ISSN 1392-3730 / eISSN 1822-3605

VILNIUS TECH
Vilnius Gediminas Technical University

JOURNAL of CIVIL ENGINEERING and MANAGEMENT

2025
Volume 31
Issue 3
Pages 206–223
https://doi.org/10.3846/jcem.2025.23083

# A FRAMEWORK FOR EFFECTIVE CONSTRUCTION WORKERS SAFETY TRAINING USING FLIPPED LEARNING

Abdul REHMAN[1], Muhammad Usman HASSAN[1✉], Muhammad Umer ZUBAIR[2], Taha AZIZ[1], Khursheed AHMED[1]

[1] *School of Civil & Environmental Engineering, NUST Institute of Civil Engineering, National University of Sciences & Technology, Islamabad, Pakistan*
[2] *Department of Civil and Environmental Engineering, College of Engineering, King Faisal University, Al Ahsa, Saudi Arabia*

**Article History:**
- received 24 February 2024
- accepted 18 September 2024

**Abstract.** Effective safety training plays an important part in safety management on construction sites. Construction workers safety and safety training education remain to be the main issues in the construction industry, as current practices rely on traditional methods. These methods often lack classroom interaction, hindering active worker engagement and fail to accommodate diverse learning paces and styles. To enhance safety awareness among workers, there is a need for a more effective system for safety training programs within the construction industry. Therefore, this study aims to comprehensively analyse an experimental intervention using flipped learning to reduce costs and enhance learning outcomes in construction safety training. Flipped learning transforms traditional classroom learning by introducing students to web-based videos, presentations, and readings before class, freeing up in-class time for discussions and problem-solving. An intervention study was carried out to confirm the effectiveness of flipped learning approach within the construction industry. In this study, 40 personnel from a leading construction firm in Pakistan underwent safety training, with 20 following the traditional method and the remaining 20 following the proposed flipped model. The final quiz revealed a score increase from 27.9 to 31.5 in flipped learning, indicating a 12.90% increase. Based on these findings, it is suggested that adopting the flipped learning approach leads to better learning outcomes within the construction industry, as workers can pause, rewind, and replay the lectures at their leisure. This not only makes safety training more accessible but also enhances on-site safety in a cost-effective manner.

**Keywords:** flipped learning, construction safety, training and education.

✉Corresponding author. E-mail: *usman.hassan@nice.nust.edu.pk*

## 1. Introduction

In construction industry, a worker is three times more prone to fatalities and two times more prone to injuries compared to other industries (Sousa & Teixeira, 2004), owing to complex nature of construction works (Perttula et al., 2006; Pinto et al., 2011). One of the core areas where the construction industry needs improvement is in the field of health and safety (Patton, 2009), because despite representing only 7% of the global workforce, the construction industry accounts for 30%–40% of worksite fatalities. These higher accidents rates have adversely affected the construction industry resulting in serious project delays and cost overruns (Le et al., 2014). Numerous studies and research efforts have been directed towards adopting safety practices and policy making in construction. However, these efforts have not significantly reduced accident rates. According to Occupational Safety and Health Administration [OSHA] (2023), the United States recorded 5,486 fatal work injuries in 2022, marking a 15.15% increase from the 4,764 reported in 2020 with workers in construction having the second most fatalities compared to other occupations. This translates to 3.7 fatalities per 100,000 workers, up from 3.4 per 100,000 in 2020. This fatal injury rate is the highest reported from 2013 to 2022 (Bureau of Labor Statistics [BLS], 2022). The data pertaining to safety incidents in developing countries is worse and highly unreliable (Lingard, 2013). Construction workers in developed countries face a three to four times higher probability of experiencing a fatal accident compared to workers in other industries. However, the situation is even more dire in less developed countries, where construction workers face a risk three to six times greater (International Labour Organization [ILO], 2018).

These incidents not only impact profit margins but also threaten the survival of construction companies (Zou & Sunindijo, 2015). Construction employers invest millions of dollars in training their workforce on safety issues including hazard recognition, hazard management, and adoption of effective injury prevention methods. The incorporation of safety training has revolutionized the culture of precaution adoption and hazard identification throughout the construction industry (Ahn et al., 2020; Dong et al., 2004; Gillen et al., 2002; Varonen & Mattila, 2000). A proactive and collective method to recognise and eliminate hazards prior to any casualty at a site is known as the health and safety management system. Formulating hazard-specific programs to protect workers is more effective due to adoption and implementation of safety and health management systems (OSHA, 2023). Despite such efforts and investments in safety training, construction workers often lack essential safety knowledge and skills. In fact, Haslam et al. (2005) found that over 70% of construction injuries are linked to inadequate safety knowledge or skill. The advantages of safety tutelage are welcomed within the construction community extensively; and the importance of safety education has been highlighted in years of research carried out in construction context (Haslam et al., 2005). The construction community widely acknowledges the benefits of safety education, yet current training practices have not yielded the anticipated benefits due to inefficient training practices (Jeelani et al., 2017b).

Education and skill enhancement of masses working at a construction site is a vital issue in safety management (Hosseinian & Torghabeh, 2012). To ensure a safe and healthy environment in a construction workspace, it is essential to adopt advanced educational practices in safety perspectives. However, current learning methods, which are lecturer-centred, have failed to motivate and engage learners (Pham et al., 2018). Current research trends demonstrate that a large part of safety hazards remain unidentified at construction sites (Albert et al., 2014; Jeelani et al., 2017b; Mihić, 2020). Traditional hazard recognition methods and training programs have failed in hazards recognition (Carter & Smith, 2006). According to research conducted by Haslam et al. (2005), workers despite having safety training (through traditional process) fail to comply with standards and identify hazards.

Health and safety training is an essential element for the success of construction projects (Guo et al., 2017). Health and safety training ensures a person is informed about the hazards existing at construction workplaces, and incorporates a relevant perception-reaction sense into personnel regarding safety hazards (Seppala, 1995). There are a number of ways in which H&S training can be implemented, some such applications are: online training programs, easily accessible safety training applications, Building Information Modelling (BIMCHAIN, 2018) accident simulations, immersive Virtual Reality (VR), Augmented Reality (AR), Mixed Reality (MR) and game engines techniques, etc. (Li et al., 2012, 2015; Wang et al., 2014). Owing to technological advancement, "The Flipped Classroom" model has emerged as a revolutionary approach (Albert & Beatty, 2014). This model extends beyond technological applications, such as video lessons, to foster an engaging and interactive classroom environment (Bergmann & Sams, 2012). In this approach, learners can access the relevant material in an outdoor setting prior to the lectures. This pre-class preparation enables them to get familiar with the topic, allowing for deeper understanding during the class. Class time is then strategically used for more complex tasks such as collaborative discussions, peer interaction sessions, problem-solving exercises, in-depth experiments, or simulations (Hao, 2016). Therefore, there is a need to adopt technologies such as online safety training, training workshops and virtual reality for safety education to provide a better physical or virtual experience to the attendee, resulting in better occupational safety behaviour.

The purpose of this research is to develop a simple learning framework that incorporates safety norms and practices at construction sites using this modern pedagogical approach. There are three main objectives of this study: 1) To determine inefficiencies in construction safety training education; 2) To develop a framework for construction safety training tool based on flipped learning and 3) To evaluate the performance of the developed flipped learning safety training tool. Section 2 of this article deals with the literature analysis of flipped classroom system along with identification of the inefficiencies associated with safety education. Section 3 deals with the proposed flipped model as an adoption framework in construction safety training practices. Section 4 deals with the aspect of the behaviour of this framework. As such the results covered in terms of a comparative influential analysis will also be made part of section 4 of this article. Section 5 will include the conclusion and recommendations for a future work on the proposed model.

## 2. Literature review

### 2.1. Construction safety and its training

Numerous studies support the critical role of safety training in enhancing workplace safety behaviors and reducing hazards (Ahn et al., 2020; Casey et al., 2021; Varonen & Mattila, 2000). Safety and health management systems are proactive and collaborative, aiming to find and fix workplace hazards before they result in injuries or illnesses. The benefits of implementing safety and health management systems include protecting workers, saving money, and making all your hazard-specific programs more effective (OSHA, 2023). Unrecognized or unmanaged hazards pose significant, often unforeseen risks to workers, potentially leading to catastrophic incidents. Recent studies reveal that many safety hazards in construction remain unrecognized. Despite various safety and hazard-recognition training programs implemented by employers, the anticipated improvements have not been achieved, largely due to ineffective training practices (Jeelani et al., 2017a). Traditional hazard recognition methods and training programs have failed to address poor hazard recognition problems (Carter & Smith, 2006). In fact, research has demonstrated workers often fail to recognize hazards even with substantial safety training due to having adopted traditional hazard recognition methods (Ojha et al., 2020; Perlman et al., 2014). Safety training is fundamental to enhance safety knowledge and skills of frontline workers.

Current health and safety training methods such as induction training sessions such as lectures or presentations, on-site training exercises, video instructions and mock training exercises suffer from being repetitive, specific, poorly engaging. They are primarily developed for complying with legislation rather than for acquiring safety skills. Similar issues can be encountered with assessment methods (Jurf et al., 2012). Construction workers are experiential learners who tend to lose interest in memorizing safety regulations, lack continuous engagement with Traditional Techniques, and prefer active learning approaches (Harfield et al., 2007). Traditionally, safety training has relied on various methods, such as safety manuals, videos, in-person or online lectures, and drills. However, many of these methods suffer from significant pedagogical limitations (Feng et al., 2018). Saleh and Pendley (2012) observed that current safety education systems have limited effectiveness. Workers active involvement in the discussions makes safety training more effective with feedback playing an important role in improved safety performance. Burke et al. (2011) argued that engaging safety training methods that facilitate dialogue, feedback, and action can result in higher learning gains. Namian et al. (2016) found that high-engagement training methods that facilitate dialogue, feedback, and action result in higher learning gains. User engagement is crucial for the success of training programs. In traditional training methods, engagement is often lacking, and trainees' attention may be poor (Gao et al., 2019). Additionally. traditional training has been considered less effective for the construction workforce due to poor knowledge transfer (Cherrett et al., 2009; Feng et al., 2018; Li et al., 2012). However, computer-aided techniques have the potential to enhance engagement levels and facilitate better knowledge transfer (Ahn et al., 2020; Gao et al., 2019).

It has become necessary for research efforts to focus on developing engaging and learner-centric training programs. Recent developments focus on interactive solutions to enhance training (Ahn et al., 2020; Albert et al., 2014; Feng et al., 2018; Li et al., 2012). Wilkins (2011) recommends replacing current training methods with more engaging methods to achieve desirable safety outcomes. Therefore, there is a need for more research in construction to understand the relationship between training methods and outcomes like hazard recognition and safety risk perception.

## 2.2. Flipped learning

Digital technologies have spread rapidly worldwide with flipped learning emerging as a novel teaching and learning method for higher education institutions (Steed, 2012). According to the Bergmann and Sams (2014), Flipped Learning is a pedagogical approach that transfers direct instruction from group space to individual space. The group space is transformed into a dynamic, interactive learning environment where the educator guides students in a creative matter. Flipped classroom model of instruction started with secondary science teachers Jonathan Bergmann and Aaron Sams, who decided to start recording their live lectures for absent students (Bergmann & Sams, 2012). The popularity of the instructional videos grew proportionately, as all students seem to appreciate being able to review material at home and engage in interactive activities in the classrooms (Birgili et al., 2021; Conley et al., 2017; Lo & Hew, 2019).

In flipped learning, activities traditionally conducted in the classroom (e.g., content presentation) become home activities, and activities usually considered homework are performed in class (Bergmann & Sams, 2012; Sohrabi & Iraj, 2016). This method has created a virtual space for the provision of online video lessons while also encouraging active student participation in lectures (Fidalgo-Blanco et al., 2017). In a systematic review conducted by Karabulut-Ilgu et al. (2018) on flipped learning, several benefits were identified, including (1) increased flexibility, (2) enhanced interaction, (3) improved professional skills, and (4) greater student engagement with flexibility being one of the most cited advantages of flipped learning (Doo, 2021; Mok, 2014). As flipped classrooms use online materials to deliver content before a class (He et al., 2016). Students are theoretically able to learn at their own convenience (McDonald & Smith, 2013; Wang & Zhu, 2019). Flipped model allows students to study at their own pace, which appeals especially to students with busy schedule (Bergmann & Sams, 2012). Similarly, González-Gómez et al. (2016) reported that students can pause, rewind, and review lectures using technology that is typically available in the flipped model. In a flipped classroom approach, students are better able to achieve higher learning outcomes. In a flipped classroom, more time is available for activities that promote active, constructive, and interactive engagement, in comparison to traditional teaching which often focuses on passive lecture-based engagement (van Alten et al., 2019). Interaction between teachers and students in the classroom becomes more frequent and students have more opportunities to develop higher-order thinking (Lai & Hwang, 2016; Wang & Zhu, 2019). Several researchers found that students came to class better prepared (Birgili et al., 2021; Jungić et al., 2015; Mok, 2014) and form more effective study habits compared to those in traditional setting (Birgili et al., 2021).

Flipped learning in tertiary education aims to increase student engagement, enhance the learning experience, and improve student outcomes (Chiang & Chen, 2017; Day, 2018; Karabulut-Ilgu et al., 2018). Lo and Hew (2019) found out that flipped learning led to increased achievement when implemented in education. The authors classified the reason into three categories (1) preclass learning, (2) preclass and in-class connection, and (3) in-class learning. Through preclass, flipped classroom allows for self-paced learning, with students watching instructional videos or studying online resources at their own speed before class (McDonald & Smith, 2013; Wang & Zhu, 2019). The digital video environment of flipped teaching is more convenient and provides more accessible content resources for learning (Alpaslan et al., 2015; Hao & Lee, 2016). Al-Zahrani (2015) argued that these tools should be carefully prepared to promote a higher level of student engagement and satisfaction, while Ryan and Reid (2016) concluded that the length of videos should match the students' attention span to ensure more effective engagement. For the preclass and in-class connection, preclass learning supports students in preparing for class activities, facilitating their active engagement during class. Moreover, the repetition of course materials in the flipped classroom enhances learning compared to traditional lecture classes (Birgili et al., 2021; Jungić et al., 2015; Mok, 2014; Wang & Zhu, 2019). In the classroom, the incorporation of more problem-solving activities and enhanced interactions with instructors led to increased student achievement. Gilboy et al. (2015) stated that in flipped model, student centered activities in class increases student-instructor interaction. Van den Bergh et al. (2014) demonstrated that teachers in active learning classrooms (i.e., a classroom in which students engage in learning activities instead of passively listening) provide essential feedback, guiding students' learning processes. Thus, in a flipped classroom, there may be more room for students to receive effective feedback and instructions from their instructors. Hew and Lo (2018), Lo et al. (2017) found that using quizzes at the start of classes in a flipped classroom leads to higher learning outcomes.

Flipped learning is a learner-centered approach where the educator actively considers the best way to use class time, so that learning and retention are maximized (Furse & Ziegenfuss, 2020; Nederveld & Berge, 2015). However, misconceptions about flipped learning still exist, and little literature exists supporting its implementation in the workplace. Flipped learning extends beyond merely watching lecture videos outside of the classroom and completing homework during class time.

## 2.3. Training using flipped learning

Currently, training programs in the construction industry utilize traditional methods of delivery, primarily lecture-based formats such as classroom sessions and handouts. Although offering safety training is widely practiced in the industry, the effectiveness of these programs has been questioned in a large body of recent research. For example, several researchers have questioned the effectiveness of the widely adopted lecture-based format of training. Recent studies have found traditional safety training methods to be highly ineffective because, for any given work period, researchers found that workers were only able to recognize and communicate less than half of all hazards in their work environment (Alsharef et al., 2020; Bhandari et al., 2019; Jeelani et al., 2017b).

Outside of construction, flipped approaches are being applied for training in corporate settings. The use of blended (synchronous and asynchronous activities) and flipped (inside and outside of the classroom activities) learning environments, combined with technologies such as Learning Management Systems (LMSs), video repositories, and mobile devices, create active learning spaces where employees can practice skills before applying them at work (Conley et al., 2017). Gathering feedback from sponsors and stakeholders addresses potential concerns and discusses necessary conditions for adopting the flipped training model. Informing stakeholders early about benefits such as reduced time away from work, improved retention, and faster application to enhance learning transfer can translate into significant organizational benefits (Conley et al., 2017). Flipping the corporate classroom has benefits for both the trainers and learners. For learners, it offers complete control over learning content consumption, using class time for practice under expert supervision, and reducing travel and work absence. For trainers, it includes emphasizing practice, leading to better coaching opportunities, learning transfer, and training ROI (Conley et al., 2017). In a corporate setting, additional benefits are possible such as reduced travel costs, reduced opportunity costs and increased practice time. Both employees and managers may see improved training time returns, solving real problems in the training environment (Lee & Recker, 2013). All trainees get more time for application-related questions, with demonstrations and tactile activities being the focus (Pierce, 2013).

Vayuvegula (2014) describes a flipped model for software training where employees first complete e-learning and then attend a virtual session for practical queries, enhancing applicability. Similarly, in the hair care industry, a flipped approach is considered for product training, involving pre-workshop instructional videos for more hands-on practice (Bergmann & Sams, 2014). The Professional Convention Management Association is exploring flipped models for conferences, encouraging pre-session video previews for more engaged and informative sessions (Bergmann & Sams, 2014). Freeing up class time for real-world application of content means trainees can partake in on-the job, skills-based training by reducing the need for additional sessions and increasing training efficacy and workforce productivity (Majumdar, 2013). Many learning content, such as prerecorded lectures, are inexpensive to produce, and trainers can receive real-time evaluation data and immediate indications of training success (Pierce, 2013).

Therefore, flipped learning could be beneficial in various aspects, including construction education safety training, where traditional methods haven't resulted in proper adherence to safety standards. This innovative approach could make safety training more engaging and effective.

## 2.4. Inefficiencies in construction safety education

It has become necessary for research efforts to focus on developing engaging and learner-centric training programs. Haslam et al. (2005) argued that the use of unengaging training methods can instill negative attitudes among workers to safety issues, which in turn can adversely impact safety performance. To address these issues, recent efforts have focused on developing more engaging and interactive training solutions (Albert et al., 2014; Li et al., 2012). For effective training, employers must adopt training practices that will yield maximum benefits. However, there is a dearth of research in construction that evaluates the relationship between training efforts and objective training outcomes such as hazard recognition and safety risk perception. Wilkins (2011) recommends replacing such unengaging training methods with more engaging methods to achieve desirable safety outcomes. There are few effective interactive methods applied which can objectively engage trainer and trainees and assess their performance during and after training sessions. Inefficiencies mentioned in the literature are shown in Table 1. The relevant databases for literature like *Science Direct*, *Emerald Insight*, *Google scholar* was used to extract the maximum number of inefficiencies in training. Several combinations of different key words like construction safety, training and education, inefficiencies, factors, and terms of similar meanings were used to obtain maximum results.

**Table 1.** Inefficiencies pointed out from literature

| Inefficiencies | Authors |
|---|---|
| Lack of engagement of trainee during training | Burke et al. (2011), Cherrett et al. (2009), Demirkesen and Arditi (2015), Fernando et al. (2008), Forst et al. (2013), Gao et al. (2017), Haslam et al. (2005), Jeelani et al. (2017a, 2017b), Liaw et al. (2012), Namian et al. (2016), Teizer et al. (2013) |
| Lack of effectiveness in training | Bunch (2007), Burke et al. (2011), Demirkesen and Arditi (2015), Fernando et al. (2008), Forst et al. (2013), Gao et al. (2017), Han et al. (2008), Haslam et al. (2005), Ismail et al. (2012), Jeelani et al. (2017a, 2017b), Li et al. (2012), Loosemore (1998), Loosemore and Andonakis (2007), Mohamed (1999), Namian et al. (2016), Sokas et al. (2009), Tam and Fung (2012), Teizer et al. (2013), Thuy Pham and Swierczek (2006), Wong et al. (2015), Xu et al. (2019), Zin and Ismail (2012) |
| Lack of interest in training or training is boring | Choudhry and Fang (2008), Demirkesen and Arditi (2015), Furnham (2012), Rowland et al. (2006) |
| Training cost is high | Forst et al. (2013), Furnham (2012), Kelloway et al. (2011), Loosemore and Andonakis (2007), Mohamed (1999), Wang et al. (2010), Wong et al. (2015), Zou and Sunindijo (2015) |
| Trainer and trainee spend more time in training | Kelloway et al. (2011), Ruttenberg and Lazo (2004), Wang et al. (2010), Wong et al. (2015) |
| No timely feedback about training | Burke et al. (2011), Cherrett et al. (2009), Demirkesen and Arditi (2015), Fernando et al. (2008), Furnham (2012), Ismail et al. (2012), Jeelani et al. (2017a, 2017b), Li et al. (2012), Loosemore (1998), Namian et al. (2016), Teizer et al. (2013) |
| Training content not well designed according to the need of trainee | Bunch (2007), Choudhry and Fang (2008), Demirkesen and Arditi (2015), Furnham (2012), Haslam et al. (2005), Namian et al. (2016), Tam and Fung (2012) |
| Unqualified training staff | Bunch (2007), Demirkesen and Arditi (2015), Namian et al. (2016) |
| Lack of awareness about the importance of safety training | Ai Lin Teo et al. (2005), Bottani et al. (2009), Choudhry and Fang (2008), Demirkesen and Arditi (2015), Forst et al. (2013), Haslam et al. (2005), Li et al. (2012), Loosemore (1998), Ruttenberg and Lazo (2004), Tam et al. (2004), Tam and Fung (2012), Wang et al. (2018), Wong et al. (2015), Xu et al. (2019), Zin and Ismail (2012) |
| Lack of management during safety training | Demirkesen and Arditi (2015), Fernando et al. (2008), Ismail et al. (2012), Namian et al. (2016), Tam et al. (2004) |
| No incentive for timely completion of training | Ismail et al. (2012), Namian et al. (2016) |
| Communication gap between trainers and trainee | Bottani et al. (2009), Han et al. (2008), Ismail et al. (2012), Loosemore and Andonakis (2007), Tam and Fung (2012) |
| Lack of innovations in training | Demirkesen and Arditi (2015), Furnham (2012), Jeelani et al. (2017a, 2017b), Tam et al. (2004) |
| Lack of immersive and realistic environments | Demirkesen and Arditi (2015), Gao et al. (2017), Jeelani et al. (2017a, 2017b), Le et al. (2014), Li et al. (2012), Liaw et al. (2012), Wang et al. (2018) |
| Lack of evaluation in safety training | Han et al. (2008), Liaw et al. (2012), Rowland et al. (2006) |
| Lack of motivation about safety training | Han et al. (2008), Liaw et al. (2012) |
| Improper training delivery method | Burke et al. (2011), Haslam et al. (2005), Jeelani et al. (2017a, 2017b), Namian et al. (2016) |
| Lack of interest for investment in safety training | Furnham (2012), Namian et al. (2016) |

**Table 2.** Qualitative analysis on inefficiencies identified

| Rank | Inefficiencies | Literature Score | Normalized Score | Cumulative Score |
|---|---|---|---|---|
| 1 | Lack of effectiveness in training | 15.789 | 0.235 | 0.353 |
| 2 | Lack of engagement of trainee during training | 7.895 | 0.118 | 0.118 |
| 2 | No timely feedback about training | 7.895 | 0.118 | 0.580 |
| 3 | Lack of awareness about the importance of safety training | 6.316 | 0.094 | 0.745 |
| 4 | Lack of immersive and realistic environments | 4.605 | 0.069 | 0.914 |
| 5 | Training cost is high | 3.158 | 0.047 | 0.424 |
| 6 | Training content not well designed according to the need of trainee | 2.763 | 0.041 | 0.622 |
| 7 | Trainer and trainee spend more time in training | 2.632 | 0.039 | 0.463 |
| 7 | Improper training delivery method | 2.632 | 0.039 | 0.994 |
| 8 | Communication gap between trainers and trainee | 2.368 | 0.035 | 0.822 |
| 9 | Unqualified training staff | 1.974 | 0.029 | 0.651 |
| 9 | Lack of management during safety training | 1.974 | 0.029 | 0.775 |
| 9 | Lack of evaluation in safety training | 1.974 | 0.029 | 0.943 |
| 10 | Lack of interest in training or training is boring | 1.579 | 0.024 | 0.376 |
| 10 | Lack of innovations in training | 1.579 | 0.024 | 0.845 |
| 11 | No incentive for timely completion of training | 0.789 | 0.012 | 0.786 |
| 11 | Lack of motivation about safety training | 0.789 | 0.012 | 0.955 |
| 12 | Lack of interest for investment in safety training | 0.395 | 0.006 | 1.000 |

**Table 3.** Demographics of respondents

| Experience | No of Questionnaires filled | Percentage |
|---|---|---|
| 0–5 years | 12 | 40% |
| 6–10 years | 10 | 33.33% |
| 11–15 years | 5 | 16.67% |
| 15+ years | 3 | 10% |

**Table 4.** Field survey analysis

| Rank | Inefficiencies | Average Survey Score | Normalized Score |
|---|---|---|---|
| 1 | Companies are not willing to invest in safety training | 4.233 | 0.847 |
| 2 | Lack of awareness about the importance of safety training | 4.067 | 0.813 |
| 3 | Low incentives for successful completion of training | 4.033 | 0.807 |
| 4 | Lack of interest in training or training is boring | 3.933 | 0.787 |
| 5 | Lack of engagement of trainee | 3.867 | 0.773 |
| 5 | Lack of monitoring in safety training by higher management | 3.867 | 0.773 |
| 6 | Trainees are not motivated about safety training | 3.667 | 0.733 |
| 7 | Trainees are not assessed at the end of training | 3.567 | 0.713 |
| 8 | Lack of innovations in training techniques | 3.433 | 0.687 |
| 9 | Improperly designed training content | 3.300 | 0.660 |
| 10 | High cost of training | 3.267 | 0.653 |
| 11 | Lack of effectiveness in training | 3.233 | 0.647 |
| 12 | Communication gap between trainers and trainee | 3.100 | 0.620 |
| 13 | Lack of immersive and realistic environments | 3.000 | 0.600 |
| 14 | Lack of feedback about training | 2.967 | 0.593 |
| 15 | Trainer and trainee spend more time in training | 2.833 | 0.567 |
| 15 | Unqualified training staff | 2.833 | 0.567 |
| 16 | Improper training delivery method | 2.633 | 0.527 |

The Table 1 of inefficiencies was scrutinized and analyzed for their literature score and results obtained are shown in Table 2. The literature score was calculated by assessing the frequency of repetition of identified inefficiencies across 38 papers and assigning an importance score to each inefficiency based on its perceived significance within the specified literature. A preliminary survey was conducted among the professionals working in the field related to the construction industry. The survey questionnaire asked about criticality of the inefficiencies in construction safety training education. A survey form was made on google forms and circulated via links on email and other social media facilities. The survey involved respondents rating the extent of agreement with the identified inefficiencies on a 5-point Likert scale with 1 (*not important*) to 5 (*absolutely critical*). In total 32 responses were recorded. The following Table 3 shows the demographics of the professionals who completed the questionnaire. Analysis of field survey is illustrated in Table 4. The responses for each inefficiency were averaged by calculating their arithmetic mean. After obtaining the field score, the overall scores were calculated. They were added in a proportion of 60 to 40, the former representing field score while the latter being literature score. Table 5 shows the overall ranking of the inefficiencies.

## 3. Methodology

### 3.1. An inverted training framework

Creating an interactive engagement environment is essential for conducting an effective training session. Such an environment not only boosts the interest of trainees but also creates the confidence for adaptation. To achieve such environment a framework has been devised which comprises of three different sectional activities; namely, pre-session, during session and post session. Figure 1 presents the proposed framework.

**Table 5.** Overall ranking of inefficiencies

| Rank | Inefficiencies | Field Score | Literature Score | Overall Score |
|---|---|---|---|---|
| 1 | Lack of awareness about the importance of safety training | 0.813 | 0.094 | 0.526 |
| 2 | Lack of interest for investment in safety training | 0.847 | 0.006 | 0.510 |
| 3 | No incentive for timely completion of training | 0.807 | 0.012 | 0.489 |
| 4 | Lack of interest in training or training is boring | 0.787 | 0.024 | 0.481 |
| 5 | Lack of engagement of trainee during training | 0.773 | 0.118 | 0.511 |
| 6 | Lack of effectiveness in training | 0.647 | 0.235 | 0.482 |
| 7 | Lack of management during safety training | 0.773 | 0.029 | 0.476 |
| 8 | Lack of motivation about safety training | 0.733 | 0.012 | 0.445 |
| 9 | Lack of evaluation in safety training | 0.713 | 0.029 | 0.440 |
| 10 | Lack of innovations in training | 0.687 | 0.024 | 0.421 |
| 11 | Training content not well designed according to the need of trainee | 0.660 | 0.041 | 0.412 |
| 12 | Training cost is high | 0.653 | 0.047 | 0.411 |
| 13 | No timely feedback about training | 0.593 | 0.118 | 0.403 |
| 14 | Lack of immersive and realistic environments | 0.600 | 0.069 | 0.387 |
| 15 | Communication gap between trainers and trainee | 0.620 | 0.035 | 0.386 |
| 16 | Trainer and trainee spend more time in training | 0.567 | 0.039 | 0.356 |
| 17 | Unqualified training staff | 0.567 | 0.029 | 0.352 |
| 18 | Improper training delivery method | 0.527 | 0.039 | 0.331 |

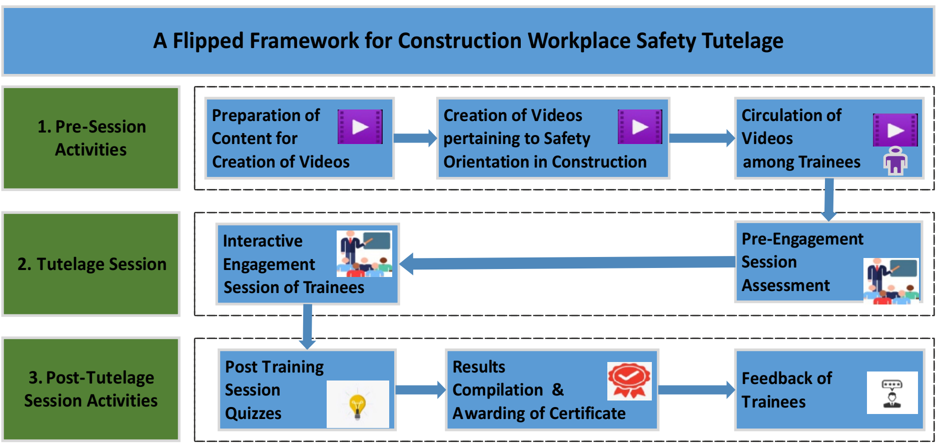


**Figure 1.** Flipped framework for construction safety education

### *3.1.1. Pre-session activities*

This section of the framework deals with the activities related to the pre-interaction session. In this part the trainer aims to create a sense of affiliation with topic by giving pre-learning knowledge. This is basically adopted via circulation of virtual learning resources. This resource could be in form of videos or any other e-learning content. The videos and content creation are dependent upon the trainer skills. The proposed framework deals with creation of pre-session videos as its initial stage. These videos are based on the lectures which are to be provided by the trainer. Its creation starts with conceptualization of the tutelage topic and its aspects of coverage. Then this content is converted to a virtual presentation/recorded lecture which is created by using video creation and editing tools. The video resource is to be created by using any tools pertaining to creation of video lecture. After creation of videos, they are circulated among the trainees. These videos are circulated to get the trainee affiliated with training aspects.

### *3.1.2. Tutelage session*

This section of the framework deals with the interaction session among the trainees and tutor. But before this interactive engagement session, a pre session quiz is held to find the effectiveness of video lecture circulated at initial stage. Following the completion of the quiz, the engagement session commences. In the engagement session a physical cross-questioning and concept clearing session is held among the instructor and trainees. This session also comprises discussion between the instructor and trainees. This discussion ultimately results in conceptualization of the aspect to be covered in the training session. This session is directly related to the topics circulated in the first phase of the framework. Moreover, this phase of the framework is focused on resolving any queries or concerns raised by the trainees.

### *3.1.3. Post session activities*

This section of framework deals with the activities that occur after the tutelage session, primarily focusing on the completion process of the training. In this section, a final quiz is taken and based on the results, trainees are awarded a certificate of completion. Apart from post training quiz and completion certificates, a feedback session is also included in this portion of the framework. This feature of acquiring feedback regarding tutelage framework will help to improve practice in future endeavours. This aspect of the framework contributes to creating a sense of competence in the training aspect.

## 3.2. Evaluation of the proposed framework

The evaluation of the framework involves a comparative analysis with traditional training practices. The processes as shown in Figure 2 were followed to achieve the evaluation prospect of the developed framework for inverted learning process. A subset of participants was chosen, and they underwent tutoring from two different perspectives. Subsequently, their performance was analysed in relation to the obtained results.

### *3.2.1. Data collection*

A total of 40 personnel from a leading construction firm in Pakistan underwent construction safety training. Many flipped intervention studies have utilized a sample ranging 24–57 (Al-Zahrani, 2015; Khayat et al., 2021; Lai & Hwang, 2016; Sohrabi & Iraj, 2016). Therefore, sample size of 40 was deemed sufficient. 20 trainees followed the traditional training method, while remaining 20 were tutored using the proposed flipped model. The subsequent results were compared. In the traditional method, 20 professionals were instructed on various safety aspects within a physical setup. The overall demographic makeup included 32 males and 8 females, all employees of the construction firm with a background in civil engineering, as depicted in Figure 3.

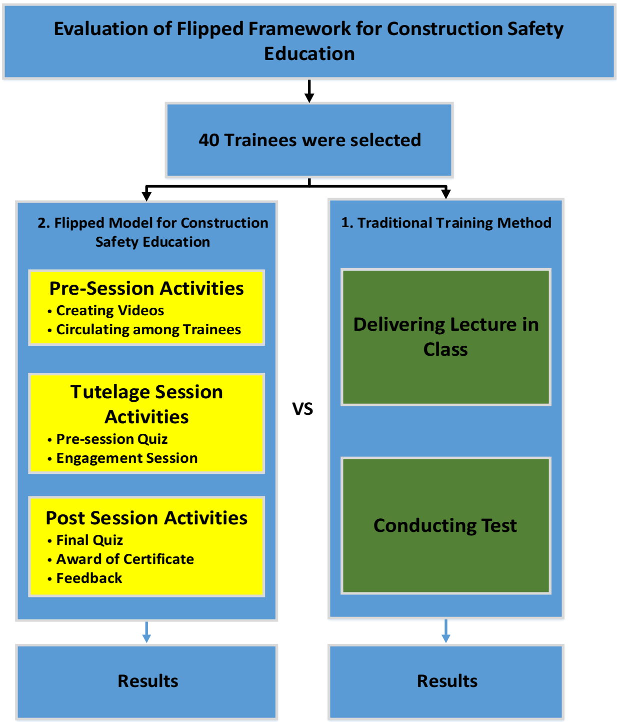


**Figure 2.** Evaluation methodology

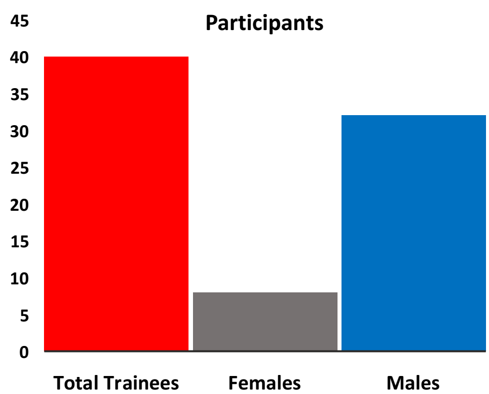


**Figure 3.** Bifurcation chart of trainees in terms of gender

The participants were evenly divided into two groups for different teaching models. Specifically, 20 individuals underwent traditional tutelage, with 16 males and 4 females. Similarly, for the flipped method, the remaining 20 participants were chosen, with a distribution of 16 males and 4 females. After successful tutelage of the trainees using different teaching methods, both groups were involved into an assessment process. The assessment was carried in the form of a paper-based quiz administered to the trainees at the end of the physical lectures. The quiz comprised of a total of 48 questions. This quiz was formed in accordance with the lecture delivered. (see Appendix for the quiz). The quizzes were graded, and their results will be compared to validate the effectiveness of the flipped learning method.

### *3.2.2. Statistical analysis*

The study aimed to assess the impact of the flipped classroom model on trainees' classroom engagement in learning safety. The collected data though assessment was analysed using IBM SPSS 25.0 statistical software. Initially, the intention was to apply an independent samples t-test, a statistical tool for comparing mean scores between two groups. However, our data failed to meet the conditions for parametric tests, including the assumption of normal data distribution and a large sample size (at least 30 individuals per group) (Green & Salkind, 2008). Since the number of individuals in the groups is under 30, i.e., 20, there is no need to use the Kolmogorov-Smirnov Normal Distribution Test. Instead, Mann Whitney U Test is a suitable alternative for data analysis. The Mann-Whitney U test is a non-parametric statistical test used to assess whether there is a difference between two independent groups based on their ranks. A statistical significance of 0.05 is utilized to determine whether to reject or fail to reject the null hypothesis (Nachar, 2008).

### *3.2.3. Traditional teaching process*

Following the traditional tutelage process, a total of 20 trainees, sharing the background of civil engineering were engaged. The training took place in a physical classroom setting where they received instruction on safety orientation and its various aspects. Three one-hour lectures were delivered to the trainees, and subsequently, a test or quiz was administered after each lecture. The quiz included questions related to the content covered in the lectures and assessed participants' knowledge of safety-related concepts. Questions cover topics such as hazard identification, risk management, safety signs, near-misses, and basic fire safety. Following the quizzes, assessments were conducted, and the results were finalized. These results will be compared to those obtained from the flipped learning model for further analysis.

### *3.2.4. Flipped model for construction safety tutelage*

In total, 20 trainees went through this phase of tutelage. They were tutored according to the proposed flipped model for construction safety. For phase 1, pre-session activities involved the conceptualization of content in a presentable format. Three different lectures were prepared and processed for video creation. As depicted in Figure 4, the video creation process began with initiating presentable content using MS PowerPoint. Additionally, Adobe Presenter Video Express 2017 was utilized to create presentation videos. The software's feature to record the screen along with the live webcam under the option of "Both" was used to capture the presentation along with the live screen. This facilitated the creation of presentation videos comprising the instructor's live lecture along with tutelage aspects of respective topics as e-learning resources. After recording, the lectures were published in MP4 format. For better visualization and enhancement of the created videos, Adobe Premiere Pro was considered for substantial editing and enhancement. The videos were then finalized, edited, and further processed according to the requirements of the flipped model for construction safety tutelage.

After the creation and development of videos, as shown in Figure 5, Figure 6 and Figure 7, these videos were circulated via multiple sources. Firstly, all the videos were uploaded on Google Drive, and a shareable link was generated and shared with participants via email. Additionally, a WhatsApp group comprising all participants to be trained under the flipped model was created, and the link was shared in that group. After the circulation of videos, the next session started. In the tutelage session, three pre-session quizzes pertaining to all the circulated videos were held. These quizzes evaluated trainees on various safety aspects, including housekeeping, electrical tool safety, fire extinguisher usage, flammable liquids handling, lifting techniques, and confined space awareness. After these quizzes, the engagement session began, differing from the traditional lecture delivery method. This session recognized the active participation of trainees and their discussion regarding the circulated videos. In this session, mostly interactive talks and cross-questioning were conducted.

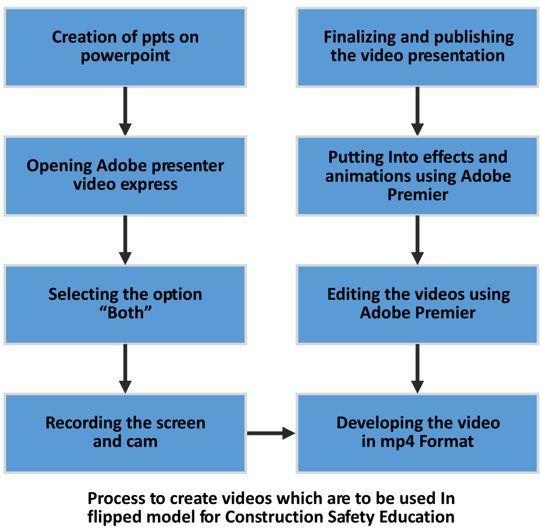


**Figure 4.** Framework for video content creation


**Figure 5.** Video Lecture Part 1


**Figure 6.** Video Lecture part 2

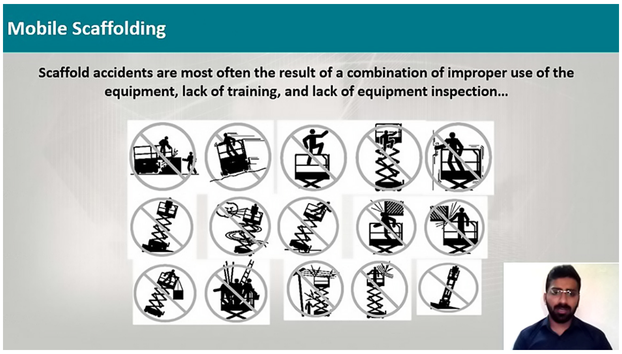


**Figure 7.** Video Lecture part 3

Alongside, some physical demonstrations of PPEs and other safety equipment were observed. Moreover, after the conclusion of the engagement session, a post-session quiz stage was held. This stage is included in the final part of the framework, viz., post-session activities. Three final quizzes regarding the whole training session were held. These quizzes evaluated participants' understanding of hazards, risks, safety signs, near-misses, fire safety, manual handling, ladder safety, confined space, and personal protective equipment (PPE). After these quizzes, the session concluded with the award of completion certificates, and participants provided feedback on the tutelage method.

# 5. Results

## 5.1. Assessment results

The results for the quiz in traditional tutelage show an average score of 27.9. In flipped model, after circulation of video lectures the trainee were assesed in the session physically, via a pre-session quiz. This quiz played a crucial role in pinpointing the areas where trainees faced challenges. After successful tutelage the trainees were involved in a final assesment process. Similary as before, this assesment was carried in the form of quiz. It comprised of a total of 48 questions same as final quiz of traditional tutelage. The results for the quiz in flipped tutelage show an average score of 31.5. Comparing the results from the final quiz of both methods, as illustrated in Figure 8, shows an average score increase of 12.90%. The comparative analysis is based on the final quizzes held at the end of both the teaching methods. The major factor for better performance of flipped method is focus on a pre-session quiz and topic familiarity through video lectures. Circulation of video lectures has acted a sources of entertaining the trainees to get familiarity with the trianing topics / contents and research on them accordingly. The pre-quiz after this video circulation helped the trainer / instructor to asses a trainee's area of weakness.

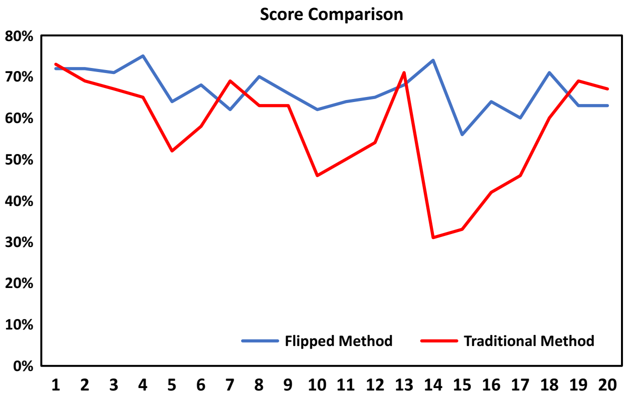


**Figure 8.** Score between flipped and traditional method

## 5.2. Analysis results

As $p > 0.05$, null hypothesis is rejected and there is a significant difference between traditional based teaching and the proposed flipped method. Table 6 shows the summary for the test.

The present interverntion study confirmed that the flipped learning approach is more effective than traditional safty training in the construction industry. In fact, flipped learning approach enable the participants to develop interests before commencement of the training. In addition, the circulated video lecture help them to understant the

**Table 6.** Summary of Mann-Whitney U test

| Null Hypothesis | Test | Significance level | Mann-Whitney U | $p$ | Decision |
|---|---|---|---|---|---|
| The distribution of score is the same across categories of Group | Independent-Samples Mann-Whitney U Test | 0.05 | 284.00 | 0.023 | Reject the null hypothesis |

content of the training, which in trun improve the engagement of the participants in the training. In contrary to traditional method, the interactive engagement session of flipped learning session fully engage the participants into the workshop, which reduces the comunication gap between trainers and trainee. Ultimately, it improve interest and motivation in the training session and perform beter than traditional method. More importantly, the circulation of virtual learning resources enhance the awareness regarding the significance of the training, whic makes a big difference from traditional method.

## 5.3. Discussion

This paper identified 18 factors contributing to inefficiencies through a detailed literature analysis and ranked them by their frequency of occurrence and field score, gathered from a survey filled out by experts. Following this, the study conducted an intervention to assess the benefits of flipped learning in the training programs of the construction industry.

"Lack of awareness about the importance of safety training" ranked as 1st in the overall scores, confirming with the findings of Choudhry and Fang (2008) and Tam et al. (2004). Traditionally, construction safety training has been provided in a classroom setting. However, adopting newer teaching methods can lead to better overall awareness and comprehension of the potential hazards present on site (Wang et al., 2018). The low return on investment in safety training by companies is another major reason for ineffective training on sites. Despite the investments made, the implemented programs have failed to deliver the desired return. Namian et al. (2016) identified that the issue of training transfer has largely been ignored in the construction context. Only 10–15% of training investments translate into concrete benefits, while the majority of the resources are wasted. No incentive for timely completion of training emerged as the 3rd most important inefficiency in construction safety training in our study. Previous studies, such as Namian et al. (2016), which ranked it 7th, and Ismail et al. (2012), which ranked it the lowest, have generally underestimated its benefits. Offering rewards and incentives for desired behavior can motivate workers to repeat it, while acknowledging their effective application of training knowledge can improve learning transfer. A study by Ghasemi et al. (2015) supports this, showing that incentives improve employees' safety performance in the short term. However, to maintain the incentive's effectiveness, the amount and types of incentives need to be evaluated and modified annually or biannually.

Lack of interest in training is mainly due to the usage of traditional approaches. Most workers find the content of the training boring (Choudhry & Fang, 2008; Rowland et al., 2006). The effectiveness of these traditional methods has been repeatedly questioned, with numerous limitations highlighted and have been criticized for being passive and boring (Pham et al., 2018). Engagement of trainees during training ranks 5th with a great number of studies considering it to be a significant factor in ineffective safety training (Cherrett et al., 2009; Liaw et al., 2012; Namian et al., 2016; Teizer et al., 2013). Teizer et al. (2013) point out traditional training program ends up with some practice during training sessions and often it does not engage the trainees as much as needed. Namian et al. (2016) argues that high engagement methods enable greater knowledge transfer during safety training compared to low engagement methods. Ineffective training methods are also one of the leading causes for poor hazard recognition. Professional safety trainers and construction managers need more effective training practices targeted at improving hazard recognition (Jeelani et al., 2017a). Effective training programs require effective learning among workers, emphasizing that employers' goals of improving site safety may not be achieved unless they focus on the effectiveness of learning during training sessions (Demirkesen & Arditi, 2015). Lack of proper management during safety training is often due to the attitudes of top management in a project. Tam et al. (2004) identified several issues with safety management in construction. Most contractors lack proper documented safety management systems and don't provide the necessary Personal Protective Equipment (PPE) to workers. Top management often has a nonserious attitude towards safety, and only a few contractors offer systematic safety training.

After the systematic literature review, this paper implemented an intervention study to evaluate the efficiency of flipped learning in construction industry training programs. The study was carried out on 40 professionals from a leading construction company and the results indicated a notable improvement in the safety learning outcomes of the professionals. Flipped learning in safety training addresses various inefficiencies by enhancing engagement, effectiveness, and overall learning outcomes. It increases awareness about the importance of safety training, fosters interest and participation among trainees, and promotes active engagement during training sessions. Moreover, flipped learning improves the effectiveness of safety training programs, provides structured management of training sessions, and ultimately leads to better learning outcomes for participants (Gilboy et al., 2015; Karabulut-Ilgu et al., 2018; Lo & Hew, 2019; Nederveld & Berge, 2015; Van den Bergh et al., 2014). Despite the many benefits of flipped learning, it does have some limitations. Some instructors might not possess the IT skills required to create online media content. Additionally, professionals may encounter difficulty accessing online materials due to limited internet connectivity or the unavailability of free time. Some people might struggle with the transition to a more active learning process and may feel overwhelmed by the shift in teaching methodology (Karabulut-Ilgu et al., 2018).

# 6. Conclusions

Training in construction safety has been lacking behind in terms of updates since its inception and it is considered of lesser importance in our traditional culture. Safety education training will not only help to reduce the number of accidents/incidents happening at a construction site but will also help to safeguard the basic human right of health. Safety education in accordance with compliance of all the international standards is of immense importance. Pursuing the compliance of OSHA standards will ultimately cause a cut-off in numbers of accidents at a construction site. In the contemporary world of global competitiveness, It is important to endorse safety norms to achieve success. Unfortunately, construction industry has not been able to fully adopt safety norms and practices till date. Despite several researches highlighting the importance of construction safety and the adoption of new techniques to improve its performance, more emphasis is needed on safety education. A relatively new education model, namely, Flipped learning, has been endorsed in this research to enhance construction safety education. Flipped learning enhances student engagement by allowing them to learn foundational concepts independently at their own pace, freeing up class time for interactive and collaborative activities.

Therefore, this study proposed a framework incorporating flipped learning to enhance safety training. In this study, 40 personnel were selected as test subjects, with 20 taught using the traditional method and the remaining 20 taught using the proposed flipped framework. Performance was assessed through a quiz, and statistical analysis revealed a significant difference between the two groups. Participants in the flipped framework showed a noteworthy increase of 12.90% in the average score. This is due to the fact that in flipped classroom model, students can interact one-on-one with teachers and peers and study course content independently of time and space. The model offers benefits like ensuring preparedness for lessons, fostering an engaging learning environment, providing teacher guidance, and motivating students through a competitive atmosphere. The integration of technology supports individualized learning, contributing to increased student success. These advantages are expected to positively influence students' classroom engagement levels. Based on these findings, it is suggested to adopt flipped learning approach to effectively dessiminate safety training to the professionals in the workforce of construction industry.

The major contributions of this study are: 1) Identifying factors along with their weightages affecting safety training through literature review; 2) Development of a flipped based framework for enhancing safety training; 3) Validating the proposed framework through real-life experiments. In conclusion, the proposed framework presents a compelling solution to enhance safety training, addressing crucial factors and promoting a proactive approach. Implementation of this model will help minimize accidents on construction sites, fostering a culture of safety. Embracing such advancements is key to creating a safer and more secure work environment.

This research is pioneer effort to investigate the feasibility of flipped learning approach for the safety training in the construction industry. However, it also involves few limitations, including limited training sessions, which may hinder the generalizability of the results. Normally, professionals resist participating in such training due to their work and family commitments. It is suggested to consider the time and honorarium to encourage the maximum participants and arrange at the suitable times for the participants.

## Funding

This work was supported by the Deanship of Scientific Research, Vice Presidency for Graduate Studies and Scientific Research, King Faisal University, Saudi Arabia (GRANT No. KFU 242472). The APC was funded by the same "Grant No. KFU242472".

## Acknowledgements

The authors acknowledge the Deanship of Scientific Research, Vice Presidency for Graduate Studies and Scientific Research, King Faisal University, Saudi Arabia (GRANT No. KFU242472). The authors extend their appreciation for the financial support that has made this study possible.

## References

Ahn, S., Kim, T., Park, Y.-J., & Kim, J.-M. (2020). Improving effectiveness of safety training at construction worksite using 3D BIM simulation. *Advances in Civil Engineering*, *2020*, Article 2473138. https://doi.org/10.1155/2020/2473138

Ai Lin Teo, E., Yean Yng Ling, F., & Sern Yau Ong, D. (2005). Fostering safe work behaviour in workers at construction sites. *Engineering, Construction and Architectural Management*, *12*(4), 410–422. https://doi.org/10.1108/09699980510608848

Al-Zahrani, A. M. (2015). From passive to active: The impact of the flipped classroom through social learning platforms on higher education students' creative thinking. *British Journal of Educational Technology*, *46*(6), 1133–1148. https://doi.org/10.1111/bjet.12353

Albert, A., Hallowell, M. R., Kleiner, B., Chen, A., & Golparvar-Fard, M. (2014). Enhancing construction hazard recognition with high-fidelity augmented virtuality. *Journal of Construction Engineering and Management*, *140*(7), Article 04014024. https://doi.org/10.1061/(ASCE)CO.1943-7862.0000860

Albert, M., & Beatty, B. J. (2014). Flipping the classroom applications to curriculum redesign for an introduction to management course: Impact on grades. *Journal of Education for Business*, *89*(8), 419–424. https://doi.org/10.1080/08832323.2014.929559

Alpaslan, S., Baki, C., & Yunus, E. Z. (2015). Flipping a college calculus course: A case study. *Journal of Educational Technology & Society*, *18*(3), 142–152. http://www.jstor.org/stable/jeductechsoci.18.3.142

Alsharef, A., Albert, A., Jaselskis, E., & Bhandari, S. (2020). Construction safety training: Barriers, challenges, and opportunities. In *Construction Research Congress 2020*: *Safety*, *Workforce*, *and Education*. https://doi.org/10.1061/9780784482872.059

Bergmann, J., & Sams, A. (2012). *Flip your classroom*: *Reach every student in every class every day*. International Society for Technology in Education.

Bergmann, J., & Sams, A. (2014). Flipped learning. *Learning & Leading with Technology*, *41*(7), 18–23. http://webcasts.astd.org/uploads/assets/264/document/TDFlippedLearning.pdf

Bhandari, S., Hallowell, M. R., & Correll, J. (2019). Making construction safety training interesting: A field-based quasi-experiment to test the relationship between emotional arousal and situational interest among adult learners. *Safety Science*, *117*, 58–70. https://doi.org/10.1016/j.ssci.2019.03.028

BIMCHAIN. (2018). *BIMCHAIN, Accelerating BIM through the Blockchain*.

Birgili, B., Seggie, F. N., & Oğuz, E. (2021). The trends and outcomes of flipped learning research between 2012 and 2018: A descriptive content analysis. *Journal of Computers in Education*, *8*(3), 365–394. https://doi.org/10.1007/s40692-021-00183-y

Bottani, E., Monica, L., & Vignali, G. (2009). Safety management systems: Performance differences between adopters and non-adopters. *Safety Science*, *47*(2), 155–162. https://doi.org/10.1016/j.ssci.2008.05.001

Bunch, K. J. (2007). Training failure as a consequence of organizational culture. *Human Resource Development Review*, *6*(2), 142–163. https://doi.org/10.1177/1534484307299273

Bureau of Labor Statistics. (2022). *National Census of fatal occupational injuries in 2022*. https://www.bls.gov/news.release/pdf/cfoi.pdf

Burke, M. J., Salvador, R. O., Smith-Crowe, K., Chan-Serafin, S., Smith, A., & Sonesh, S. (2011). The dread factor: How hazards and safety training influence learning and performance. *Journal of Applied Psychology*, *96*(1), 46–70. https://doi.org/10.1037/a0021838

Carter, G., & Smith, S. (2006). Safety hazard identification on construction projects. *Journal of Construction Engineering and Management*, *132*(2), 197–205. https://doi.org/10.1061/(ASCE)0733-9364(2006)132:2(197)

Casey, T., Turner, N., Hu, X., & Bancroft, K. (2021). Making safety training stickier: A richer model of safety training engagement and transfer. *Journal of Safety Research*, *78*, 303–313. https://doi.org/10.1016/j.jsr.2021.06.004

Cherrett, T., Wills, G., Price, J., Maynard, S., & Dror, I. E. (2009). Making training more cognitively effective: Making videos interactive. *British Journal of Educational Technology*, *40*(6), 1124–1134. https://doi.org/10.1111/j.1467-8535.2009.00985.x

Chiang, F.-K., & Chen, C. (2017). Modified flipped classroom instructional model in "Learning sciences" course for graduate students. *The Asia-Pacific Education Researcher*, *26*(1), 1–10. https://doi.org/10.1007/s40299-016-0321-2

Choudhry, R. M., & Fang, D. (2008). Why operatives engage in unsafe work behavior: Investigating factors on construction sites. *Safety Science*, *46*(4), 566–584. https://doi.org/10.1016/j.ssci.2007.06.027

Conley, Q., Lutz, H. S., & Miller, C. L. (2017). The flipped training model: Six steps for getting employees to flip out over training. *Performance Improvement*, *56*(5), 18–31. https://doi.org/10.1002/pfi.21692

Day, L. J. (2018). A gross anatomy flipped classroom effects performance, retention, and higher-level thinking in lower performing students. *Anatomical Sciences Education*, *11*(6), 565–574. https://doi.org/10.1002/ase.1772

Demirkesen, S., & Arditi, D. (2015). Construction safety personnel's perceptions of safety training practices. *International Journal of Project Management*, *33*(5), 1160–1169. https://doi.org/10.1016/j.ijproman.2015.01.007

Dong, X., Entzel, P., Men, Y., Chowdhury, R., & Schneider, S. (2004). Effects of safety and health training on work-related injury among construction laborers. *Journal of Occupational and Environmental Medicine*, *46*(12), 1222–1228.

Doo, M. Y. (2021). Understanding flipped learners' perceptions, perceived usefulness, registration intention, and learning engagement. *Contemporary Educational Technology*, *14*(1), Article ep331. https://doi.org/10.30935/cedtech/11368

Feng, Z., González, V. A., Amor, R., Lovreglio, R., & Cabrera-Guerrero, G. (2018). Immersive virtual reality serious games for evacuation training and research: A systematic literature review. *Computers & Education*, *127*, 252–266. https://doi.org/10.1016/j.compedu.2018.09.002

Fernando, Y., Zailani, S., & Janbi, L. (2008). The determinant factors of safety compliance at petrochemical processing area: Moderator effects of employees experience and engineering background. In *Proceedings of 9th Asia Pacific Industrial Engineering and Management Systems Conference* (pp. 1442–1452).

Fidalgo-Blanco, A., Martinez-Nuñez, M., Borrás-Gene, O., & Sanchez-Medina, J. J. (2017). Micro flip teaching – An innovative model to promote the active involvement of students. *Computers in Human Behavior*, *72*, 713–723. https://doi.org/10.1016/j.chb.2016.07.060

Forst, L., Ahonen, E., Zanoni, J., Holloway-Beth, A., Oschner, M., Kimmel, L., Martino, C., Rodriguez, E., Kader, A., & Ringholm, E. (2013). More than training: Community-based participatory research to reduce injuries among hispanic construction workers. *American Journal of Industrial Medicine*, *56*(8), 827–837. https://doi.org/10.1002/ajim.22187

Furnham, A. (2012). *The psychology of behaviour at work*: *The individual in the organization*. Psychology Press. https://doi.org/10.4324/9780203506974

Furse, C. M., & Ziegenfuss, D. H. (2020). A busy professor's guide to sanely flipping your classroom: Bringing active learning to your teaching practice. *IEEE Antennas and Propagation Magazine*, *62*(2), 31–42. https://doi.org/10.1109/MAP.2020.2969241

Gao, Y., González, V. A., & Yiu, T. W. (2017). Serious games vs. traditional tools in construction safety training: a review. In *Proceedings of the Joint Conference on Computing in Construction* (*JC3*) (Vol. 1, pp. 653–660), Heraklion, Greece. http://doi.org/10.24928/JC3-2017/0070

Gao, Y., Gonzalez, V. A., & Yiu, T. W. (2019). The effectiveness of traditional tools and computer-aided technologies for health and safety training in the construction sector: A systematic review. *Computers & Education*, *138*, 101–115. https://doi.org/10.1016/j.compedu.2019.05.003

Ghasemi, F., Mohammadfam, I., Soltanian, A. R., Mahmoudi, S., & Zarei, E. (2015). Surprising incentive: An instrument for promoting safety performance of construction employees. *Safety and Health at Work*, *6*(3), 227–232. https://doi.org/10.1016/j.shaw.2015.02.006

Gilboy, M. B., Heinerichs, S., & Pazzaglia, G. (2015). Enhancing student engagement using the flipped classroom. *Journal of Nutrition Education and Behavior*, *47*(1), 109–114. https://doi.org/10.1016/j.jneb.2014.08.008

Gillen, M., Baltz, D., Gassel, M., Kirsch, L., & Vaccaro, D. (2002). Perceived safety climate, job demands, and coworker support among union and nonunion injured construction workers. *Journal of Safety Research*, *33*(1), 33–51. https://doi.org/10.1016/S0022-4375(02)00002-6

González-Gómez, D., Jeong, J. S., Airado Rodríguez, D., & Cañada-Cañada, F. (2016). Performance and perception in the flipped learning model: an initial approach to evaluate the effectiveness of a new teaching methodology in a general science classroom. *Journal of Science Education and Technology*, *25*, 450–459. https://doi.org/10.1007/s10956-016-9605-9

Green, S. B., & Salkind, N. J. (2008). *Using SPSS for Windows and Macintosh*: *Analyzing and understanding data* (6th ed.). Pearson/Prentice Hall.

Guo, H., Yu, Y., & Skitmore, M. (2017). Visualization technology-based construction safety management: A review. *Automation in Construction*, *73*, 135–144. https://doi.org/10.1016/j.autcon.2016.10.004

Han, S. H., Park, S., Jin, E., Kim, H., & Seong, Y. (2008). Critical issues and possible solutions for motivating foreign construction workers. *Journal of Management in Engineering*, *24*(4), 217–226. http://doi.org/10.1061/(ASCE)0742-597X(2008)24:4(217)

Hao, Y. (2016). Exploring undergraduates' perspectives and flipped learning readiness in their flipped classrooms. *Computers in Human Behavior*, *59*, 82–92. https://doi.org/10.1016/j.chb.2016.01.032

Hao, Y., & Lee, K. S. (2016). Teaching in flipped classrooms: Exploring pre-service teachers' concerns. *Computers in Human Behavior*, *57*, 250–260. https://doi.org/10.1016/j.chb.2015.12.022

Harfield, T., Kenley, R., Panko, M., & Davies, K. (2007). *A comparison of group learning-style profiles; construction students, law students & student teachers*. https://hdl.handle.net/10652/2258

Haslam, R. A., Hide, S. A., Gibb, A. G. F., Gyi, D. E., Pavitt, T., Atkinson, S., & Duff, A. R. (2005). Contributing factors in construction accidents. *Applied Ergonomics*, *36*(4), 401–415. https://doi.org/10.1016/j.apergo.2004.12.002

He, W., Holton, A., Farkas, G., & Warschauer, M. (2016). The effects of flipped instruction on out-of-class study time, exam performance, and student perceptions. *Learning and Instruction*, *45*, 61–71. https://doi.org/10.1016/j.learninstruc.2016.07.001

Hew, K. F., & Lo, C. K. (2018). Flipped classroom improves student learning in health professions education: A meta-analysis. *BMC Medical Education*, *18*(1), Article 38. https://doi.org/10.1186/s12909-018-1144-z

Hosseinian, S. S., & Torghabeh, Z. J. (2012). Major theories of construction accident causation models: A literature review. *International Journal of Advances in Engineering & Technology*, *4*(2), 53–66.

International Labour Organization. (2018). *Safety and health in the construction sector – overcoming the challenges*. https://www.ilo.org/meetings-and-events/safety-and-health-construction-sector-overcoming-challenges

Ismail, F., Ahmad, N., Janipha, N. A. I., & Ismail, R. (2012). Assessing the behavioural factors' of safety culture for the Malaysian construction companies. *Procedia - Social and Behavioral Sciences*, *36*, 573–582. https://doi.org/10.1016/j.sbspro.2012.03.063

Jeelani, I., Albert, A., Azevedo, R., & Jaselskis, E. J. (2017a). Development and testing of a personalized hazard-recognition training intervention. *Journal of Construction Engineering and Management*, *143*(5), Article 04016120. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001256

Jeelani, I., Albert, A., & Gambatese, J. A. (2017b). Why do construction hazards remain unrecognized at the work interface?. *Journal of Construction Engineering and Management*, *143*(5), Article 04016128. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001274

Jungić, V., Kaur, H., Mulholland, J., & Xin, C. (2015). On flipping the classroom in large first year calculus courses. *International Journal of Mathematical Education in Science and Technology*, *46*(4), 508–520. https://doi.org/10.1080/0020739X.2014.990529

Jurf, N., Dawood, N., & Naji, K. (2012). New methods for health & safety training in the Quatar building construction industry. In *CIB W78* 2012, Beirut, Lebanon.

Karabulut-Ilgu, A., Jaramillo Cherrez, N., & Jahren, C. T. (2018). A systematic review of research on the flipped learning method in engineering education. *British Journal of Educational Technology*, *49*(3), 398–411. https://doi.org/10.1111/bjet.12548

Kelloway, E. K., Kelloway, E. K., & Cooper, C. L. (2011). *Occupational health and safety for small and medium sized enterprises*. Edward Elgar Publishing. https://doi.org/10.4337/9780857938701

Khayat, M., Hafezi, F., Asgari, P., & Talebzadeh Shoushtari, M. (2021). Comparison of the effectiveness of flipped classroom and traditional teaching method on the components of self-determination and class perception among university students. *Journal of Advances in Medical Education & Professionalism*, *9*(4), 230–237. https://doi.org/10.30476/jamp.2021.89793.1385

Lai, C.-L., & Hwang, G.-J. (2016). A self-regulated flipped classroom approach to improving students' learning performance in a mathematics course. *Computers & Education*, *100*, 126–140. https://doi.org/10.1016/j.compedu.2016.05.006

Le, Q. T., Lee, D. Y., & Park, C. S. (2014). A social network system for sharing construction safety and health knowledge. *Automation in Construction*, *46*, 30–37. https://doi.org/10.1016/j.autcon.2014.01.001

Lee, B., & Recker, J. (2013). *How to apply the flipped classroom model for business learning*.

Li, H., Chan, G., & Skitmore, M. (2012). Multiuser virtual safety training system for tower crane dismantlement. *Journal of Computing in Civil Engineering*, *26*(5), 638–647. https://doi.org/10.1061/(ASCE)CP.1943-5487.0000170

Li, W., Liang, W., Zhang, L., & Tang, Q. (2015). Performance assessment system of health, safety and environment based on experts' weights and fuzzy comprehensive evaluation. *Journal of Loss Prevention in the Process Industries*, *35*, 95–103. https://doi.org/10.1016/j.jlp.2015.04.007

Liaw, Y.-L., Lin, K.-Y., Li, M., & Chi, N.-W. (2012). Learning assessment strategies for an educational construction safety video game. In *Proceedings of Construction Research Congress 2012: Construction Challenges in a Flat World* (pp. 2091–2100). https://doi.org/10.1061/9780784412329.210

Lingard, H. (2013). Occupational health and safety in the construction industry. *Construction Management and Economics*, *31*(6), 505–514. https://doi.org/10.1080/01446193.2013.816435

Lo, C. K., & Hew, K. F. (2019). The impact of flipped classrooms on student achievement in engineering education: A meta-analysis of 10 years of research. *Journal of Engineering Education*, *108*(4), 523–546. https://doi.org/10.1002/jee.20293

Lo, C. K., Hew, K. F., & Chen, G. (2017). Toward a set of design principles for mathematics flipped classrooms: A synthesis of research in mathematics education. *Educational Research Review*, *22*, 50–73. https://doi.org/10.1016/j.edurev.2017.08.002

Loosemore, M. (1998). The three ironies of crisis management in construction projects. *International Journal of Project Management*, *16*(3), 139–144. https://doi.org/10.1016/S0263-7863(97)00041-0

Loosemore, M., & Andonakis, N. (2007). Barriers to implementing OHS reforms – The experiences of small subcontractors in the Australian construction industry. *International Journal of Project Management*, *25*(6), 579–588. https://doi.org/10.1016/j.ijproman.2007.01.015

Majumdar, A. (2013). *Flipped classrooms in corporate learning: Concept or reality?*. https://www.gc-solutions.net/blog/flipped-classrooms-in-corporate-learning-concept-or-reality

McDonald, K., & Smith, C. M. (2013). The flipped classroom for professional development: part I. Benefits and strategies. *The Journal of Continuing Education in Nursing*, *44*(10), 437–438. https://doi.org/10.3928/00220124-20130925-19

Mihić, M. (2020). Classification of construction hazards for a universal hazard identification methodology. *Journal of Civil Engineering and Management*, *26*(2), 147–159. https://doi.org/10.3846/jcem.2020.11932

Mohamed, S. (1999). Empirical investigation of construction safety management activities and performance in Australia. *Safety Science*, *33*(3), 129–142. https://doi.org/10.1016/S0925-7535(99)00028-4

Mok, H. N. (2014). Teaching tip: The flipped classroom. *Journal of Information Systems Education*, *25*(1), 7–11.

Nachar, N. (2008). The Mann-Whitney U: A test for assessing whether two independent samples come from the same distribution. *Tutorials in Quantitative Methods for Psychology*, *4*, 13–20. https://doi.org/10.20982/tqmp.04.1.p013

Namian, M., Albert, A., Zuluaga Carlos, M., & Jaselskis Edward, J. (2016). Improving hazard-recognition performance and safety training outcomes: Integrating strategies for training transfer. *Journal of Construction Engineering and Management*, *142*(10), Article 04016048. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001160

Nederveld, A., & Berge, Z. L. (2015). Flipped learning in the workplace. *Journal of Workplace Learning*, *27*(2), 162–172. https://doi.org/10.1108/JWL-06-2014-0044

Occupational Safety and Health Administration. (2023). *OSHA commonly used statistics*. https://www.osha.gov/data/commonstats

Ojha, A., Seagers, J., Shayesteh, S., Habibnezhad, M., & Jebelli, H. (2020). Construction safety training methods and their evaluation approaches: A systematic literature review. In *The 8th International Conference on Construction Engineering and Project Management*, Hong Kong.

Patton, J. R. (2009). Task diminishment: Construction value loss through sub-optimal task execution. *Technology Interface Journal*, *10*(2).

Perlman, A., Sacks, R., & Barak, R. (2014). Hazard recognition and risk perception in construction. *Safety Science*, *64*, 22–31. http://doi.org/10.1016/j.ssci.2013.11.019

Perttula, P., Korhonen, P., Lehtelä, J., Rasa, P., Kitinoja, J.-P., Mäkimattila, S., & Leskinen, T. (2006). Improving the safety and efficiency of materials transfer at a construction site by using an elevator. *Journal of Construction Engineering and Management*, *132*(8), 836–843. https://doi.org/10.1061/(ASCE)0733-9364(2006)132:8(836)

Pham, H. C., Dao, N.-N., Pedro, A., Le, Q. T., Hussain, R., Cho, S., & Park, C. (2018). Virtual field trip for mobile construction safety education using 360-degree panoramic virtual reality. *International Journal of Engineering Education*, *34*, 1174–1191.

Pierce, R. (2013). Student performance in a flipped class module. In *Proceedings of Society for Information Technology* & *Teacher Education International Conference* (pp. 942–954). Association for the Advancement of Computing in Education (AACE).

Pinto, A., Nunes, I. L., & Ribeiro, R. A. (2011). Occupational risk assessment in construction industry – Overview and reflection. *Safety Science*, *49*(5), 616–624. https://doi.org/10.1016/j.ssci.2011.01.003

Ruttenberg, R., & Lazo, M. (2004). *Spanish-speaking construction workers discuss their safety needs and experiences*. http://www.bilingualbiz.com/PDF%20DOCUMENTS/Articles/Spanish%20Speaking%20Const%20workers.PDF

Rowland, B., Watson, B., & Wishart, D. (2006). Integration of work-related fleet safety within a Workplace Health and Safety Management System: A case study approach. In *Proceedings of 2006 Australasian Road Safety Research*, *Policing and Education Conference*. Able Video and Multimedia Pty Ltd.

Ryan, M. D., & Reid, S. A. (2016). Impact of the flipped classroom on student performance and retention: A parallel controlled study in general chemistry. *Journal of Chemical Education*, *93*(1), 13–23. https://doi.org/10.1021/acs.jchemed.5b00717

Saleh, J. H., & Pendley, C. C. (2012). From learning from accidents to teaching about accident causation and prevention: Multidisciplinary education and safety literacy for all engineering students. *Reliability Engineering* & *System Safety*, *99*, 105–113. https://doi.org/10.1016/j.ress.2011.10.016

Seppala, A. (1995). Promoting safety by training supervisors and safety representatives for daily safety work. *Safety Science*, *20*(2–3), 317–322. https://doi.org/10.1016/0925-7535(95)00020-H

Sohrabi, B., & Iraj, H. (2016). Implementing flipped classroom using digital media: A comparison of two demographically different groups perceptions. *Computers in Human Behavior*, *60*, 514–524. https://doi.org/10.1016/j.chb.2016.02.056

Sokas, R. K., Jorgensen, E., Nickels, L., Gao, W., &Gittleman, J. L. (2009). An intervention effectiveness study of hazard awareness training in the construction building trades. *Public Health Reports*, *124*(4, Suppl. 1), 161–168. https://doi.org/10.1177/00333549091244S118

Sousa, S., & Teixeira, J. (2004). Prevention measures to reduce risk of falling from heights. In *IX National Symposium of ISMAI*, Porto, Portugal.

Steed, A. (2012). The flipped classroom. *Teaching Business* & *Economics*, *16*(3), 9–11.

Tam, C. M., Zeng, S. X., & Deng, Z. M. (2004). Identifying elements of poor construction safety management in China. *Safety Science*, *42*(7), 569–586. https://doi.org/10.1016/j.ssci.2003.09.001

Tam, V. W., & Fung, I. W. (2012). Behavior, attitude, and perception toward safety culture from mandatory safety training course. *Journal of Professional Issues in Engineering Education and Practice*, *138*(3), 207–213. https://doi.org/10.1061/(ASCE)EI.1943-5541.0000104

Teizer, J., Cheng, T., & Fang, Y. (2013). Location tracking and data visualization technology to advance construction ironworkers' education and training in safety and productivity. *Automation in Construction*, *35*, 53–68. https://doi.org/10.1016/j.autcon.2013.03.004

Thuy Pham, N., & Swierczek, F. W. (2006). Facilitators of organizational learning in design. *The Learning Organization*, *13*(2), 186–201. https://doi.org/10.1108/09696470610645502

van Alten, D. C. D., Phielix, C., Janssen, J., & Kester, L. (2019). Effects of flipping the classroom on learning outcomes and satisfaction: A meta-analysis. *Educational Research Review*, *28*, Article 100281. https://doi.org/10.1016/j.edurev.2019.05.003

Van den Bergh, L., Ros, A., & Beijaard, D. (2014). Improving teacher feedback during active learning: Effects of a professional development program. *American Educational Research Journal*, *51*(4), 772–809. https://doi.org/10.3102/0002831214531322

Varonen, U., & Mattila, M. (2000). The safety climate and its relationship to safety practices, safety of the work environment and occupational accidents in eight wood-processing companies. *Accident Analysis* & *Prevention*, *32*(6), 761–769. https://doi.org/10.1016/S0001-4575(99)00129-3

Vayuvegula, A. (2014). *Key element for the success of flipped classroom concept in corporate training*. http://blog.commlabindia.com/elearning/flipped-classroom-elearning

Wang, K., & Zhu, C. (2019). MOOC-based flipped learning in higher education: students' participation, experience and learning performance. *International Journal of Educational Technology in Higher Education*, *16*(1), Article 33. https://doi.org/10.1186/s41239-019-0163-0

Wang, Y., Goodrum, P. M., Haas, C., Glover, R., & Vazari, S. (2010). Analysis of the benefits and costs of construction craft training in the United States based on expert perceptions and industry data. *Construction Management and Economics*, *28*(12), 1269–1285. https://doi.org/10.1080/01446193.2010.524238

Wang, X., Truijens, M., Hou, L., Wang, Y., & Zhou, Y. (2014). Integrating augmented reality with building information modeling: Onsite construction process controlling for liquefied natural gas industry. *Automation in Construction*, *40*, 96–105. https://doi.org/10.1016/j.autcon.2013.12.003

Wang, P., Wu, P., Wang, J., Chi, H.-L., & Wang, X. (2018). A critical Review of the Use of Virtual Reality in construction engineering education and training. *International Journal of Environmental Research and Public Health*, *15*(6), Article 1204. https://doi.org/10.3390/ijerph15061204

Wilkins, J. R. (2011). Construction workers' perceptions of health and safety training programmes. *Construction Management and Economics*, *29*(10), 1017–1026. https://doi.org/10.1080/01446193.2011.633538

Wong, J. Y. Y., Gray, J., & Sadiqi, Z. (2015). Barriers to good occupational health and safety (OHS) practices by small construction firms. *NICMAR Journal of Construction Management*, *30*(1), 55–66. https://eprints.qut.edu.au/87062/

Xu, S., Zhang, M., & Hou, L. (2019). Formulating a learner model for evaluating construction workers' learning ability during safety training. *Safety Science*, *116*, 97–107. https://doi.org/10.1016/j.ssci.2019.03.002

Zin, S. M., & Ismail, F. (2012). Employers' behavioural safety compliance factors toward occupational, safety and health improvement in the construction industry. *Procedia - Social and Behavioral Sciences*, *36*, 742–751. https://doi.org/10.1016/j.sbspro.2012.03.081

Zou, P. X., & Sunindijo, R. Y. (2015). Safety management in construction and engineering: An introduction. In *Strategic safety management in construction and engineering* (pp. 1–16). Wiley. http://doi.org/10.1002/9781118839362.ch1

# APPENDIX

## Final Quiz for the assesment of training methods

1. **What is a hazard?**
   A. Anything with the potential to cause harm
   B. Where an accident is likely to cause harm
   C. The likelihood of something going wrong
   D. An Accident waiting to happen

2. **What is risk?**
   A. The management of the environment
   B. The probability of the accident happening
   C. The likelihood of someone being harmed or injured as a result of the hazard
   D. None of the above

3. **MANDATORY OR COMPULSORY sign is ____________ in color**
   A. BLUE
   B. YELLOW
   C. RED
   D. Green

4. **WARNING SIGN is _______ in color**
   A. BLUE
   B. YELLOW
   C. RED
   D. Green

5. **PROHIBITION SIGN is _______ in color**
   A. BLUE
   B. YELLOW
   C. RED
   D. Green

6. **EMERGENCY ESCAPE OR FIRST-AID SIGN is ____ in color**
A. BLUE
B. YELLOW
C. RED
D. GREEN

7. **Regarding near-misses, select the best answer:**
   A. Major incidents are rare events.
   B. Prevent the non-serious events and the injuries will take care of themselves.
   C. By reporting near-misses, any organization can detect problems and intervene before more serious accidents happen.
   D. You can prevent what you can see.
   E. All of the above

8. **A "near miss" should be investigated in the same manner as an actual accident.**
   A. True
   B. False

9. **Close calls that could result in minimal or no injury to an employee should not be reported.**
   A. True
   B. False

10. **When you spot a hazard, what is the best way to respond?**
    A. Fix it right away if you can do so safely
    B. Ignore it until someone else fixes it
    C. Put it on your list of things to fix or report later

11. **Which of the following would not likely cause a slip, trip or fall?**
    A. Changes in walking direction
    B. Walking at the same speed
    C. Unexpected footing conditions
    D. All the above

12. **Which of the following could help to cause a fall?**
    A. Slowing down up when carrying a heavy load
    B. Taking your time to complete a job
    C. Cracked splintered or rutted damage to decking
    D. All the above

13. **... are the result of unrecoverable slips or trips.**
    A. Injuries
    B. Law suits
    C. Falls
    D. None of the above

14. **What is the most frequent cause of a slip, trip, or fall?**
    A. Wearing the wrong shoes
    B. Shoes untied
    C. Trash on the floor
    D. Lack of awareness

**15. If you are involved in a slip, trip or fall incident, you should report it to your supervisor even if you aren't injured.**
A. True
B. False

**16. The severity of a shock depends on what?**
A. The path of the current through your body
B. The amount of current (amps)
C. The duration of the shock
D. All of the above

**17. To be effective a fire extinguisher must be ______________?**
A. In Working Order
B. Readily accessible and suitable for the hazard
C. Large enough to control the size fire
D. All of these

**18. As A General Rule You Should Not Attempt to Fight A Fire That Is Spreading Rapidly?**
A. True
B. False

**19. Where Should You Aim a Fire Extinguisher Nozzle When Putting Out A Fire**
A. At The Top Of The Fire
B. At The Base Of The Fire
C. At The Centre Of The Fire
D. Away From the Fire

**20. Proper handling and storage of flammable liquids is important to eliminate dangers and prevent:**
A. Safety
B. Fires
C. Smoking
D. Flashpoint

**21. Keep flammable liquid containers ______________ when not in use.**
A. Closed
B. Open
C. Near ignition sources
D. Empty

**22. It is very important not to store or use flammable liquids around a(n) ______________.**
A. Fire extinguisher
B. Storage cabinet
C. Ignition source
D. Safety can

**23. Should this sling be used for lifting?**
A. Yes, its fine.
B. Maybe, if the load isn't too heavy.
C. No, use a different one.

**24. What are the 3 ingredients a fire needs in order to burn?**
A. Water, heat and fuel
B. Fuel, heat and Oxygen
C. Gas, fuel and Oxygen

**25. What does FDAS stand for?**
A. Pull, Arm, Shout, Squeeze
B. Fire Detection and Alarm System
C. Pull, Aim, Squeeze, Sweep
D. Push, Aim, Shoot, Shout

**26. You should stand ______ feet away from a fire when using fire extinguisher.**
A. 5
B. 6
C. 8
D. 10

**27. 5S stands for ____________________**

**28. Which of these should you stop and think about before attempting to lift a load?**
A. The weight of the load
B. The size and shape of the load
C. The best way of gripping the load
D. All of the above

**29. Which one of the following is NOT classified as a manual handling activity?**
A. Throwing
B. Pushing
C. Carrying
D. Pulling
1. Which kind of injury is the most common when manual handling?
A. Broken Limbs
B. Headaches
C. Sprains
D. Musculoskeletal disorders

**30. Which type of accident kills the most construction workers? Give one answer**
A. Being hit by a falling object
B. Being run over by site transport
C. Contact with electricity
D. Falling from height

**31. When can you use a ladder at work? Give one answer**
A. If it is long enough
B. If other people do not need to use it for access
C. If you are doing light work for a short time
D. You must never use a ladder on site

**32. What must you do when you are climbing a ladder? Give one answer**
A. Have three points of contact with the ladder at all times
B. Have two people on the ladder at all time
C. Have two points of contact with the ladder at all times
D. Use a safety harness

**33. How many people should be on a ladder at the same time? Give one answer**
A. One
B. One on each section of an extension ladder
C. Three, if it is long enough
D. Two

**34. A Personal Fall Arrest System should ensure that it brings the employee to a complete stop and its maximum deceleration distance should be:**
A. 3 ½ feet
B. 5 feet
C. 6 feet
D. 6 ½ feet

**35. The angle of the ladder should be so that the ladder's base is one foot out from the ledge for each four feet of a ladder's height.**
A. True
B. False

**36. A confined space has the following characteristics:**
A. Large enough and so configured that an employee can bodily enter and perform work
B. Limited or restricted means of entry or exit
C. Not designed for continuous human occupancy
D. All of the above.

**37. Which of the following are hazards that may be encountered in a confined space:**
A. Materials that can engulf an entrant
B. Moving machinery
C. Oxygen deficiency
D. All of the above

**38. An empty chemical storage tank is not considered a confined space:**
A. True
B. False

**39. The fire watch is only allowed to watch for fires and does not have the authority to stop the hot work operation.**
A. True
B. False

**40. A fire watch should be performed for at least how long after the work is completed**
A. 5-minutes
B. 15-minutes
C. 30-minutes
D. 60-minutes

**41. Companies are required to:**
A. Provide certain types of PPE at no cost to the employee.
B. Train employees on the use of PPE.
C. Monitor and enforce the use of required PPE.
D. All the above.

**42. Properly selected hand protection can protect employees from burns, electrical shock, and chemical absorption.**
A. TRUE
B. FALSE

**43. PPE must be inspected prior to use.**
A. TRUE
B. FALSE

**44. What type of protection is needed when you are exposed to hazards from flying particles?**
A. Eye protection
B. Face protection
C. Head protection
D. Both A and B

**45. Power tools should not be used in damp or wet locations.**
A. TRUE
B. FALSE

**46. It is safe to use the top step of a ladder.**
A. TRUE
B. FALSE