A FRAMEWORK FOR EFFECTIVE CONSTRUCTION SAFETY TRAINING USING FLIPPED LEARNING

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This is to certify that the

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DEDICATED

TO

MY LOVING PARENTS

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ABSTRACT

The effectiveness of safety training practices is an important part of safety management on a construction site. In order to promote construction worker safety on a construction site, a sound safety training regime has to be inculcated. Lack of importance given to safety training and high cost of training has adversely affected the safety landscape in the construction industry. Flipped learning has become popular across the world as a new form of teaching. It is a pedagogical approach in which the conventional concept of classroom-based learning is altered, so that students are introduced to the learning material before class in the form of web-based informational videos, power point presentations, and assigned readings. The first stage of the study involved detailed literature about safety training issues and inefficiencies. Subsequently, benefits of Flip Learning were identified, and the link between them and inefficiencies of safety training was found. Some benefits of flip learning can, in theory, mitigate the inefficiencies of safety training. A case study comparing two groups of trainees showed a higher understanding of concepts by those taught with the Flipped Classroom Model. This study after conducting a comprehensive analysis of both approaches, traditional and Flip, concludes that the latter cuts cost and improves learning outcomes in construction safety training education. Workers are able to pause, rewind, and replay the lectures in the proposed flipped learning model. It saved the time of both workers and trainers, thus improving safety on site in an affordable manner.

Chapter 1

INTRODUCTION

1.1 STUDY BACKGROUND

A total of 7% of the workforce around the globe is a part of the construction industry; enabling the industry to be accountable for a large share of fatalities and casualties (Sunindijo 2015). The industry has a vital role in the GDP contribution and economic growth of a country; in view of encompassing the availability of modern infrastructure depicting the status of development in a country (Ishkov, Mishlanova, and Grabovyi 2016). The industry is more prone to mishaps at the workplace which could easily escalate to constitute critical issues if adequate safety training is not provided. These mishaps could be prevented by educating the masses about protective policies and instrumentation used at workspace via proper safety tutelage (Pereira et al. 2019). Labor forces are an essential asset of the construction industry; thus, their protection is a highly important task that needs to be resolved on a priority basis. The industry has been facing a plague recording a high rate of safety incidents apart from contributing to the national economy (Shahab Hosseinian and Jabbarani Torghabeh 2012). In the context of safety, the construction industry has manifested to be a hazard-prone one, although efforts are being made to increase safety performance in the industry (Shahab Hosseinian et al. 2015).

To ensure safety at a workspace one of the best techniques is safety training, which can prove to be a source of awareness of masses and hazard recognition. 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 the construction context (Haslam et al. 2005). Contemporary findings have manifested that a greater proportion of safety perils remain unrecognized in construction workplaces. Pertaining to improvisation of safety practices at construction workspace there is a dire need to adopt a specific training and hazard recognition practice. Though safety tutelage has been adopted by the construction industry but yet it had not manifested any significant effect in contrast to the anticipated benefits; it is due to inefficient training practices (Jeelani, Asce, et al. 2017). Most construction worker education and training environments apply traditional instructing using conventional teacher-student classroom settings. Therefore, an innovative environment is required to make training more effective.

Education and skill enhancement of masses working at a construction site is a vital issue in safety management (Shahab Hosseinian and Jabbarani Torghabeh 2012). To ensure a safe and healthy environment in a construction workspace it is essential to adopt education practice from a safety perspective; on the contrary, the contemporary pedagogical approach has been unable to demonstrate safety practices to the students in physical format and experiencing (Le, Pedro, and Park 2015). One of the core areas where the construction industry needs improvement is in the field of health and safety (Paton 2009). It is conclusively evident that the incorporation of safety training has revolutionized the culture of precaution adoption and hazard identification throughout the construction industry from the latest figures (Dong et al. 2004). A proactive and collective method to recognise and eliminate hazards prior to any casualty at a site is known as health and safety management system. Protection of workers, saving money, and formulating hazard-specific programs more effective due to adoption and implementation of safety and health management systems (OSHA n.d.). Regrettably, current research trends demonstrate that a large part of safety hazards remain unidentified at construction sites. Employer adopt a variety of safety and hazard-recognition training programs for improving hazard-recognition levels.

1.2 PROBLEM STATEMENT

Poor hazards recognition has been a flaw in the construction industry despite the adoption of safety education practice; traditional hazard recognition methods and training programs have failed to address the beforementioned issues (Shahab Hosseinian et al. 2015). Research conducted by (Haslam et al. 2005) manifests that workers despite having enough (based on traditional teaching process) safety training fail to comply with standards and identify hazards. (Guo et al. 2012) identified improper safety training and outdated teaching methods to be the reason for the rise in on-site injuries. Health and safety training is an essential element for the success of construction projects (Guo, Yu, and Skitmore 2017). Health and

Safety Training ensures a person to be learned about hazards existing at construction workplaces, alongside, incorporates a relevant perception-reaction sense into personnel regarding safety hazards (Dumrak et al. 2008).

Backed by technological advancement, the world has revolutionized itself in many aspects, one of such belongs to the education sector in face of a reverted model known as “The Flipped Classroom” (Majumdar 2013). This model has not limited to technology-related activities only i.e. video lessons pertaining to the curriculum but it also incorporates an effective classroom with maximum engagement and interest of learners (Sams and Washington 2012). Learners are provided with the relevant material in an outdoor environment prior to the lectures, which enable them to already get affiliated with a respective idea of a concerned topic and be learned at the time of perusal on one hand. On the other hand, the engagement session that is to be held is devoted to problem solving via strategy formulation and class interaction such as collaborative discussions, peer interaction sessions, problem-solving exercises, in-depth experiments, or simulations (Hao 2016).

Several studies have been done to address the issues in construction safety education. There are numerous ways to implement the training pertinent to Health and Safety, some such applications are: online training programs, easily accessible safety training applications, Building Information Modelling (BIM) accident simulations, immersive Virtual Reality (VR), Augmented Reality (AR), Mixed Reality (MR) and game engines techniques, etc. (Xu, Zhang, and Hou 2019). Wang et al. (2016) have used BIM and Augmented Reality accidental simulations for safety training. VR was used to train workers about Safety Practices by (Dumrak et al. 2008). (Gao, Gonzalez, and Yiu 2019)have employed game engine techniques for better understanding about Safety. The training for health and safety has been vital to the success of construction projects (Guo et al. 2017).

None of the above-mentioned studies have used the technique of Flipped learning in safety training education, thus leaving a gap for a new study. So the question arises whether Flip Learning model can mitigate the inefficiencies of the safety training education

In brief, the traditional methods of safety training have several inherent problems and there is a need to adopt new techniques and technologies for safety education which provide a physical or virtual experience to the attendee in order to achieve better results in occupational safety behaviour.

1.3 RESEARCH OBJECTIVES

- To determine inefficiencies in construction safety training education
- To develop a framework for construction safety training tool based on flipped learning.
- To evaluate the performance of the developed flipped learning safety training tool.

1.4 SIGNIFICANCE OF STUDY

Safety training has been neglected over decades, but now the trend is shifting as people are getting aware of the need for safety implementation on site. As construction training cost is very high and interactive methods, for trainees' effective engagement, to improve the quality of training performances are quite limited. This study undertaken would help our construction safety industry to teach the workers more effectively in terms of cost and performance.

This thesis is divided into five chapters starting with the study's introduction, including its problem statement and the need for carrying out the study. A literature review follows the introductory portion in chapter 2, explaining previous research related to construction safety and flip learning. It also draws a correlation between the two as the thesis moves onto the next chapter with the conceptualization of the framework for the case study and validation. The fourth chapter deals with results and its subsequent discussion. This portion highlights what the study results entail and what were the outcomes of performing the said study. It also includes feedback obtained after the implementation of the study to help us understand the benefits of the Flipped model implementation from a trainee perspective. Finally, the last chapter concludes the thesis with a well-rounded summary of the problems of safety training, the benefits of flip learning, and how the Flipped model implementation could relieve some of the inefficiencies. It also highlights the limitation of the case study and future lines of research.

Chapter 2

LITERATURE REVIEW

2.1 SAFETY

Owing to its complex nature of work the construction industry is most prone to accidents (Shahab Hosseinian et al. 2015). In 2014, a total of 21% of accidents and fatalities that occurred globally were investigated to be observed on construction sites (Saleh and Pendley 2012). The construction workers are more prone to fatalities due to the observed probability of fatality being 3 times higher and injury being 2 times higher than any other employee of other industry (Sousa and Teixeira 2004). Project delays and cost overruns have been observed as the prime consequences resulting due to the complicated environment of the industry that is still vulnerable to high accident rates (Lee, Salama, and Kim 2016). The construction industry remains vigorously dangerous even after the number of years in research, policy reformation, and advanced initiatives in several domains and fragments of the globe. One clear example is that in 2015, the Australian construction industry had to face 37 fatalities during construction execution (Safe Work Australia 2015). A similar case has also been observed in the UK construction industry where 35 fatalities were also reported in the same year (HSE 2015). Due to meager resources for safety insurance, the statistics of developing countries manifest to be much worse and highly unreliable. More than sixty thousand fatal cases are reported annually from construction projects around the world (Lingard 2013).

The survival of companies has been quite a challenge due to safety accidents. These may cause harm to the reputation of the firm transitioning from stellar to tarnished; alongside, the cost incurred for these incidents prominently impinges on profit margins and severely impacts the success of projects (Sunindijo 2015). Millions of dollars have been invested by construction firms for the betterment of safety performance via training of their workforce on safety challenges comprising hazard identification, management, and effective prevention methodology. Amid such efforts, recent researches demonstrate that construction workers are lacking fundamental safety knowledge and skills. (Haslam et al. 2005) observed that inadequate safety knowledge or skill has been the root cause of over 70% of the incidents occurring on a construction site.

A proactive and collaborative process to identify and mitigate workplace hazards before an injury or illness is known as a safety and health management system. Protection of construction workers, saving resources, and effective hazard-specific programs are some pros of the safety and health management system (OSHA n.d.). A severe incident or injury could be resulted due to unidentified or mishandled hazards that expose workers to non-contemplated safety risks. Unfortunately, the recent trend observed in distinct research manifests that maximum safety hazards at construction sites remain unidentified. Thus, the necessary benefits from safety training have not been conceived as per expectations. Adoption of poor and ineffective training practices had been the main problem for such failed attempts of training (Jeelani et al. 2016). The conventional method for hazard recognition and training manuals has not fulfilled the purpose of poor hazard identification (Burke et al. 2011). Research has demonstrated that despite having the implementation of hazard recognition methods and substantial safety training the workers have not been able to properly recognize a hazard (Shahab Hosseinian et al. 2015). Guo et al. (2012) pointed out that a major increase in on-site injuries has resulted from improper safety training.

Traditional tutelage comprises conventional practices such as the delivery of the lecture, verbal apprise of using the toolbox, handouts, and audio as well as visual material (e.g., video demonstration) (Blanchard and Simmering 2008). Due to the nature of being an experiential learner, a construction worker is prone to losing interest in memorizing safety regulations and would require more proactive tutelage mechanisms (Harfield et al. 2007). Contemporary training mechanisms for health and safety such as induction training sessions, lectures or presentations, on-site training sessions, video demonstration, and mock training practices have the disadvantage to be dyadic, specific, outdated, and are often created to comply with legislation instead of acquiring modern skills. Assessment methods also encounter the aforementioned problems (Z. Ismail et al. 2012).

2.2 INEFFICIENCIES IN CONSTRUCTION SAFETY EDUCATION

The education of the workforce and its upskilling is a core issue in the safety management system (Shahab Hosseinian and Jabbarani Torghabeh 2012). Thus, to improve and enhance the performance of the construction industry in the execution stage, health and safety training is the basic area that needs to be carried out effectively (Paton 2009). A considerable change in performance to an improvement of safety behavior and reduction of hazards in the workplace have been observed through the intervention of safety training (Dong et al. 2004).

To attain the first objective of this study an extensive literature review was carried out that identified the inefficiencies existing in construction safety education. Table 1 shows the inefficiencies pointed out in the literature and collated in a tabular form. There were 18 identified inefficiencies from 38 research papers studied during this literature review. The third column in the table mentions the papers in which each inefficiency is stated.

Table 1. Inefficiencies in construction safety training identified from literature

Notation	Inefficiencies	Authors
X1	Lack of engagement of trainee during the training	(Burke et al. 2006; Cherrett et al. 2009; Dumrak et al. 2008; Forst et al. 2013; Haslam et al. 2005; Jeelani, Asce, et al. 2017; Teizer, Cheng, and Fang 2013)
X2	Lack of effectiveness in training	(Bunch 2007; Burke et al. 2011; Demirkesen and Arditi 2015; Dumrak et al. 2008; F. Ismail et al. 2012; Jeelani, Han, and Albert 2017; Nielsen 2014; Tam and Fung 2012)
X3	Training is boring	(Bevan, Barry, and Darren 2007; Choudhry and Fang 2008; Demirkesen and Arditi 2015; Furnham 2005a)b
X4	Training cost is high	(Forst et al. 2013; Furnham 2005b; Kelloway, Kelloway, and Cooper 2011; Loosemore and Andonakis 2007; Sunindijo 2015; Wang et al. 2010)

X5	Trainer and trainee spend more time in training	(Kelloway et al. 2011; Li et al. 2015; Ruttenberg 2004; Wang et al. 2010)
X6	No timely feedback about training	(Burke et al. 2011; Cherrett et al. 2009)
X7	Training content is not well designed according to the need of the trainee	(Bunch 2007; Choudhry and Fang 2008; Demirkesen and Arditi 2015; Haslam et al. 2005; Tam and Fung 2012)
X8	Unqualified training staff	(Bunch 2007; Demirkesen and Arditi 2015; Namian et al. 2016)
X9	Lack of awareness about the importance of safety training	(Bottani, Monica, and Vignali 2009; Choudhry and Fang 2008; Demirkesen and Arditi 2015; Forst et al. 2013; Haslam et al. 2005; Z. Ismail et al. 2012; Loosemore and Andonakis 2007; Ruttenberg 2004; Tam, Zeng, and Deng 2004; Wang, Zou, and Li 2016)
X10	Lack of management during safety training	(Alarcón et al. 2016; Demirkesen and Arditi 2015; Namian et al. 2016; Tam et al. 2004)
X11	No incentive for timely completion of training	(Z. Ismail et al. 2012; Namian et al. 2016)
X12	Lack of communication gap between trainers and trainee	(Bottani et al. 2009; Dumrak et al. 2008; Lee, Hackett, and Estrada 2015; Loosemore and Andonakis 2007; Tam and Fung 2012)
X13	Lack of innovations in training	(Demirkesen and Arditi 2015; Furnham 2012; Jeelani, Han, et al. 2017; Tam et al. 2004)de
X14	Lack of immersive and realistic environments	(Demirkesen and Arditi 2015; Gao, González, and Yiu 2017; Jeelani, Han, et al. 2017; Liaw et al. 2012; Lo, Hew, and Chen 2017; Wang et al. 2018)
X15	Lack of evaluation in safety training	(Bevan et al. 2007; Dumrak et al. 2008; Liaw et al. 2012)
X16	Lack of motivation about safety training	(Han et al. 2008; Liaw et al. 2012)
X17	Improper training delivery method	(Burke et al. 2011; Haslam et al. 2005; Jeelani, Han, et al. 2017; Namian et al. 2016)
X18	Lack of interest for investment in safety training	(Furnham 2005b; Namian et al. 2016)

Then these inefficiencies were subject to content analysis for their literature-based scoring and measuring of their critical impact as shown in Table 2. From the table, we can see the most pressing issues in the safety training education include less effectiveness and engagement, no timely feedback about training, high cost of training and a lack of motivation to implement safety. Other factors include poor communication gap between the trainer and trainees, poor management, lack of ICT integration, and shortage of competent trainer.

Table 2. Content Analysis to determine literature score

Rank	Inefficiencies	Literature Score	Normalized Score	Cumulative Score
1	Lack of effectiveness in training	15.789	0.235	0.352
2	Lack of engagement of trainee during the training	7.894	0.117	0.117
2	No timely feedback about training	7.894	0.117	0.580
3	Lack of awareness about the importance of safety training	6.315	0.094	0.7450
4	Lack of immersive and realistic environments	4.605	0.068	0.913
5	Training cost is high	3.157	0.0470	0.423
6	Training content is not well designed according to the need of the trainee	2.763	0.041	0.621
7	Trainer and trainee spend more time in training	2.631	0.039	0.462
7	Improper training delivery method	2.631	0.039	0.994
8	Lack of communication gap between trainers and trainee	2.368	0.035	0.821
9	Unqualified training staff	1.973	0.029	0.650
9	Lack of management during safety training	1.973	0.029	0.774
9	Lack of evaluation in safety training	1.973	0.029	0.943

Rank	Inefficiencies	Literature Score	Normalized Score	Cumulative Score
10	Lack of interest in training or training is boring	1.578	0.023	0.376
10	Lack of innovations in training	1.578	0.023	0.845
11	No incentive for timely completion of training	0.789	0.011	0.786
11	Lack of motivation about safety training	0.789	0.011	0.954
12	Lack of interest for investment in safety training	0.394	0.005	1

Subsequently, to validate these inefficiencies, a preliminary survey was conducted among the professionals working in the field related to the construction industry. The survey questionnaire asked about the 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. Due to the unavailability of the proper data sample size of 30 was assumed and in total 32 responses were recorded. The demography of respondents is recorded in Table 3.

Table 3. Experience of respondents

Experience	No of Questionnaires filled	Percentage
0 - 5 years	12	40 %
6-10 years	10	33 %
11 - 15 years	5	17 %
More than 15 years	3	10 %

Furthermore, an analysis was performed to calculate the relative importance index of the inefficiencies to gauge their impact on construction safety training education thus yielding in field based ranking of the found inefficiencies. As seen in Table 4, Companies' unwillingness to invest in safety, lack of awareness about safety and inadequate incentivisation related to trainings are the top three hurdles to effective safety education.

Table 4. Field Analysis of the responses for validation of inefficiencies

Rank	Inefficiencies	Average Survey Score	Normalized Score
1	Companies are not willing to invest in safety training	4.233	0.846
2	Lack of awareness about the importance of safety training	4.066	0.813
3	Low incentives for successful completion of training	4.033	0.806
4	Lack of interest in training or training is boring	3.933	0.786
5	Lack of engagement of trainee	3.866	0.773
5	Lack of monitoring in safety training by higher management	3.866	0.773
6	Trainees are not motivated about safety training	3.666	0.7333
7	Trainees are not assessed at the end of the training	3.566	0.713
8	Lack of innovations in training techniques	3.433	0.686
9	Improperly designed training content	3.312	0.666
10	High cost of training	3.266	0.653
11	Lack of effectiveness in training	3.233	0.646
12	The communication gap between trainers and trainee	3.123	0.622
13	Lack of immersive and realistic environments	3.067	0.611
14	Lack of feedback about training	2.966	0.593
15	Trainer and trainee spend more time in training	2.833	0.566
15	Unqualified training staff	2.833	0.566
16	Improper training delivery method	2.633	0.526

After obtaining the field score, the merging of field and literature scores was done. A ratio of Sixty to Forty was used such that the former represent field score while the latter is literature score. The final ranking and respective score of inefficiencies is given in Table 5. Field was given higher weightage to reflect the input from the industry.

Table 5. Sixty-Forty Analysis of Field and Literature Score

Rank	**Inefficiencies**	**Field Score**	**Literature score**	**60-40**
1	Lack of awareness about the importance of safety training	0.813	0.094	0.525
2	Lack of interest for investment in safety training	0.846	0.005	0.510
3	No incentive for timely completion of training	0.806	0.011	0.488
4	Lack of interest in training or training is boring	0.786	0.023	0.481
5	Lack of engagement of trainee during the training	0.773	0.117	0.511
6	Lack of effectiveness in training	0.646	0.235	0.482
7	Lack of management during safety training	0.773	0.029	0.475
8	Lack of motivation about safety training	0.733	0.011	0.444
9	Lack of evaluation in safety training	0.713	0.029	0.439
10	Lack of innovations in training	0.686	0.023	0.421
11	Training content not well designed according to the need of the trainee	0.667	0.041	0.412

Rank	Inefficiencies	Field Score	Literature score	60-40
12	Training cost is high	0.653	0.047	0.410
13	No timely feedback about training	0.593	0.117	0.403
14	Lack of immersive and realistic environments	0.613	0.068	0.387
15	Lack of communication gap between trainers and trainee	0.623	0.035	0.386
16	Trainer and trainee spend more time in training	0.566	0.039	0.355
17	Unqualified training staff	0.566	0.0294	0.351
18	iImproper training delivery method	0.5266	0.0392	0.331

2.2 FLIPPED LEARNING

To attain productive, creative, effective, and attractive learning platforms, several technological approaches have been devised i.e. visualization, educational software and learning management platforms, etc. (Sezer, Elcin, and Topbaş 2018). With the widespread adoption and increasing fame of digital technologies in the world, flipped tutelage has also evolved as a creative learning practice for advanced studies (Steed 2012). Traditional teaching has mostly emphasized instructor-based lecture delivery. But now this traditional teaching paradigm has shown a transition towards a flipped classroom that focuses on student learning (Hew and Lo 2018). The roots of Flipped tutelage method are associated with the science teachers Jonathan Bergmann and Aaron Sams at the secondary education level, upon their idea of recording live videos of lectures for the students who missed their class (Jonathan 2012). These instructional videos started to gain fame proportionately, as they enabled the student to review information at home while addressing their home assignments (Conley, Lutz, and Miller 2017).

According to (Sams et al. 2014): an academic-related approach dealing with direct instruction transfer/movement from group learning platform to individual learning platform is known as Flipped Learning. The guidance of students for concept application and creative engagement in subject content is the result of this transformation of group space. An inverted method of tutelage that flips the traditional activities i.e. the class-based work as content presentation etc. become home-based activities and the home-based works like assignments etc. become class content is a new and popular instructional model (Sams et al. 2014). In this technique, the student commands and governs the learning process and pace individually while the tutor encourages the students rather than just delivering the information (Caviglia-Harris 2016). The time of class is consumed in activities like group discussions, cross-examination, concept clearing, and interactive learning as the tutor can engage with students comprehensively due to no physical lecture concept. Nowadays, flipped learning idea has widely been acknowledged and adopted in various disciplines like math, social sciences, humanities, etc., and also in schools and universities around the world (Hao 2016). The model involves a collaborative learning process enabling the students to incorporate a sense of responsibility for group learning along with individual learning tasks by interactive classes (Sams et al. 2014).

The flipped technique is a learner-centric approach whose concept has unfortunately been miscarried by many learning professionals, it is not merely about watching visual/graphical lectures from outside the classroom and doing homework in class but here the educator actively considers the best technique to use class time so that learning and retention are maximized (Nederveld and Berge 2015).

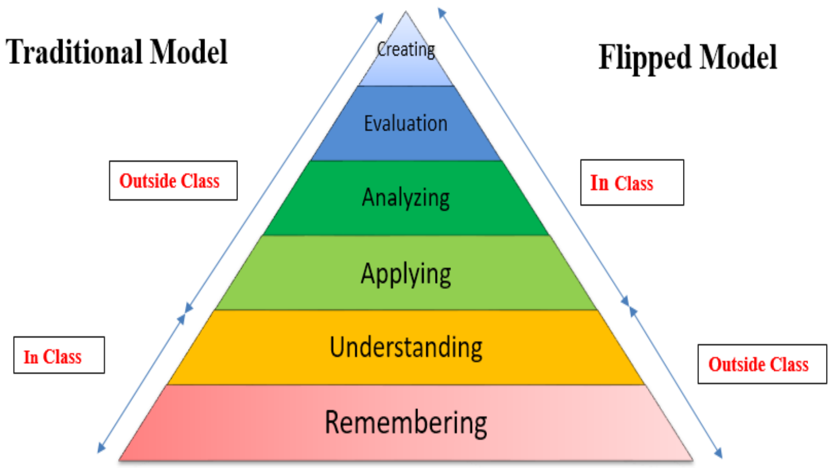

Figure 1 Traditional Model vs Flipped Model

2.3 BENEFITS OF FLIPPED LEARNING

Numerous studies have been carried out in the domain of flipped tutelage that describes its importance (Akçayır and Akçayır 2018); one such importance is the adoption of technological advancements for interactive learning and understanding of students. Moreover, this method of tutelage creates a virtual space for the availability of online video lessons while actively motivating the class to participate in the lectures (Fidalgo-Blanco et al. 2017). This feature of flipped tutelage helps students with ample time to embark upon and conduct research on a particular topic in pre-class time and be prepared for a better understanding of the topic during class sessions (McDonald and Smith 2013). Alongside, this flexibility of content availability also helps the overburdened student to be able to learn any missed lecture (Jonathan 2012).

There are several benefits of flipped tutelage but the most prominent are flexibility in learning, interactive engagement of all the participants, constructive outcomes, and objective achievement for better understanding (Velegol, Zappe, and Mahoney 2015). In this method, the student is better able to achieve higher learning outcomes due to ample availability of discussion time for learning modules that enhances active, constructive, and interactive engagement; on the contrary, conventional tutelage consumes more time in lecture delivery with a passive mode of learning (van Alten et al. 2019). Contemporary studies manifest that students are coming better prepared in this mode of learning and are devoted more time to learning along with better study techniques comparing to regular classroom approaches (Papadopoulos and Roman 2010).

2.4 FLIPPED LEARNING AND TRAINING

In contrast to the benefits of flipped learning in education and instruction in classrooms, a parallel potential domain exist in training for corporate sector professionals. The use of learning platforms like Human Resource Management Systems etc. in the distinct blended way, and flipped learning environments can generate modern, interactive learning spaces for education and training of employees to capitalize on their capabilities before implementing them on the job (Conley et al. 2017). Flipping of the corporate sector in the training domain bring about a lot of benefits like a reduction in travel cost, actively engaging and generating learning content within the office premises that will add a value point for practice and efficient training of the professionals (Conley et al. 2017).

One of the potential domain is training in planning and strategic management of distinct knowledge areas like procurement, stakeholder engagement, work ethics, Human Resource Management, Safety Management, quality management, etc. in which the usage of class time to simulate on-the-job scenarios produce the opportunity to determine learner potential and its usage for firm's successfulness (Pierce 2011). The adoption of the inverted classroom method can lead to having effective training in various aspects of the construction industry too, one such aspect is Health and safety that has been a core problem /challenge.

2.5 FLIPPED LEARNING AND BLOOM'S TAXONOMY

Bloom's taxonomy (Bloom et al. 1956) was utilized to induce critical-thinking skill sets into multiple-choice examinations with questions that were formulated to span the full range of Bloom's taxonomy categories. Bloom's taxonomy was suggested by Benjamin Bloom who was committed to the study of educational objectives and intellectual behaviors important in pedagogy. He proposed a taxonomy of educational motives to facilitate communication to minutely define and categorize randomly defined terms such as "thinking" and "problem-solving."

It highlights six cognitive skill levels in order of increasing complexity, organizing the types of thinking required to achieve learning goals, and developing or assess critical thinking skills (Krathwohl 2017). 2001 (and 1956) Bloom's Taxonomy (Zimmaro and Ph 2010): consists of six overlapping levels of thinking skills that are comprised of remembering**,** understanding**,** applying**,** analyzing**,** evaluating, and creating. The first three levels are considered for lower-order thinking skills, while the last three are recognized higher-order thinking skills.

This version of Bloom's Taxonomy is linked to flipped learning in that the passing-over of information, which is the foundation for learning, is obtained without any influence and outside of class; while the assimilation of information, which requires greater critical and logical reasoning that occurs during class under the supervision of a potential supervisor or trainer (Zainuddin and Halili 2016).

In the Flipped Classroom, knowledge is categorized into many different levels by using Bloom's taxonomy. Information that is communicated outside the classroom in the form of a video tutorial is given classification at the low levels of Bloom's taxonomy (remembering and understanding) (Gross and Musselman 2018). These levels do not need much effort from the learner and can be achieved from outside the classroom. It is based on the direct instruction method. At the same time, it is privileged by the information processing theory by splitting the content into small sequential chunks to refrain from the issue of cognitive load upon the learner (Morton and Colbert-Getz 2017; Tolks et al. 2016). Tasks that are implemented inside the classroom are classified at the top levels of Bloom's taxonomy (applying, analyzing, evaluating, and creating). These levels benefit from the power of the active learning technique, whose foundation lies in learner-centered theories by encouraging learners to establish their knowledge under the supervision of the teacher (Bishop and Verleger 2013; Galway et al. 2014).

The chapter enumerated the inefficiencies inherent to the traditional safety training models prevalent in the construction industry. These inefficiencies identified from the literature helped us gauge the extent of issues and their effects in traditional training models, thus calling for a novel approach which could mitigate them. This new approach can be flip learning, whose benefits were also enlisted from literature. The correlation between one system's inefficiencies to the other's benefits also reinforces our belief that flip learning could prove helpful in developing an advanced training method with a major focus on application rather than theoretical learning. Hence, the Flip training model can be helpful in addressing the issues inherent to traditional safety trainings.

Chapter 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter of the study describes the technique and method to achieve the objectives described in chapter 1. The research is designed in compliance with the detailed research process (including literature review, framework development, and its validation).

3.2 RESEARCH DESIGN

For the first objective of our research, a detailed literature review has been carried out from several research articles to identify the inefficiencies that exist in our construction safety education. A preliminary survey has also been carried out among the professionals in our construction industry, to validate the existence of inefficiencies identified from the literature.

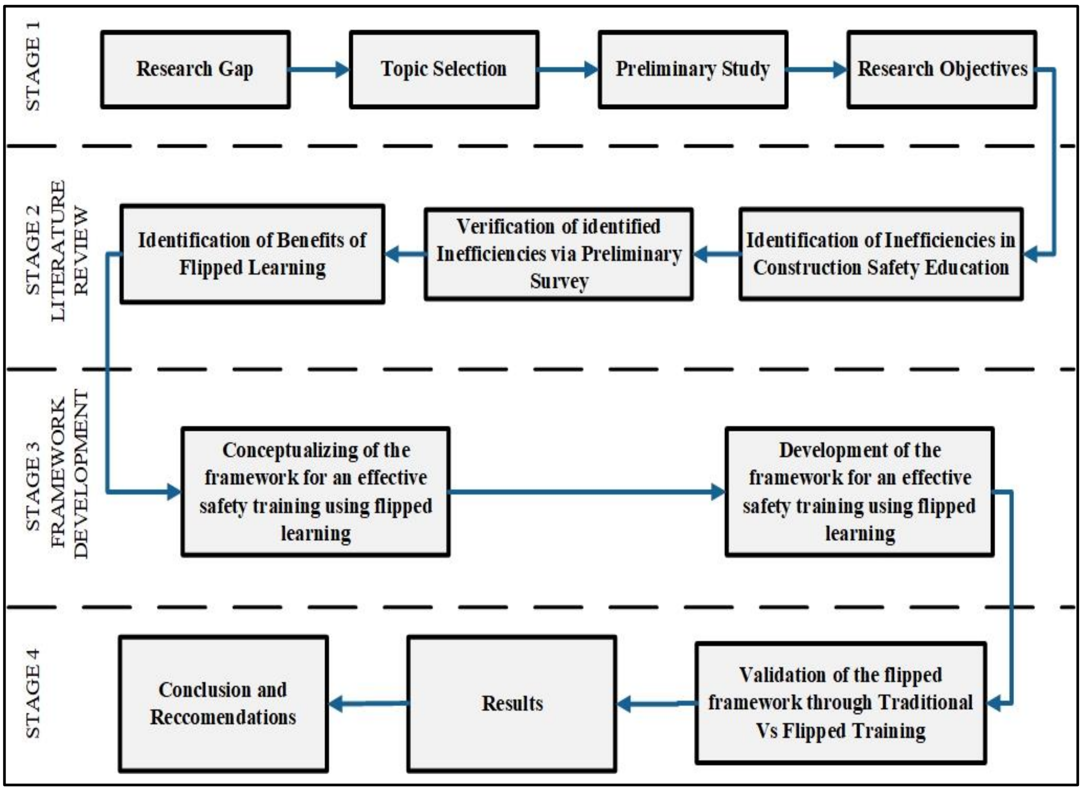

Figure 2 Process Flow Chart of Research

We studied the potential of construction safety education and Flipped Learning, discussed in the literature to eradicate the inefficiencies identified in the first phase. To achieve the second objective, the elements of the framework are to be decided in accordance with Flipped Learning. The contents shall include pre-class, in-class, and assessment features. These features will be sub-divided in detail based on Flipped Classroom model. To achieve the last objective this framework will be validated by implementing the designed model on a construction site and obtaining the difference between the traditional and Flipped model. Figure 2 shows the methodology of this research.

3.2 A FLIPPED TRAINING FRAMEWORK FOR CONSTRUCTION SAFETY

It is essential to create an interactive engagement environment to carry out an effective training session. Such an environment will not only boost the interest of trainees but also it will create the confidence for adaptation. The development of the flipped classroom framework for this study starts with extensive research of previous implementation models of the flipped training model.

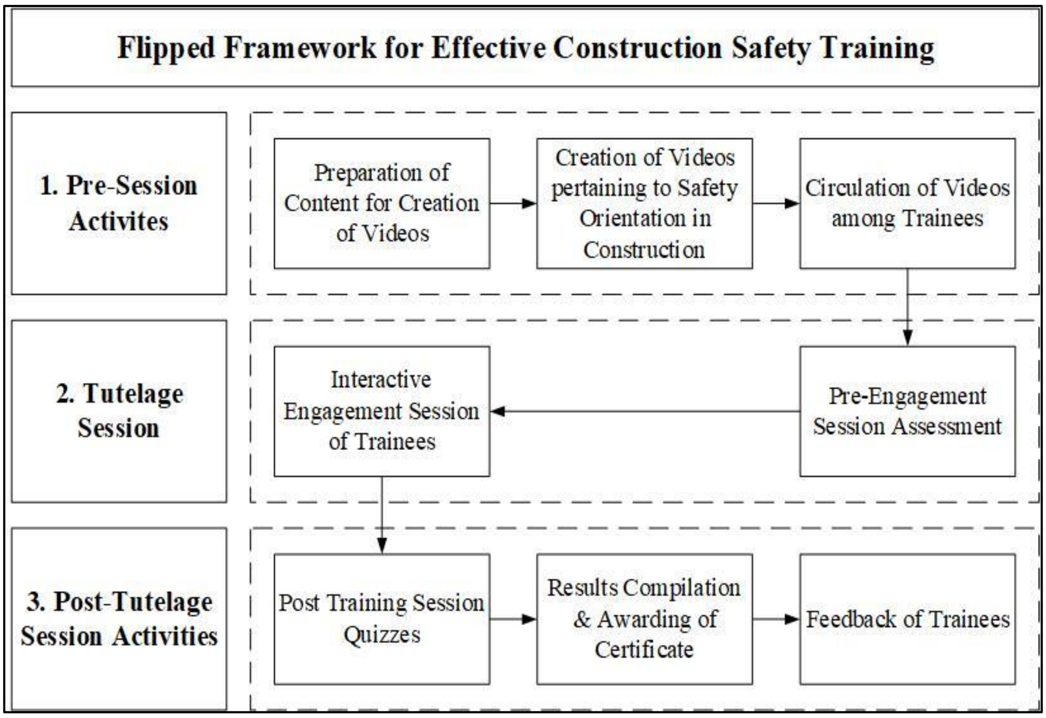

Figure 3 Flipped framework for construction safety education

The model relies on teaching two separate groups with different tutoring styles. One group study is based on the traditional model, while the other group is taught through the flipped classroom or the inverted classroom concept. There are three broad categories of the proposed framework, as shown in Figure 3, to implement the Flipped model in the construction safety education.

3.2.1 Pre-Session Activities:

This section of the framework deals with the activities dealing with the pre-interaction session. In this part, the trainer adopts to create a sense of affiliation of the topic by giving pre-learning knowledge. This is adopted via the 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's skills. The proposed framework deals with the 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 the conceptualization of the tutelage topic and its aspects of coverage, as shown in Figure 3. Then this content is subjected 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 the creation of video lectures. After the creation of videos, they are circulated among the trainees. These videos are circulated to get the trainee affiliated with training aspects.

3.2.2 Tutelage Session:

This section of the framework deals with the interaction session among the trainees and tutors. But before this interactive engagement session, a pre-session quiz is held to find the effectiveness of the video lecture circulated at the initial stage. The engagement session is held in accordance with the results of the quiz held. In the engagement session, a cross-questioning and concept clearing session is held physically among the instructor and trainees. This session also comprises a discussion between the instructor and trainees. This discussion ultimately results in the conceptualization of the aspect to be covered in the training session. The session relates to the topic circulated in 1st phase of the framework. Moreover; this phase of the framework is focused upon resolving the issues observed by a trainee when going through the virtual learning resource, as shown in Figure 3.

3.2.3 Post Session Activities:

This section of the framework deals with the activities that are to be held after the tutelage session, as shown in Figure 3. This part is mostly concerned with the complete process of the training. In this section, a final quiz for the award of completion certificate is held. On basis of the results, trainees are awarded a certificate of completion. Apart from post-training quizzes and completion certificates, a feedback session is also included in this portion of the framework. This feature of acquiring feedback regarding the tutelage framework will help to improve practice in future endeavours. This part of the framework helps in creating a sense of competence for the training aspect.

Chapter 4

EVALUATION

As conducted by (Gilboy, Heinerichs, and Pazzaglia 2015) in their study, the evaluation process for the framework is processed in the same way of contrasting the devised framework against traditional training practice. Two groups of trainees are delivered the same course content and assessed similarly. However, one group is given instructions based on the flipped learning model, while the other group receives instructions in the traditional lecture-style approach.

4.1 TRADITIONAL TRAINING METHOD VS FLIPPED FRAMEWORK FOR CONSTRUCTION SAFETY TRAINING

Forty personnel working in a leading firm in the construction industry of Pakistan were selected for the training of construction safety. For this process, twenty professionals were engaged in the traditional training method, and twenty professionals were tutored by using the flipped model proposed above.

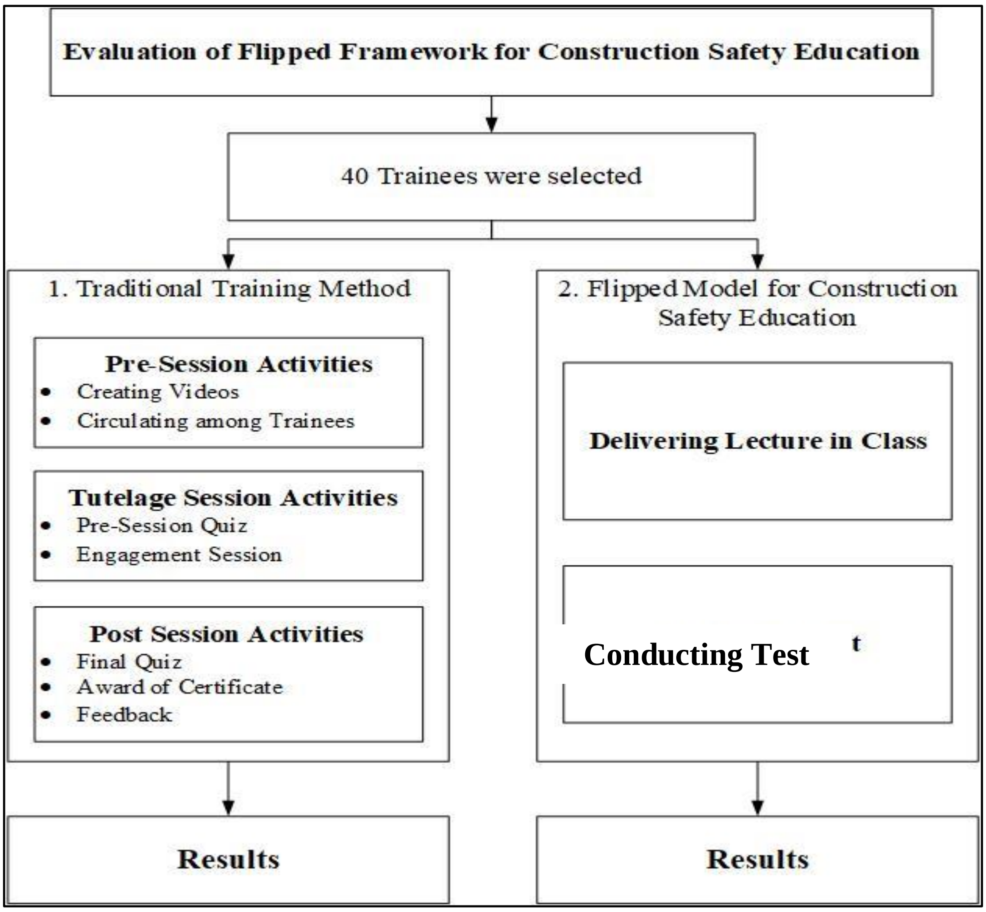

Figure 4 Evaluation Methodology

Then the results obtained after tutoring were compared. In the traditional method, 20 professionals were tutored regarding distinct aspects of safety. A physical setup for learning was established for the traditional teaching process. The processes as shown in Figure 4 were followed to achieve the evaluation prospect of the developed framework for the inverted learning process.

Gender distribution as shown in Figure 5 of the trainees was also an important factor in their selection for this study as the corporate sector in general and construction industry in particular has seen a slight increase in women’s enhanced role in every sub field. In the traditional method of safety training, the female participation in this study were four in number and hailed from different organizations where in comparison the males were a total of sixteen.

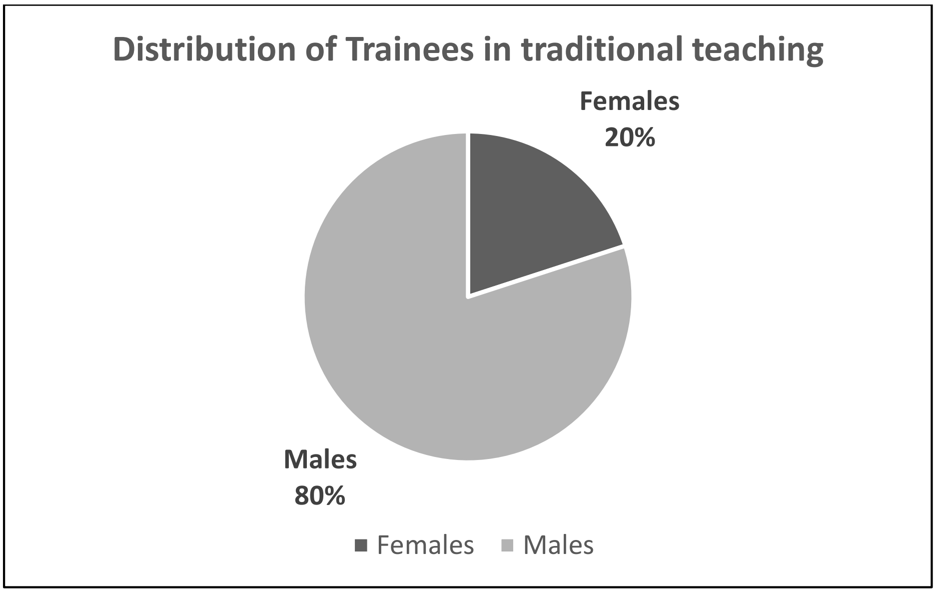

Figure 5 Pie chart of Trainees involved in Traditional teaching

The demography for students in total was 32 males and 8 females all were employees of a leading construction firm in Pakistan, and had a background in civil engineering, amongst them, they were divided in half for being part of different teaching models. twenty trainees were a part of the flipped model for construction safety tutelage, comprising of sixteen males and four females, as shown in Figure 6.

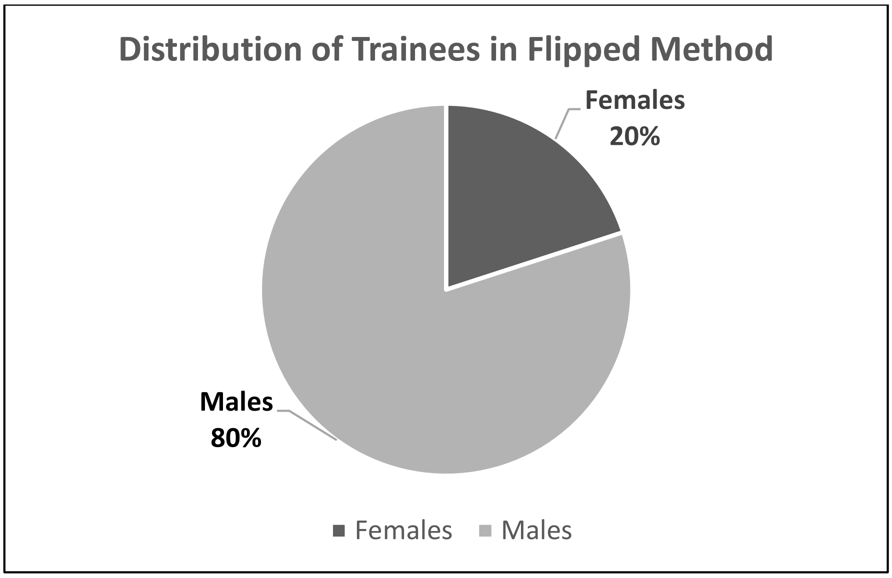

Figure 6 Pie chart of trainees involved in Flipped model

Moreover, the experience of trainees who underwent the process of this tutelage study is shown in Figure 7. As evident in the said diagram the number of trainees were chiefly young professionals from under five to ten years' experience.

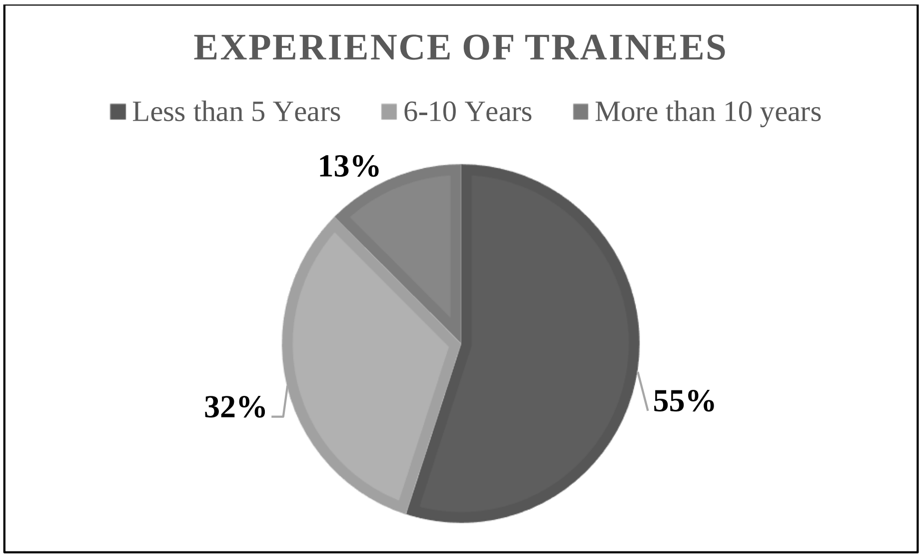

Figure 7 Experience of Trainees

4.1.1 Traditional Teaching Process

Following the process for traditional tutelage as shown in figure 4. A total of twenty trainees, sharing the background of civil engineering were entertained. During the process, they were taught physically in a classroom. They were provided information regarding safety orientation and its distinct aspects. three lectures of one hour each were delivered to the above-mentioned trainees on safety orientation. In response, a test/quiz was held after the lecture. The quiz is comprised of different questions about the lectures delivered, the quizzes are enclosed as ANNEXURE-A. After the quiz, its assessment is done, and the results are finalized. These results are to be placed in contrast to the results obtained from flipped learning model.

4.1.2 Flipped Model for Construction Safety Tutelage

In total twenty trainees gone through this phase of tutelage. They were tutored according to the proposed flipped model for construction safety tutelage, as shown in Figure 4 . For phase 1, pre-session activities; conceptualization of content in presentable format was done. A total of three different lectures were prepared and then processed for video making. As shown in Figure 8, the video creation process was subject to the initiation of presentable content which was prepared using MS PowerPoint. Further, Adobe Presenter Video Express 2017 was used for the creation of presentation videos.

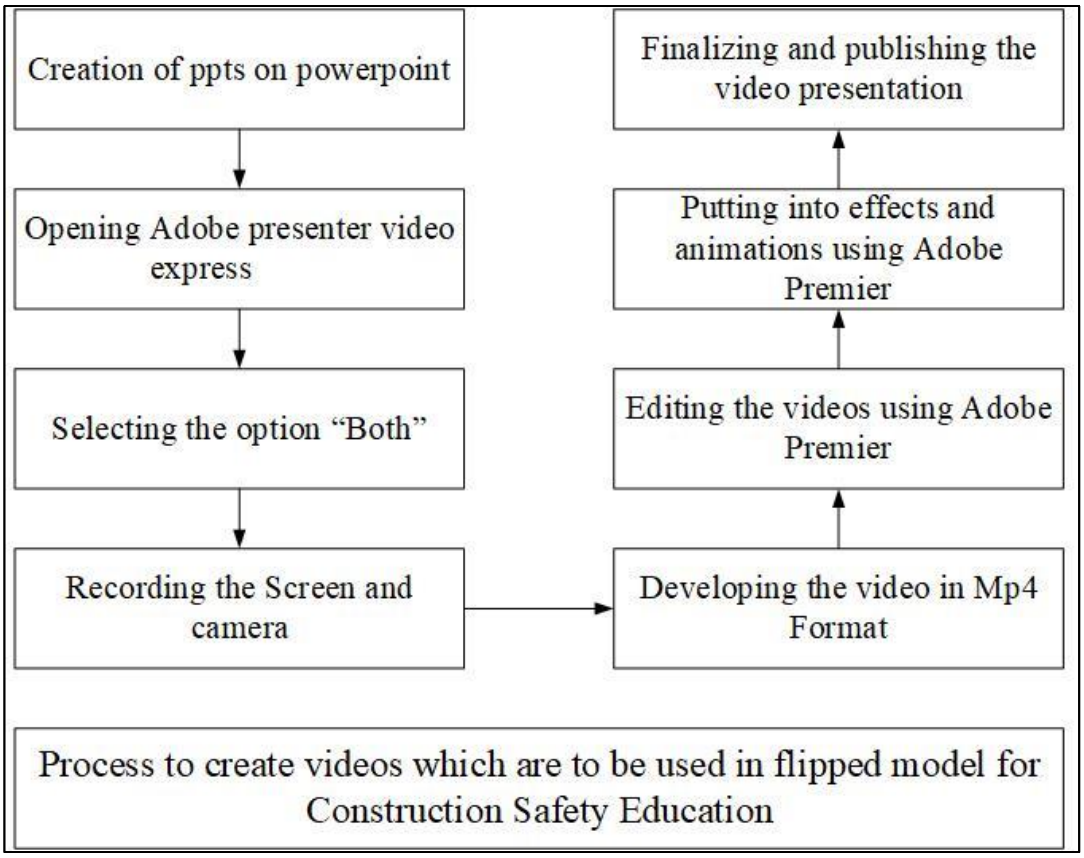

Figure 8 Framework for video content creation

The feature of this software to record the screen along with the live webcam under the option of “Both” was used to record the presentation along with the live screen. This helped to create a presentation video comprising of instructors' live lectures along with the tutelage aspect of respective topics as an e-learning resource. After recording the lecture, it was published in MP4 format. For better visualization and enhancement of the created video, Adobe Premiere pro is taken into consideration for considerable editing and enhancement in the videos created. These videos were then finalized and edited and further processed as per requirements of the flipped model for construction safety tutelage.

After the creation and development of videos as shown in Figure 9,Figure 10 and Figure 11, they are circulated via multiple sources. Firstly, all the videos were uploaded on google drive and then a shareable link was generated and shared with participants via email. Alongside, a WhatsApp group comprising of all those participants who were to be trained under flipped model was created. The link was also shared with participants in that group. After the circulation of videos, the next session started. In the tutelage session, three pre-session quizzes about all the videos circulated were held. These pre-session quizzes are attached as ANNEXURE-B. After these quizzes, the engagement session was started, and it differed from the traditional lecture delivering method. This session recognized the active participation of trainees and their discussion regarding the videos circulated among them. In this session mostly, interactive talks and cross-questioning were done. Alongside, some physical demonstration of PPE’s and other safety equipment was 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 are attached as ANNEXURE-C. After these quizzes the ending was the award of completion certificate and feedback by the participants about the tutelage method was recorded.

The first lecture as shown in Figure 9 was focused on Safety Induction which entailed HSE policies, aims, hazard identification, difference of hazard and risk, difference between accident and near misses, reasons of accidents, and the reporting of such incidents.

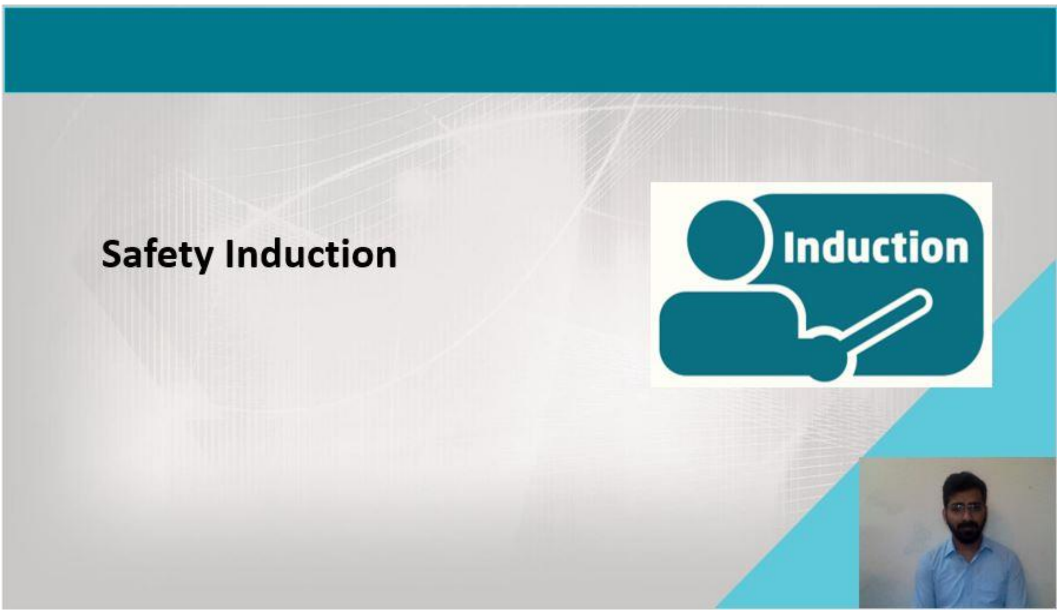

Figure 9 Video Lecture Part 1

The second lecture as shown in Figure 10 outlined the possible hazards at workplace as shown in figure. Dust, noise, electrical, and fire hazards were taught and their respective issues and diseases were identified for better understanding. The trainees were informed about various prevention and protection techniques and the equipment used in these methods. Material storage and related safety procedures were also identified.

Figure 10 Video Lecture Part 2

The third lecture as shown in Figure 11 outlined the lifting and manual handling techniques at workplace, uses of power and hand tools along with their safety measures. Also, details regarding ladder safety, mobile scaffolding, confined spaces entry were provided. At the end trainees were deeply briefed about personal protective equipment and their uses in the construction field.

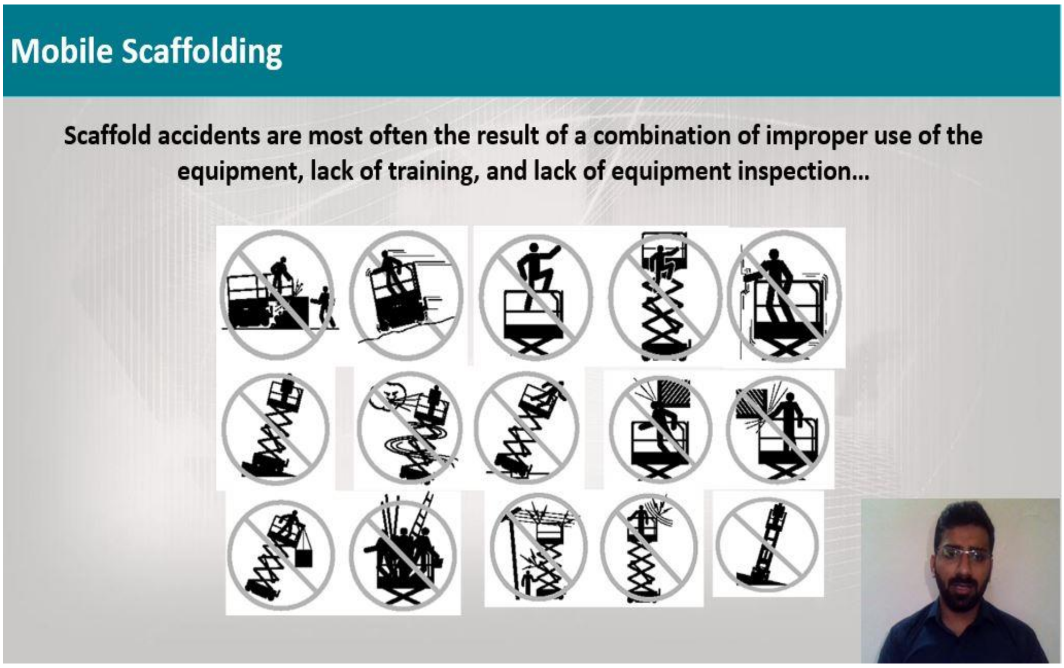

Figure 11 Video Lecture Part 3

In summary, this chapter highlights how the evaluation of the proposed Flipped training will take place. The different steps in the conceptualization of the Flipped model are discussed based on the literature backing. It highlights the importance of the course content, how it should be formulated and how it can be assessed later. The chapter also explains how the model will be implemented and judged based on a comparative analysis between two systems: traditional training and flip training.

Chapter 5

RESULTS AND DISCUSSION

This chapter deals with the results obtained from carrying out the study to assess the working of the proposed model. The results were collated, and a subsequent discussion helps us make sense of the obtained results from the study.:

5.1 RESULT OF TRAINING VIA TRADITIONAL TRAINING METHOD

After successful tutelage, the trainees were involved in an assessment process. The assessment was carried out in face of a quiz held among the trainees. The quiz comprised a total of 48 questions, as illustrated in ANNEXURE-A. This quiz is formed in accordance with the lecture delivered. Table 6 shows the result of the quiz conducted in traditional tutelage. As illustrated in Table 6 and Figure 12 the highest marks obtained in traditional tutelage are observed to be 73% percentile marks and the lowest marks were 31% percentile.

Table 6. Analysis of percentile marks by trainees in traditional training

Trainees	Final Quiz Score Obtained out of a total of 48 Marks.	Percentile Marks obtained by trainees in Traditional Training
1	35	73%
2	33	69%
3	32	67%
4	31	65%
5	25	52%
6	28	58%
7	33	69%
8	30	63%
9	30	63%
10	22	46%
11	24	50%
12	26	54%
13	34	71%
14	15	31%

15	16	33%
16	20	42%
17	22	46%
18	29	60%
19	33	69%
20	32	67%

Figure 12 shows a graphical representation of the scoring trends amongst the tainees subjected to the traditional method of training instruction. The highest marks obtained under such tutelage were below the 80 percent mark. The performance of the trainees was satisfactory but there was plenty of room for improvement. The average percentile score was 57% which again points to a satisfactory showing.

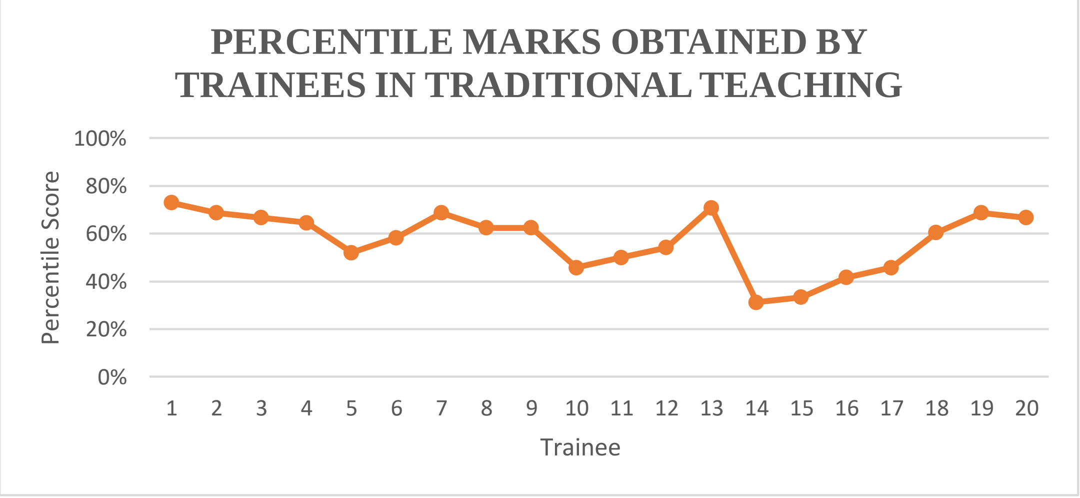

Figure 12 Chart of scoring trend in traditional teaching

5.2 RESULT OF TRAINING USING FLIPPED TRAINING METHOD

In this, after the circulation of video lectures, the trainee was assessed in the session physically, via a pre-session quiz, as shown in Table 7. This quiz helped to assess the aspects in which most of the trainees were lacking behind and the session was held to focus on these gaps and equip each trainee with all the desired aspects. The training session was conducted to address the weak points and misconceptions that were found during the pre-quiz assessment. It helped saved in-class time to be focused on training material which was difficult or concepts in which trainees were rather weak.

Table 7 Analysis of marks obtained by trainees in pre-quiz held flipped training

Trainee	Pre-quiz 1	Pre-quiz 2	Pre-quiz 3	Average Score
1	3	4	5	4.0
2	4	3	4	3.7
3	3	3	3	3.0
4	3	5	4	4.0
5	4	2	5	3.7
6	5	4	4	4.3
7	4	3	5	4.0
8	5	4	3	4.0
9	2	2	3	2.3
10	3	5	5	4.3
11	5	4	4	4.3
12	5	5	5	5.0
13	4	2	5	3.7
14	3	5	2	3.3
15	2	3	2	2.3
16	3	5	1	3.0
17	4	5	4	4.3
18	3	3	4	3.3
19	4	4	3	3.7
20	4	2	3	3.0

After successful tutelage, the trainees were involved in an assessment process. The assessment was carried out in face of a quiz held among the trainees. The quiz comprised a total of 48 questions, as illustrated in ANNEXURE-A. This quiz is formed in accordance with the lecture delivered. Table 8 shows the result of the quiz conducted in flipped tutelage. As illustrated, the highest marks obtained in flipped tutelage are observed to be 75% percentile marks and the lowest marks were 56% percentile. The table shows a positive trend, especially when compared to the traditional model of training. The scores represent an above-average performance by students subjected to flip tutelage.

Table 8.Analysis of percentile marks by trainees for flipped training

Trainee	Final quiz 1 11q	Final quiz 2 17q	Final quiz 3 20q	Percentile marks of all final quizzes
1	10	16	15	72%
2	10	15	16	72%
3	9	14	17	71%
4	9	15	18	75%
5	8	15	13	64%
6	8	15	15	68%
7	8	15	12	62%
8	8	15	16	70%
9	8	15	14	66%
10	8	12	15	62%
11	8	12	16	64%
12	7	12	17	65%
13	8	12	18	68%
14	8	13	20	74%
15	8	13	11	56%
16	8	12	16	64%
17	9	11	15	60%
18	9	15	16	71%
19	9	10	17	63%
20	9	9	18	63%

Figure 13 offers a visual representation of Table 8 and the marks obtained by trainees under the flip tutelage. The marks show a positive trend for trainees under such a tutelage session, as the scores demonstrate the trainees getting higher marks. The average percentile scores for flip tutelage is 67 percent which is about 10 points higher than the traditional mode of instruction. It shows a considerable increase in achievement of desired learning outcome in trainees under the flip program.

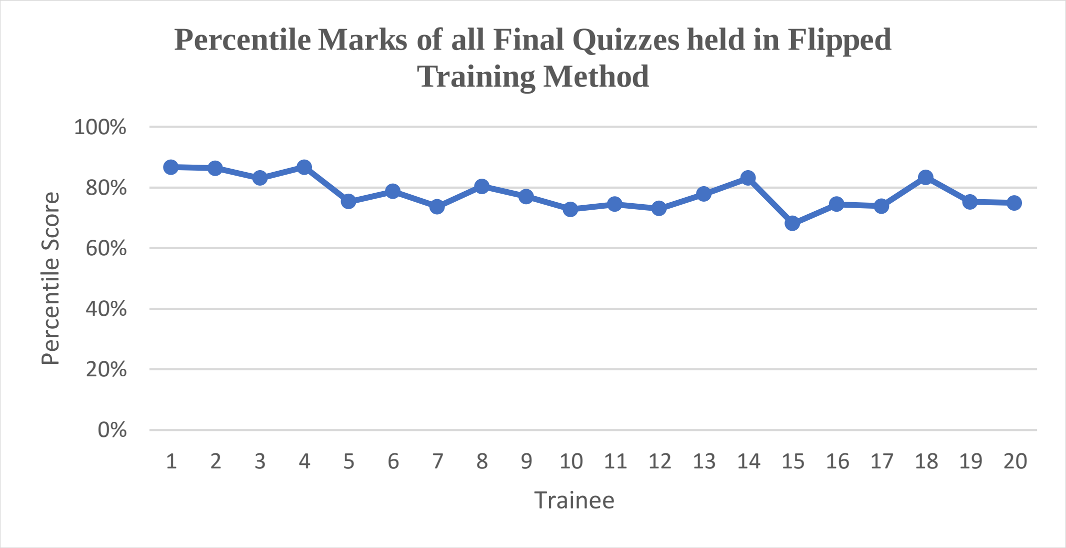

Figure 13 Chart of scoring trend in flipped method

Table 9 shows the feedback of the trainee who underwent flipped tutelage. The trainees were required to answer some questions affirmatively and negatively while some questions were asked to be rated on a 5 point Likert scale ranging from 1 being Non-satisfactory and 5 being Extremely Satisfactory. After successful completion of the safety course under flipped tutelage, the trainees filled a feedback form in which on average the framework was rated between Highly Satisfactory to Extremely Satisfactory.

Table 9. Feedback of the trainees engaged in Flipped Training

Average Feedback of all the Trainees	
Are you Satisfied with the content of the Video?	Yes
Are you satisfied with the quality of videos circulating in the pre-session phase?	Yes
Rate the Following on a scale of 1-5 based on your satisfaction and understanding level where 1 = Non-Satisfactory, 2 = Partly Satisfactory, 3= Satisfactory, 4= Highly Satisfactory and 5 = extremely Satisfactory	
The Session was Interactive	4.7
The Session was Informative	4.75
The whole process helped to a better understanding of the topic	3.95
The pre-session activities helped to better understand the training topic	4.45
The pre-session quiz helped to highlight the misunderstandings of the lecture and helped to resolve them	4.35
Specify benefits of this training ____	

5.3 COMPARATIVE ANALYSIS OF BOTH METHODS

Comparing the results obtained from the above illustrated two methods, the scoring trend favours the performance of the flipped model and manifests that the least score obtained is above 50%. While the traditional method resulted in low-scoring trends in contrast to the flipped model of tutelage for construction safety, as illustrated in Figure 14. 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 the flipped method is focused on a pre-session quiz and topic familiarity through video lectures. Circulation of video lectures has acted as a source of entertaining the trainees to get familiarity with the training topics/contents and research on them accordingly. The pre-quiz after this video circulation helped the trainer/instructor to assess a trainee's area of focus in which one is lagging. This assessment has also been a supporting pillar for this method's success. Moreover, the feature of feedback has also been a source of success by the provision of requisite enhancements from trainees. Furthermore; in the context of efficacy, the flipped model scoring trend is quite satisfactory but it needs enhancements too. In the pre-session part of the flipped framework devised above it is not mandatory to provide video lectures only. Apart from video lessons other multimedia sources and techniques could be opted to present virtual content in accordance with the aspect of learning.

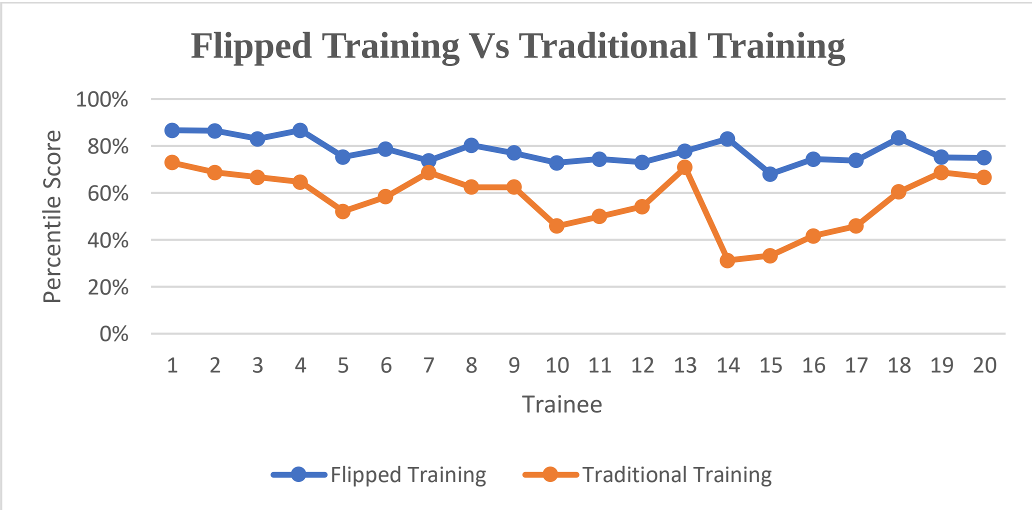

Figure 14 Flipped vs Traditional scoring trends chart

5.4 RATING OF THE COMPILED BENEFITS

The benefits that were identified by the trainees in the feedback were compiled and presented in form of a questionnaire in front of each trainee. They were required to rate these inefficiencies on a Likert scale of 1-5 where 1 being very low to 5 being very high. These were then compiled and rated as shown in Table 10. Table 10 shows that the flipped classroom inculcated self-awareness amongst students while offering a flexible environment, enabling active learning during the training delivery. Moreover, the results also point to trainees accepting this approach as innovative, which could resolve the many inefficiencies in construction safety training education. Trainees will see it as an interesting pedagogical approach rather than the traditional boredom of lectures and just lectures. Better motivation levels amongst students will result in a more productive outcome in the subsequent assessments and skills uptake.

Table 10 Rating of Benefits

Benefits of Flipped Framework	**Feedback Score**	**Ranking**
Flexibility in viewing content	4.95	1
More In-Class Engagement	4.85	2
Self-efficacy	4.75	3
Flexibility in study	4.75	3
Interactive Learning	4.75	3
innovation in teaching	4.7	4
Qualified training staff	4.7	4
Enhanced Confidence	4.6	5
Improves ICT skills	4.54	6
increasing student attendance	4.5	7
Acquaintance with topics before Class	4.45	8
Devising incentives for employees	4.4	9
Reduced Training Time	4.3…………………	10

5.5 RATING OF THE COMPILED BENEFITS

The purpose of this assessment is to gauge the performance levels based on Bloom's Taxonomy and the cognitive domain of learner's thinking skills. Traditionally, instructors use these domains to assess whether the imparted knowledge was assimilated and reproduced in the desire capacity. The results in Table show that the Flipped model was effective in engaging students' higher order cognitive skills mainly application and analysis of course content.

Figure 15 shows results were obtained by assigning each question a cognitive domain level and then measuring the performance against these questions by students. The results appear to give flip learning a considerable advantage over the traditional model. The projected benefits of flip learning are realized in this study as it helps students to solve analytically and apply the knowledge in a much better manner than the those exposed to traditional model.

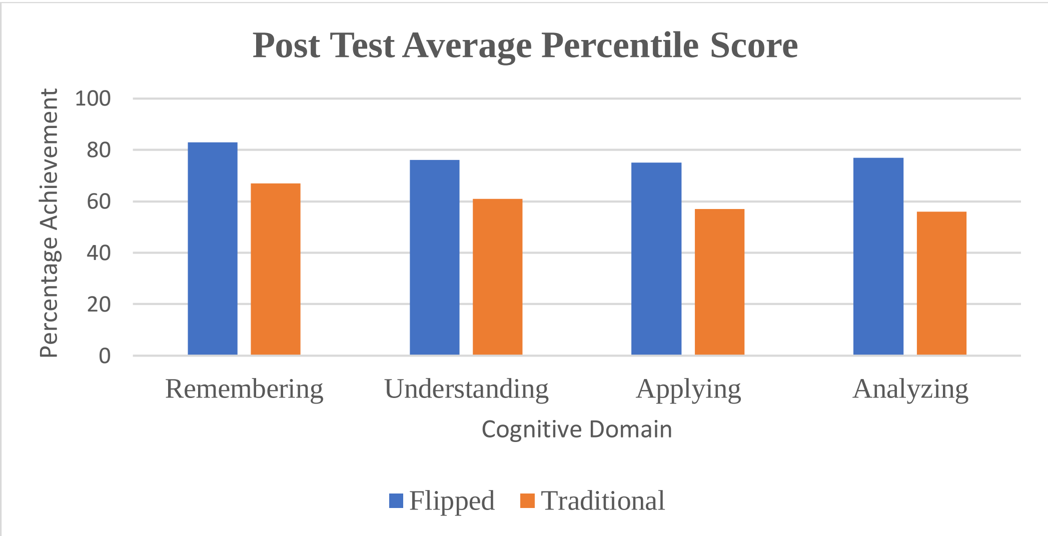

Figure 15 Analysis of Assessment based on Cognitive Levels

5.5 THE EFFICACY OF TRAINING:

To determine the efficacy of training. The incharge of trainees were interviewed after 3 months of training completion. As all the Trainees hailed from 3 different projects hence their respective project managers were contacted and asked to give satisfaction level of the trainees. This is shown in Table 11.

Table 11 Satisfaction Level by concerned Project Manager

Trainee	% age of Satisfaction by concerned PM After 3 months of training
1	80
2	75
3	75
4	80
5	75
6	80
7	75
8	80
9	75
10	80
11	80
12	75
13	80
14	80
15	75
16	80
17	75
18	80
19	75
20	80

This chapter discusses the efficacy of the proposed flip model against the traditional model's working. The results are positive in terms of the Flipped model's implementation as it elicits a good response towards higher-order learning levels in students. The reasons for such an improved performance were also discussed. The results point towards a positive response to the flip learning model.

Chapter 6

CONCLUSION

6.1 CONCLUSION

Training in construction safety has been lacking behind in terms of updating since its inception stage. It is one of the least important training considered in our traditional culture. In the contemporary world of global competitiveness, It is important to endorse safety norms to achieve success. Unfortunately, the construction industry has not been able to fully adopt safety norms and practices to date. Though several types of research have highlighted the importance of construction safety and the adoption of new techniques to improve its performance, yet it needs more weightage towards the safety education aspect. Covering one of such aspects, a relatively new education model namely, Flipped learning has been endorsed in this research to enhance construction safety education.

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 with all the international standards is of immense importance. Pursuing compliance with OSHA standards will ultimately cause a cut-off in the number of accidents at a construction site. This will help to create a sense of the success of the project because an accident will ultimately result in the delay of a construction project. Flipped method when opted for the construction safety education perspective resulted to be An effective one. Comparing the results obtained from the above illustrated two methods, the scoring trend favours the performance of the flipped model and manifests that the least score obtained is above 50%. While the traditional method resulted in low-scoring trends in contrast to the flipped model of tutelage for construction safety, as illustrated in the figure. 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 the flipped method is focused on a pre-session quiz and topic familiarity through video lectures. Circulation of video lectures has acted as a source of entertaining the trainees to get familiarity with the training topics, content, and research on them accordingly. The pre-quiz after this video circulation helped the trainer/instructor to assess a trainee's area of focus in which one is lagging. This assessment has also been a supporting pillar for this method's success. Moreover, the feature of feedback has also been a source of success by the provision of requisite enhancements from trainees. Furthermore, in the context of efficacy, the flipped model scoring trend is quite satisfactory, but it needs enhancements too. In the pre-session part of the flipped framework devised above it is not mandatory to provide video lectures only. Apart from video lessons other multimedia sources and techniques could be opted to present virtual content in accordance with the aspect of learning. Thus, the system devised proves to be an effective one when compared with traditional teaching practices used in construction safety education.

6.2 LIMITATIONS

Despite the positive results, some constraints and limitations can be further improved by research in this area. First limitation was the scarcity of time to conduct the study with COVID SOPs in place and limited in-class time available. Moreover, this training model can be expanded to departmental level to judge the efficacy of the proposed model. Studies with longer periods will certainly effectively validate the model by removing any short-term variables affecting the study. Lastly, the study method is highly reliant on the fact that the subjects have proper access to and expertise of video capable tools. This fact limits the proposed method from application on construction labor as it requires the trainee to be well acquainted with ICT.

6.3 FUTURE RECOMMENDATIONS

Flip learning technique can be used in conducting different construction trainings such as quality control, contract management, primavera and ERP training etc. This concept can also be used to assess whether it can reduce adoption time for learning new software by the individuals in the construction industry.

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ANNEXURE-A

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 a risk?

   A. The management of the environment

   B. The probability of an accident happening

   C. The likelihood of someone being harmed or injured as a result of a hazard

   D. None of the above

3. HSE stands for

   A. Health, Safety and Environment

   B. Health, Safety and Energy

   C. Health and Safety Executive

   D. Health, safety and Excellence

4. MANDATORY or COMPULSORY sign is _____ in color

   A. Blue

   B. Yellow

   C. Red

   D. Green

5. WARNING Sign is _____ in color

   A. Blue

B. Yellow

C. Red

D. Green

6. PROHIBITION Sign is _____ in color

   A. Blue

   B. Yellow

   C. Red

   D. Green

7. EMERGENCY ESCAPE or FIRST-AID Sign is _____ in color

   A. Blue

   B. Yellow

   C. Red

   D. Green

8. Regarding near-misses, select the best answer:

   A. Major incidents are rare events.

   B. Prevent non-serious events and the injuries will take care of themselves.

   C. By reporting any near misses, the organization can detect problems and intervene before more serious accidents happen.

   D. You can prevent what you can see.

   E. All of the above.

9. A "near miss" should be investigated in the same manner as an actual accident.

   A. True

   B. False

10. Close calls that could result in minimal or no injury to an employee should not be reported.

    A. True

    B. False

11. 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

    D. None of the above.

12. 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 of the above.

13. 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 of the above.

14. ________________ are the result of unrecoverable slips or trips.

    A. Injuries

    B. Lawsuits

    C. Falls

    D. None of the above

15. 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

16. 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

17. 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

18. 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 of fire

   D. All of these

19. As a general rule, you should not attempt to fight a fire that is spreading rapidly?

   A. True

   B. False

20. 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

21. Proper handling and storage of flammable liquids is important to eliminate dangers and prevent ______________.

A. Safety

B. Fires

C. Smoking

D. Flashpoint

22. Keep flammable liquid containers _______________ when not in use.

A. Closed

B. Open

C. Near ignition sources

D. Empty

23. It is very important not to store or use flammable liquids around a(n) ________________.

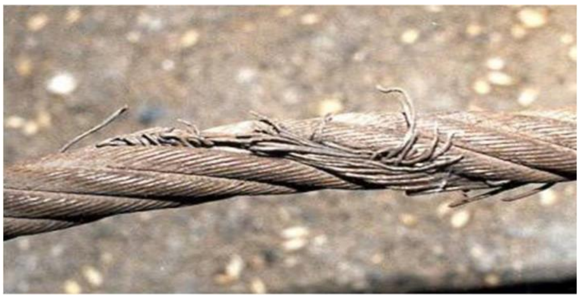
A. Fire extinguisher

B. Storage cabinet

C. Ignition source

D. Safety can

24. Should this sling be used for lifting?



A. Yes, it's fine.

B. Maybe, if the load isn’t too heavy.

C. No, use a different one.

25. What are the 3 ingredients a fire needs to burn?

A. Water, heat, and fuel

B. Fuel, heat, and Oxygen

C. Gas, fuel, and Oxygen

D. None of the above.

26. What does PASS stand for?

A. Pull, Aim, Shoot, Squeeze

B. Fire Detection and Alarm System

C. Pull, Aim, Squeeze, Sweep

D. Push, Aim, Shoot, Shout

27. You should stand ___ feet away from a fire when using fire extinguisher

A. 5

B. 6

C. 8

D. 10

28. 5S stands for ______________________

29. 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

30. Which one of the following is NOT classified as a manual handling activity?

   A. Throwing
   B. Pushing
   C. Carrying
   D. Pulling

31. Which kind of injury is the most common when manual handling?

   A. Broken Limbs
   B. Headaches
   C. Sprains
   D. Musculoskeletal disorder

32. 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

33. 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

34. What must you do when you are climbing a ladder?

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

35. 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

36. 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

37. The angle of the ladder should be so that the ladder's base is one foot out from the ledge for every four feet of a ladder's height.

A. True

B. False

38. 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.

39. 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
40. An empty chemical storage tank is not considered a confined space:
    A. True
    B. False
41. 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
42. 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

43. 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 of the above.

44. Properly selected hand protection can protect employees from burns, electrical shock, and chemical absorption.

    A. True
    B. False

45. PPE must be inspected prior to use.

    A. True
    B. False

46. 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

47. Power tools should not be used in damp or wet locations.

    A. True
    B. False

48. It is safe to use the top step of a ladder?

    A. True
    B. False

ANNEXURE-B

Pre-quiz part 1

1. HSE stands for

    A. Health, Safety and Environment

    B. Health, Safety and Energy

    C. Health and Safety Executive

    D. Health, safety and Excellence

2. What is a risk?

    A. The management of the environment

    B. The probability of an accident happening

    C. The likelihood of someone being harmed or injured as a result of a hazard

    D. None of the above

3. As a general rule, you should not attempt to fight a fire that is spreading rapidly?

    A. True

    B. False

4. 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

5. WARNING Sign is _____ in color

    A. Blue

    B. Yellow

C. Red

D. Green

Pre-quiz part 2

1. If someone has spilled a liquid on the floor, what should they be encouraged to do?
    A. Report it to their manager
    B. Clean it up straight away
    C. Inform the cleaners
    D. Leave it
2. A noise level of ______ can trigger stress reactions.
    A. 90 decibels
    B. 80 decibels
    C. 100 decibels
    D. Noise cannot trigger stress
3. When do you need to check electrical hand tools for damage?
    A. Before you use it
    B. Every day
    C. Once a week
    D. At least once a year
4. What does PASS stand for?
    A. Pull, Aim, Shoot, Squeeze
    B. Push, Aim, Shoot, Sweep
    C. Pull, Aim, Squeeze, Sweep
    D. Push, Aim, Shoot, Shout

5. Good housekeeping is the best method of preventing daily slips/trips/falls?

    A. True

    B. False

Pre-quiz part 3

1. Which part of your body are you most like to injure if you lift heavy loads?

    A. Your back

    B. Your neck

    C. Your knees

    D. Your legs

2. Heat ______ is the most serious form of heat stress.

    A. Cramps

    B. Exhaustion

    C. Rash

    D. Stroke

3. Clothes of dark-colored materials are best in hot environments?

    A. True

    B. False

4. What should you do if you find a ladder that is damaged? Give one answer

    A. Don't use it and make sure that others know about the damage

    B. Don't use it and report the damage at the end of your shift

    C. Try to mend the damage

    D. Use the ladder if you can avoid the damaged part

5. What is PPE?

    A. Personal production equipment

B. Personal protective equipment

C. Priority protective equipment

D. Poisoning protection equipment

ANNEXURE-C

Final Quiz Part 1,2 and 3

Part-1

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 a risk?

    A. The management of the environment

    B. The probability of an accident happening

    C. The likelihood of someone being harmed or injured as a result of a hazard

    D. None of the above
3. HSE stands for
    A. Health, Safety, and Environment
    B. Health, Safety, and Energy
    C. Health, Safety, and Executive
    D. Health, safety, and Excellence
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

Part-2

1. 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

2. 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

3. ________________ are the result of unrecoverable slips or trips.

   A. Injuries

   B. Law Suits

C. Falls

D. None of these

4. 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

5. 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

6. 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

7. 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 of fire

D. All of these

8. As A General Rule, You Should Not Attempt To Fight A Fire That Is Spreading Rapidly?

A. True

B. False

9. 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

10. Proper handling and storage of flammable liquids is important to eliminate dangers and prevent _______________.

    A. Safety

    B. Fires

    C. Smoking

    D. Flashpoint

11. Keep flammable liquid containers ________________ when not in use.

    A. Closed

    B. Open

    C. Near ignition sources

    D. Empty

12. It is very important not to store or use flammable liquids around a(n) _________________.

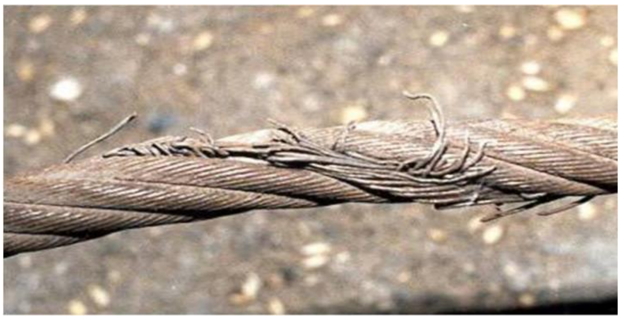
    A. Fire extinguisher

    B. Storage cabinet

    C. Ignition source

    D. Safety can

13. Should this sling be used for lifting?



A. Yes, it's fine.

B. Maybe, if the load isn’t too heavy.

C. No, use a different one.

14. What are the 3 ingredients a fire needs to burn?

A. Water, heat, and fuel

B. Fuel, heat, and Oxygen

C. Gas, fuel, and Oxygen

D. None of the above

15. What does PASS stand for?

A. Pull, Aim, Shoot, Squeeze

B. Fire Detection and Alarm System

C. Pull, Aim, Squeeze, Sweep

D. Push, Aim, Shoot, Shout

16. You should stand ___ feet away from a fire when using a fire extinguisher

A. 5

B. 6

C. 8

D. 10

17. 5S stands for _____________

Part-3

1. 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

2. Which one of the following is NOT classified as a manual handling activity?
    A. Throwing
    B. Pushing
    C. Carrying
    D. Pulling

3. Which kind of injury is the most common when manual handling?
    A. Broken Limbs
    B. Headaches
    C. Sprains
    D. Musculoskeletal disorder

4. 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

5. 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

6. 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

7. 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

8. 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

9. The angle of the ladder should be so that the ladder's base is one foot out from the ledge for every four feet of a ladder's height.

A. True

B. False

10. 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.

11. 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
12. An empty chemical storage tank is not considered a confined space:
    A. True
    B. False
13. 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
14. 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

15. 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 of the above.

16. Properly selected hand protection can protect employees from burns, electrical shock, and chemical absorption.

    A. True
    B. False

17. PPE must be inspected before use.

    A. True
    B. False

18. 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

19. Power tools should not be used in damp or wet locations.

    A. True
    B. False

20. It is safe to use the top step of a ladder?

    A. True
    B. False