completion of the first, and the third upon completion of the second. In this way, each participant completed three total trainings, one of each topic and one of each mode without any duplication in topic or mode.

A total of approximately 500 potential participants were contacted to participate in the training. Each training began with a consent form and then the participant could proceed to take a pretest which was a short quiz on that topic. This was followed by the training intervention and then a posttest. The pretests and posttests were identical and consisted of a total of seven questions. Two of the questions were questions to test "base knowledge" that served as a sort of control. They were asked before and after the intervention and were generally related to the topic but were not covered in the trainings. These served as a check on the results as these should have remained stable since they were not covered. The remaining five questions were directly covered in the training material. Scores were on a 0-5 scale. The pretest and posttest scores were considered along with the change in score for analyses. Data were organized then analyzed using SPSS for descriptive analysis to summarize the data. Paired sample t-tests, and Analysis of Variance test (ANOVA) were used to compare means.

Safety Training Materials

The videos for all three topics were made in collaboration with the Gaylord College of Journalism and mass communication at The University of Oklahoma. All three videos had musical backdrops with narration and subtitles to keep the viewers fully engaged.

Screenshots from the videos were used to make slides that delivered relevant information as seen in the videos. Screenshots were taken at key moments in the video where an important information was being delivered. It was also imperative that the slides had the information needed to answer the pretest and posttest quizzes. In other words, the slides conveyed as much as possible the same amount of information that was shown in the videos, each one having between eight and 10 slides.

Texts in the form of a single page pdf with topical information and a single graphic were used for each training topic. The graphic is a screenshot of a frame from the corresponding video topic. They were designed to be like Toolbox Talks commonly used in the construction industry. The content of the text was a near transcription of the video to keep the information consistent.

Results

A total of 305 responses were received with 40 having missing data points which were discarded. The total number of complete responses therefore was 265. Among the responses included for analyses, most were students, 64 (24%) sophomores, 104 (39%) juniors, 22 (8%) seniors, 31(12%) graduate students, and 44 (17%) working professionals.

While there were 265 responses, the total number of unique participants was less since many completed more than one training and others completed fewer than three. Since the responses were anonymous the number of unique participants had to be estimated. The warning lines training was the first in each series of linked trainings sent so the number that completed this, a total of 115, was estimated as the number of unique participants. A breakout is shown in Table 1.

Table 1

Number of participants that completed each training

Training Topics	Video	Slides	Text
Warning Lines	31	34	50
Preferred Fall Protection	24	30	23
Harness Inspection	28	23	22

A total of 26 participants, representing only 9.8% of the total sample, had a reduction in score from pretest to posttest – a negative score change. This reduction in score from before to after the training could be due to respondents guessing the answers to the questions without relying on the contents of the training. Figure 1 shows frequency of pretest and posttest scores along with the frequency of score changes on the portion of the tests that measured knowledge related to information directly covered in the intervention. The chart shows the relatively even distribution of scores in the pretests and how the posttest scores are skewed to higher scores. There was no score change for 66 respondents representing 24.9% of the total sample. There was positive score change in 173 respondents representing 65.3% of the total sample.

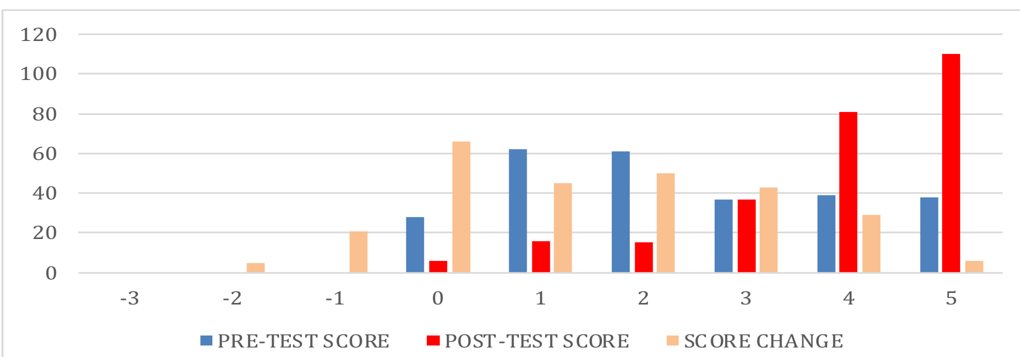

Figure 1: Comparison of score changes between Pretest and Posttest

To get a sense of whether there was large scale random guessing and to have a small set of control data, the scores on the two base knowledge questions (information not covered in the interventions) were analyzed in the same way using frequencies. Only three respondents had a drop in score of two points meaning that they got them both right the in the pretest and both wrong in the posttest. Conversely, there were only eight that got them both wrong then both right for a score change of positive two. These 11 responses may have been a result of random guessing but was a very small portion, 4.2%, of the sample. The majority of respondents scored the same on the base knowledge questions before and after the interventions which indicates two things. It indicates that respondents were likely reading the questions and answering them rather than giving a response set. Additionally, the minimal change from pretest to posttest indicates that the intervention had no effect on these questions which was expected as the information was not covered in the trainings. Figure 2 shows the number of participants associated with each possible change in the base score (between -2 and 2).

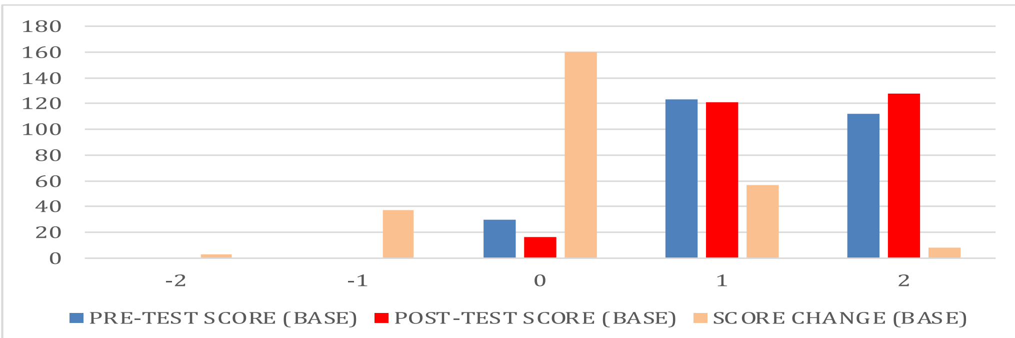

Figure 2: Comparison of base score changes

The first set of comparative statistical analyses done was to compare means of the score changes on the questions relevant to the interventions across participants, grouping them by student level, mode of instruction, and topic. The results showed there was no statistically significant difference in mean score change based on student level at the 0.05 confidence level [$F(4,260) = 1.974$, $p = 0.099$] meaning that the training intervention was equally effective for all participants, regardless of background. A summary of the results is in Table 2 below.

Table 2

Mean score change across modes of training, all topics

Topics	N	Mean (Std. Dev.)
Text/Toolbox Talk	95	1.40 (1.678)
Video	83	1.48 (1.603)
Slides	87	1.53 (1.669)

There was also no statistically significant difference in mean score change [$F(2,262) = 0.142$, $p=0.868$] based on training mode, meaning that all modes of training (videos, slides, and text) were equally effective in enabling the participants to improve their scores. However, there was a statistically significant difference in the mean score change based on training topics [$F(2,262) = 23.153$, $p < 0.001$]. This shows the training topic was a significant factor in the effectiveness of the training. The mean score change for Preferred Fall Protection ($M = 2.17$, $SD = 1.795$) was statistically higher than the mean score changes for Warning Lines ($M = 1.61$, $SD = 1.508$), and the mean score change for Warning Lines was statistically higher than the mean score changes for Harness Inspection ($M = 0.51$, $SD = 1.203$) as seen below in Table 3.

Table 3

Mean score change across topics, all modes of training

Topics	N	Mean (Std. Dev.)
Harness Inspection	73	0.51 (1.203)
Warning Lines	115	1.61 (1.508)
Preferred Fall Protection	77	2.17 (1.795)

The next set of statistical analyses were also mean comparisons, but with pairs of variables rather than larger groups. These were done to ensure that the posttest scores were indeed statistically different from the pretest scores. Previously, only the mean score changes had been compared from one topic or mode to another. In this set of analyses, the pretest and posttest scores on the same topic were compared. Three paired sample t-tests were completed to compare the mean pretest and posttest scores separated by instructional mode and by training topic. The results show that the mean posttest scores were statistically higher than the mean pretest scores on all modes and topics. The results are shown in Table 4 below.

Table 4

Comparing pretest and posttest based on mode (all topics) and topic (all modes)

Mode	N	Pretest scores mean	Posttest scores mean	Score change
		By Mode, All Topics		
Text	95	2.37	3.77	1.40*
Video	83	2.51	4.00	1.49*
Slides	87	2.39	3.92	1.53*
		By Topic, All Modes		
Harness	73	3.96	4.47	0.51*
Warning Line	115	2.03	3.64	1.61*
Preferred Fall	77	1.53	3.71	2.18*
* Significant at $p < 0.001$				

The third and final set of analyses was also mean comparisons with pairs of variables rather than larger groups. But in this case, nine paired sample t-tests were completed to compare mean pretest and posttest scores based on topics across each mode. The results show that when the training mode is slides and the topic is Harness Inspection, there is no statistically significant difference between pretest and posttest score. However, when the same mode is used with either Preferred Fall or Warning Lines training topics, there is a statistically significant difference between pretest and posttest scores. The results further reveal that when the training mode is text and the topic is Harness Inspection, there is no statistically significant difference between pretest and posttest scores. But when the training topics are either Preferred Fall or Warning Lines, there is a statistically significant difference in the pretest and posttest scores even with the same mode of text. Finally, the results show that when video is the mode of training used for any of the three training topics, there is a statistically significant difference in pretest and posttest scores. The posttest score being the higher in all instances, details are in Table 5.

Table 5

Comparing pretest and posttest based on topics (Slides)

Topic	N	Pretest scores	Posttest scores	Score Change
Slides				
Harness	23	3.96	4.26	0.30
Warning Lines	34	2.26	3.79	1.53*
Preferred Fall	30	1.40	3.87	2.47*
Text				
Harness	21	4.14	4.36	0.22
Warning Lines	50	1.98	3.54	1.56*
Preferred Fall	23	1.52	3.70	2.18*
Video				
Harness	28	3.82	4.71	0.89**
Warning Line	31	1.87	3.65	1.78*
Preferred Fall	24	1.79	3.63	1.84*

* Significant at $p < 0.001$, ** Significant at $p<0.01$

Discussion

In Figure 1, the posttest scores are skewed to the right towards the high values which sets the tone for our analyses. This, even before any statistical analyses, suggests the intervention might be responsible for improvement in the scores of the trainees. Further statistical analyses show a connection between the instructional training topics and training modes, with improvement in scores.

The results from data analyses indicate that the training topic is crucial to the effectiveness of training delivered. All the analyses done seem to confirm this. The result of the analyses shows a trend that is consistent throughout, which identifies preferred Fall Training topic as being the topic with the most impact on training outcome, followed by Warning Lines, with Harness having the least effect on training outcome. The mean score changes when comparing means or difference in pretest and posttest scores of any combination of variables was always highest with preferred Fall Protection training topic.

The reason behind Preferred Fall being more impactful is fairly evident. The participants generally had very little previous knowledge, which is why they had low scores on the pretest (a mean score of 1.53 out of a possible 5 points), leaving room for improvement on the posttest. After the intervention there was knowledge gain leading to a significant score change across training modes and this topic. The Warning Lines topic follows closely behind in terms of score change for the same reason and was effective across all training modes. It is likely that there is a lower score change in Warning Lines topic compared to Preferred Fall topics because Warning Line topics are slightly less complex. The Harness Inspection topic has the least score change and this may be because it is the least complex topic. Most of the questions related to Harness Inspection only require a bit of common sense to answer.

There was a difference in score changes depending on whether the mode of training was text similar to a toolbox talk, slides, or video (1.40, 1.49, and 1.53, respectively). However, when looked at in aggregate, none of the differences in means was found to be statistically significant and so we cannot reliably conclude that one is more effective than the other. We can only conclude that each training topic has some positive effect on test scores. When all combined together (all modes and all topics), the total average score was improved from a pretest score of 2.42 to a posttest score of 3.89 which is a 61% increase.

Conclusion

The researchers used this study to set the tone for a more elaborate future study whose results can be widely adopted in the construction industry. The findings show some encouraging results and shed light on some options for training that is tailor-made for the construction industry.

Having seen the effectiveness of these training methods, we can say that this is a very cheap way to conduct safety trainings. With fewer resources, organizations or companies can deliver highly effective safety training that improves safety awareness of their workers. The cost and time of regular in-person training is drastically reduced and more options become available for regular interval training. The results of this study show significant improvement in scores even when the participants are not under any kind of pressure that made them to be fully invested in the training they received. In other words, some of them could not have been putting in their best effort, and yet we had significantly improved scores. Even better results are expected for mandatory training where workers apply what they have learned on the jobsites. It is particularly noteworthy as an alternative to traditional classroom training which is not always effective when it comes to the category of learners that make up the construction workforce.

Finally, there is the need to review how trainings are being delivered in the construction industry. A lot of effort is being put into improving construction safety statistics and yet the situation is not improving. Everyone agrees that training helps to improve safety, but we keep hearing of incidents every day. It shows the old ways are no longer working, new training methods are needed to face the current safety challenges in the construction industry. There is the need for a concerted effort by key players and stakeholders in the industry to explore and invest in new ways of training that can help improve the situation. We know smaller companies have the worst safety records; it is our recommendation therefore that the bigger companies not only work to protect themselves but also are mandated by law to invest in research on more effective training methods that makes learning and application of what is learned useful.

Limitations

There are a few limitations with this study. The 265 responses consisted of approximately 115 unique participants. While this seems to be an acceptable sample size, the fact that they were spread across several different interventions limited the size of each intervention group. A larger pool of participants would add more validity to these results. Secondly, the time gap allowed between the intervention and the posttest was not ideal. To capture the effect of the intervention, a longer time gap should be allowed between the intervention and the posttest.

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