# ConSafe4All: A framework for language friendly safety training modules

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## TABLE OF CONTENTS

## LIST OF FIGURES

## LIST OF TABLES

**ABSTRACT**

The construction industry is different from other industries in terms of its unforeseeable working conditions. Unlike most of the other industries operating indoors within controlled environment, the construction workers share fair amount of time outdoors exposing them to different climatic and workability. These transfigurations contribute towards more vulnerability for workplace accidents. It has been observed that there is a common absence of formal construction safety training programs for fresh workers that results in work accidents. Instead, employees are expected to learn from their own experiences and mistakes. One of the main causes is the inability to understand safety training material by the masses due to its presence in uniform languages and lack of education. Considering the need to overcome these inconveniences, this study focuses on the development of a Construction Safety for All (ConSafe4All) framework to produce safety training modules for workers to overcome the language restrictions. The demonstration through the developed modules for most occurring accident types shows that the framework may be used to elaborate different construction hazards with their remedies to enhance awareness among workers, thereby mitigating work related accidents.

*Chapter 1*

# INTRODUCTION

## 1.1 Background

According to Oxford dictionary, safety means the condition of being protected from or unlikely to cause danger, risk, or injury. And safety in construction can be regarded as being protected during a construction activity (Hinze, 2008).

Construction industry is one of the vital economical contributors for a country (Crosthwaite, 2000). Construction industry is also regarded as highly unsafe and hazardous industry to work in (Perttula *et al.*, 2006; Pinto *et al.*, 2011). The safety of workers in a construction industry can be brought under danger due to a number of factors such as working under extreme conditions, working on heights, trenches as well as use of machinery with careless attitude and behavior (Choudhry, 2008). This predicament which causes loss of life, major accidents causing permanent and temporary disabilities, loss of property etc. should be confronted by making sure that workers safety is the main priority for all the stakeholders.

Construction industry is considered high risk due to different modes of activities that can be performed during repairs, alteration or during construction. For example, construction of a high rise building, deep excavation of more than 6-feet, paving of a busy roadway during peak hours etc. The workers can be exposed to severe hazards, such as falling from heights, electrocutions, unguarded machinery, being hit by an object or construction equipment, asbestos or other chemical compounds, etc.

The aim of this study is to develop a framework which would aid in building modules based upon computer generated 3D animations which then can be used by all the stakeholders in the construction industry for workers' safety training. This study is expected to help improve the safety culture in Pakistan as well as the other countries where language-barrier exist.

## 1.2 Problem Statement

Overall the construction industry worldwide still lags behind in the struggle of yielding safety on construction sites to the workers and the overall project when compared to other industries i.e., automotive, manufacturing etc. Major reasons behind safety non-conformance is the absence of proper safety training systems and on-site safety implementation. Many studies have been conducted so far that address the safety management framework but very less efforts have been made to analyze the phenomenon of actual safety training on sites.

Evia (2011) studied on designing and localizing computer-based safety training solutions for Hispanic workers in construction industry. He concluded that a computer-based course which was mostly based on English text, was ineffective for Hispanic workers i.e. those who do not speak English. He also claimed that although incorporating audio improved knowledge transfer slightly, videos based learning, especially with a story, conclusion and some humor gave the best results in understanding and clarity to teach non-native speaking workers.

According to the author, construction workers who were not proficient in English language found it difficult to understand the safety manuals, and the safety training because they consisted mostly of English language. He suggested that the transfer of knowledge was best carried out with the help of videos. This study fills this gap by developing safety training modules with the help of framework eliminating language barrier for the workers. This study is aimed at providing effective design and development of safety education targeted to multi-cultural construction workers.

## 1.3 Research Objectives

- To identify most recurring type of accidents during construction activities and assess the existing safety trainings methodologies.
- Formulate a framework for development of safety training modules targeted for construction workers in a language-barriered environment.
- Design and develop digital safety training sample modules in accordance with the safety training framework.
- To undertake the assessment of the developed modules to measure their effectiveness.

## 1.4 Overview of Study Approach

To fulfill the objectives set for the research, a detailed methodology in chapter 3 is worked out and the following research tasks are identified;

- Literature review of the previous relevant research works at national/international level and identifying the top accident causes during construction process.
- To assess in detail the current safety training methodologies with the help of current literature.
- Develop a framework for safety training and implement it for forming a computer generated 3D module for safety training.
- Obtain feedback from the target audience with the help of questionnaire and field interviews.
- Analysis and discussions.
- Conclusion and Recommendations.

## 1.5 Organization of thesis

This research is structured into five chapters. Chapter 1 introduces construction safety, describes background, problem statement, research objectives and overview of the study approach. Chapter 2 covers thorough literature review comprising of different topics relevant to this study. It identifies the main accident types during construction processes, development of framework, and preparation of computer generated 3D modules. Chapter 3 covers the research methodology adopted for this study. Chapter 4 discusses about data collection and results. Chapter 5 summarizes the findings of this study with conclusion and future recommendations.

*Chapter 2*

# LITERATURE REVIEW

## 2.1 Introduction

A safety system will be regarded as effective if it succeeds in preventing or minimizing the occurrences of accidents or hazards that can threaten the construction workers (Farrow and Hayakawa, 2002; Ayomoh and Oke, 2006). The overall construction industry employs the largest labor force, which accounts for about 11% of all occupational injuries and 20% deaths resulting from occupational accidents (Arumugam, E and Thirumurthy, 2007). The advantage that trained workers have over untrained workers is they know how to use tools and equipment safely and also knowing appropriate measures to eliminate or reduce work hazard (Huang and Hinze, 2006). Major injuries, or even minor ones, result in lost working hours, which also hampers the progress of a project in terms of cost and time (Smallwood *et.al*, 2000).

The construction industry is different from other industries because of its unforeseeable working conditions. Unlike most of the other industries operating indoors, the construction workers share fair amount of time outdoors exposing them to different climatic changes, machinery and workability variances which causes them to become more vulnerable to workplace hazards. It has been observed in countries like India, Pakistan, and Bangladesh etc. that there are no formal training programs for new workers and staff that are being carried out; no safety meetings are carried out which results in no identification and discussion about hazards. Workers are expected to learn from their own experiences and mistakes primarily to save time and money on training.

## 2.2 Top accident types in Construction Industry

Construction sites are often considered dangerous, unsafe, or hazardous places to work (Sherratt *et.al*, 2013). This can be due to the fact that more uncontrollable human errors occur as a result of diverse activities, modification in project teams and complex use of equipment and materials (Al-Humaidi and Tan, 2010).

Causes of accidents are classified into proximal (immediate causes) and distal (underlying or root causes) factors (Suraji *et al.*, 2001; Manu *et al.*, 2010). Immediate conditions are distinguishable as they include unsafe working conditions, and acts. It may include below par worksite conditions and environment, bad lighting, uncomfortable weather conditions, usability of tools and equipment, below standard materials and also the adaptability of safety rules by construction workers themselves. When the combination of above conditions happen, an eventual unsafe act could be resulted. According to the researchers, 10 per cent of accidents are caused by unsafe conditions, 88 per cent by unsafe acts, with only 2 per cent being unpreventable (Suraji *et al.*, 2001; Chi *et al.*, 2012).

According to studies explored in first-world countries, main reasons of occupational accidents were found to be; insufficient trainings and not offering the employees with personal protection equipment, not following the basic protocol and safety measures for “working at height”, not carrying out regular systematic checks for safety, working with subcontractors that fail to comply safety measures and inadequacy of inspections. One of the main shortfalls due to which accidents occurred are; most of the time it was observed that to avoid undesirable attention, some major and minor accidents were not recorded officially, which resulted in these accidents not being analyzed, risk assessments were not prepared well enough and precautions were not managed (Rivara and Thompson, 2000; Rubio *et al.*, 2008; Barlas, 2012).

Australian Safety and Compensation Council, in their Type of Occurrences Classification System, stated that the most number of moderate and minor injuries involved ‘struck by’ incidents while sever injuries were caused due to ‘heavy lifting or exertion’. While equipment or vehicular accidents contributed in more deaths (15.0%). Electrocution and equipment/vehicle related accidents were over-estimated among fatalities. Falls also contributed towards many death of construction workers (27.6%).

According to the previous studies, the most severe consequences of a construction accident were due to falling from height (Camino López *et al.*, 2008). In Singapore, Japan, South Korea, Taiwan and other far eastern countries, the construction projects which were familiar in nature, fall proved to be the biggest contributor to accidents that caused death (Cheng *et al.*, 2010). He also suggested that falls are more common in private projects than in public projects. More researchers also stressed that falling from a height is the major cause of casualties (Jackson and Loomis, 2002; Meldrum *et al.*, 2009). Arquillos, Romero and Gibb (2012) found that falls and loss of machine control were higher in serious, very serious and fatal construction accidents in Spain. Wang *et al.*

(2002) also evaluated that height and struck-by objects contributed to more than half of the construction accidents. Struck by private vehicles, hit by horizontally transported materials, hit by equipment, all come under the ‘struck-by’ accidents category which also are a high contributor in construction accidents (Hinze *et al.*, 2005). Perttula *et al.* (2003) found construction worker loses his focus towards work when he is exposed under extreme conditions and suffer from exhaustion. Electrocution cases which included electric discharge or contact with electricity is also regarded as a major contributor towards accidents in construction industry (Wong *et al.*, 2009). For fatal falls, edge protection proved to be the most reliable remedy in the Netherlands (Ale *et al.*, 2008).

After finding the top and most hazardous accident types occurred during a construction activity, the researcher carried out an on-field expert interviews by visiting different construction sites. A non-formal one-to-one interviews were conducted, which affirmed the findings previously highlighted with the help of literature studies. The researcher then shortlisted these accident types to be further used in this study.

The findings of the studies discussed above has been summarized and given a literature score according to their quantitative and qualitative assessment. The quantitative assessment has been calculated by comparing the number of authors highlighting the type of respective accident in their publication against the total number of studies reviewed by the researcher. That qualitative assessment underlines the severity of the particular accident type, again computed from the respective research publications. Both the assessments are combined to form a single literature score, where “1” denotes that all of the authors discussing a specific type of accident, and considering it as an extremely dangerous hazard, followed by a similar scoring trend. The research findings are shown in following Table 1:

Table 1 Literature for top accident types

| **Types of accidents** | **Literature Score** | **Authors** |
|---|---|---|
| Fall from height | 1 | (Haslam *et al.*, 2005; N.Aniekwu, 2007; Alinaitwe, Mwakali and Hansson, 2007; Dėjus, 2007; Ale *et al.*, 2008; López *et al.*, 2008; Rahim *et al.*, 2008; Gürcanli, Müngen and Akad, 2008; Im *et al.*, 2009; Li and Poon, 2009; Ling, Liu and Woo, 2009; Pérez-Alonso *et al.*, 2012; Halvani *et al.*, 2012; Mohammed and Ishak, 2013; Solís-Carcaño and Arcudia-Abad, 2013; Dumrak *et al.*, 2013; Chong and Low, 2014; Yilmaz, 2015; Asanka and Ranasinghe, 2015; Winge and Albrechtsen, 2018; GÜRCANLI and MÜNGEN, 2013; Ali, Khahro and Memon, 2014; Williams, Adul Hamid and Misnan, 2018) |
| Being struck by / hit by an object | 0.96 | (Haslam *et al.*, 2005; Alinaitwe, Mwakali and Hansson, 2007; Dėjus, 2007; Ale *et al.*, 2008; López *et al.*, 2008; Rahim *et al.*, 2008; Gürcanli, Müngen and Akad, 2008; Im *et al.*, 2009; Li and Poon, 2009; Ling, Liu and Woo, 2009; Pérez-Alonso *et al.*, 2012; Halvani *et al.*, 2012; Mohammed and Ishak, 2013; Solís-Carcaño and Arcudia-Abad, 2013; Dumrak *et al.*, 2013; Chong and Low, 2014; Yilmaz, 2015; Asanka and Ranasinghe, 2015; Winge and Albrechtsen, 2018; GÜRCANLI and MÜNGEN, 2013; Ali, Khahro and Memon, 2014; Williams, Adul Hamid and Misnan, 2018) |
| Contact with electricity | 0.6 | (Haslam *et al.*, 2005; Mohan and Zech, 2005; Alinaitwe, Mwakali and Hansson, 2007; T. Dėjus, 2007; N.Aniekwu, 2007; Ale *et al.*, 2008; Gürcanli, Müngen and Akad, 2008; Im *et al.*, 2009; J Dumrak *et al.*, 2013; Solís-Carcaño and Arcudia-Abad, 2013; Chong and Low, 2014; Yilmaz, 2015; Williams, Adul Hamid and Misnan, 2018) |

| **Types of accidents** | **Literature Score** | **Authors** |
|---|---|---|
| Machine / equipment mishandling | 0.48 | (Mohan and Zech, 2005; Haslam *et al.*, 2005; N.Aniekwu, 2007; T Dėjus, 2007; Alinaitwe, Mwakali and Hansson, 2007; Ale *et al.*, 2008; López *et al.*, 2008; Rahim *et al.*, 2008; Im *et al.*, 2009; Ling, Liu and Woo, 2009; Mohammed and Ishak, 2013; Solís-Carcaño and Arcudia-Abad, 2013; Gürcanli and Müngen, 2013; J. Dumrak *et al.*, 2013; Ali, Khahro and Memon, 2014; Yilmaz, 2015; Asanka and Ranasinghe, 2015; Williams, Adul Hamid and Misnan, 2018b; Winge and Albrechtsen, 2018) |
| Caught in-between | 0.144 | (Mohan and Zech, 2005; N.Aniekwu, 2007; Gürcanli, Müngen and Akad, 2008; Halvani *et al.*, 2012; Dumrak *et al.*, 2013; Gürcanli and Müngen, 2013) |
| Exposure to bio-hazard chemical and gases | 0.336 | (Haslam *et al.*, 2005; Ale *et al.*, 2008; Camino López *et al.*, 2008; Rahim *et al.*, 2008; Pérez-Alonso *et al.*, 2012; Solís-Carcaño and Arcudia-Abad, 2013; Dumrak *et al.*, 2013; Gürcanli and Müngen, 2013; Mohammed and Ishak, 2013; Chong and Low, 2014; Asanka and Ranasinghe, 2015; Yilmaz, 2015; Winge and Albrechtsen, 2018) |
| Being trapped / squeezed | 0.216 | (Haslam *et al.*, 2005; Ale *et al.*, 2008; Rahim *et al.*, 2008; Camino López *et al.*, 2008; Gürcanli, Müngen and Akad, 2008; Li and Poon, 2009; Solís-Carcaño and Arcudia-Abad, 2013; Dumrak *et al.*, 2013; Gürcanli and Müngen, 2013; Mohammed and Ishak, 2013; Ali, Khahro and Memon, 2014; Yilmaz, 2015; Asanka and Ranasinghe, 2015; Winge and Albrechtsen, 2018) |
| Exhaustion / exertion of the worker | 0.216 | (N.Aniekwu, 2007; Ale *et al.*, 2008; Camino López *et al.*, 2008; Rahim *et al.*, 2008; Pérez-Alonso *et al.*, 2012; Mohammed and Ishak, 2013; Yilmaz, 2015; Williams, Adul Hamid and Misnan, 2018) |

| **Types of accidents** | **Literature Score** | **Authors** |
|---|---|---|
| Accidents caused by sharp objects and cuts | 0.12 | (Alinaitwe, Mwakali and Hansson, 2007; Dėjus, 2007; Gürcanli, Müngen and Akad, 2008; Pérez-Alonso *et al.*, 2012; Winge and Albrechtsen, 2018) |
| Accidents caused by bumping / collision of workers | 0.072 | (Camino López *et al.*, 2008; Pérez-Alonso *et al.*, 2012; Winge and Albrechtsen, 2018) |
| Accidents caused due to overturning of machines, vehicles, equipment | 0.024 | (Camino López *et al.*, 2008; Pérez-Alonso *et al.*, 2012; Winge and Albrechtsen, 2018) |
| Accidents caused due to burns / fire | 0.24 | (Mohan and Zech, 2005; N.Aniekwu, 2007; Camino López *et al.*, 2008; Gürcanli, Müngen and Akad, 2008; Im *et al.*, 2009; Solís-Carcaño and Arcudia-Abad, 2013; Ali, Khahro and Memon, 2014; Chong and Low, 2014; Asanka and Ranasinghe, 2015; Winge and Albrechtsen, 2018) |
| Accidents caused due to over-stepping / treading on objects | 0.096 | (Dėjus, 2007; Camino López *et al.*, 2008; Mohammed and Ishak, 2013; Asanka and Ranasinghe, 2015) |
| Accidents caused due to human error | 0.008 | (Camino López *et al.*, 2008) |
| Accidents caused due to suffocation | 0.048 | (Halvani *et al.*, 2012; Dumrak *et al.*, 2013) |

| Types of accidents | Literature Score | Authors |
|---|---|---|
| Accidents caused by being hit by a moving vehicle | 0.24 | (Mohan and Zech, 2005; Alinaitwe, Mwakali and Hansson, 2007; Dėjus, 2007; Camino López *et al.*, 2008; Gürcanli, Müngen and Akad, 2008; Im *et al.*, 2009; Li and Poon, 2009; Pérez-Alonso *et al.*, 2012; Solís-Carcaño and Arcudia-Abad, 2013; Chong and Low, 2014) |
| Accidents caused due to structure collapse | 0.072 | (Gürcanli, Müngen and Akad, 2008; Im *et al.*, 2009; Solís-Carcaño and Arcudia-Abad, 2013) |
| Accidents caused due to drowning | 0.008 | (Im *et al.*, 2009) |
| Accidents caused by mishandling of crane | 0.12 | (Mohan and Zech, 2005; Ling, Liu and Woo, 2009; Asanka and Ranasinghe, 2015) |
| Accidents caused during loading / unloading of material, machinery or equipment | 0.008 | (Chong and Low, 2014) |
| Accidents caused by animals / reptiles bite | 0.008 | (Ali, Khahro and Memon, 2014) |

## 2.3 Current Safety Training Methodologies

A training needs evaluation is carried out to confirm whether the workplace problem can be addressed with suitable training. It is a "continuous process to determine training needs by gathering data to help the organization accomplish its objectives" (Brown, 2002). In other words, it is the operation of collecting continuous information and data regarding an organizational requirement that could be fulfilled by carrying out a training program. Some of the widely accepted safety training methodologies are discussed as below:

### 2.3.1 Training with the aid of Visual representations

According to Cambridge English dictionary, the word "visual" means relating to seeing, something such as picture or a photograph to explain something. When we use a visual aid in order to instruct an audience, we can regard it as visual based learning. If consumed appropriately, a video could be an effective teaching medium (Shephard, 2003; Hartsell and Yuen, 2006). According to (Hoover, 2006; Oishi, 2007), video helps grab a student's attention, since a highly realistic representation of reality is essential for an efficient transfer of knowledge (for e.g. medical surgeries) (Brunvand and Fishman, 2006; De Leng *et al.*, 2007).


*Figure 2.1 Safety video tutorial (Source https://www.youtube.com/watch?v=QGkyYkx2NFY)*

Figure 2.1 shows a safety tutorial on YouTube. Some authors define video as an influential and expressive non-textual way to capture and exhibit information; and video is a powerful medium that can be utilized in electronic learning. It can deliver information in such a consistent manner that the viewer does not lose interest. The effect of instructional video learning has also been investigate in previous studies. A video can be very dominant teaching tool to grasp the attention of the audience as well as building motivation for more learning potential (Whatley and Ahmad, 2007).

In many studies carried out in the past, it has been proven that the education given with the help of visual aid is more effective than that based on simple text books. According to the survey carried out by Brecht and Ogilby (2008), 68.5% of the students being aided by videos and visual learning indicated that it helped them understand course information better and prepare for their examination than the conventional text based learning. 72.2% said that videos helped them complete their homework. 63% of the pupils told that they get help from them to provide themselves with tutoring help.

One of the studies conducted by Van Der Meij and Van Der Meij (2014), where they compared paper-based training against video tutorial learning, resulted in favor of presentation of software instructions via video rather than through papers. The participants who had viewed a video achieved a success rate of 87%, as compared to 63% for the participants that were provided with paper-based material. A user can view a task sequence as he pleases, creating a harmony between the screen animation and real-life course of action (Tversky *et al.*, 2002). After a number of similar experiments carried out, one can conclude that visual based training is indeed very effective for teaching.

### 2.3.2 Training with the aid of Simulation

Replication or representation of a physical object or an abstractive idea in full or parts is termed as Simulation. The term simulation in this study refers to applications of simulators for education or training. According to Cooper and Taqueti (2008) the term simulation is a technologies to recreate the full environment in which one or more targeted tasks are carried out. Simulations allow the user to upload their responses and feedback in real-time, creating an interactive environment between the user and the computer.

(Cha *et al.*, 2012) advocates that Virtual Reality (VR) which is a sub-domain of simulation, has been used with varied success for the training of firefighters. The same technology has also been used in the field of civil engineering education (Sampaio *et al.*, 2010), (Setareh *et al.*, 2005) suggests that it has also been used in constructability analysis.

Simulation is a technique used widely in many industries to replace and amplify real life-like experiences with the help of simulators. They replicate the natural situations for the learner to experience the same “immersive” feeling without unnecessary risks involved. “Immersive” here implies that participants are immersed in a task or setting as if it were the real world. (Gaba, 2004)

Simulation based training can be used to design a pre-fabricated learners experience, as well as a tool to measure the learner's competencies and capabilities. It's widely implemented in the field of aviation and military training. For example a "Flight Simulator" resembles an environment of flying an airplane which is available in a small room. People can experience the real environment for flying a plane with no risk of plane crash and dying (Singh, 2011). Figure 2.2 shows an example. The realistic experience and scenarios help the learner to quickly grasp useful information, gaining experience and knowledge simultaneously. Due to its effectiveness, it's gaining popularity in many more industries including medicine, manufacturing, construction etc.


*Figure 2.2 Simulation of concreting by workers (Pedro et al, 2015)*

### 2.3.3 Training with the aid of Lectures

It is a conventional method of teaching. A formal talk or speech given to a group of people, principally to students about a subject (Farooq, 2012). (Bartsch and Cobern, 2003) suggest that lectures are not likely to stop being used even after the introduction of more diverse teaching methods. It can comprise of an organized oral presentation of the subject on a particular topic prepared by an instructor. Lectures offer declarative knowledge that are required for developing skills and implementing them in the real world (Salas *et al.*, 2009). It could also be accompanied by additional methods, like discussions, question answers, visual presentations etc. Figure 2.3 shows the lecture on safety from (Enerpac, 2017).

(Burke *et al.*, 2006) labeled lectures as least engaging form of training method, claims that they are commonly used in health and safety related information exchanges. However according to their research, it is as not effective as other forms of training. Prevalent practice suggests that properly shaped lectures may be the optimum teaching method for many subjects and students, and lectures may be especially well-suited to the transmission of conceptual and systematic knowledge (Charlton, 2006).

*Figure 2.3 Lecture on safety (Enerpac, 2017)*

### 2.3.4 Training with the aid of Group Discussions

"Group Discussion" is a process in which a collection of individuals of similar traits exchange information or ideas in a face-to-face situation to achieve an objective. It is a conversation where more than one person puts their views and thoughts on a particular topic or subject (Juneja, 2017). (Williams *et al.*, 2010) discuss the effectiveness of group discussions carried out for Latino day laborer in construction industry and concluded that the workers had a positive effect on their on-site attitudes, work practices, and injury rates. Group discussions allow exchange of expert ideas, integrating individuals experience to group intelligence. (Chen Yang and Zhao Yong, 2011). (Bender, 2005; Phillips, 2005) suggest that group discussion help solve problems, improve learning and promotes critical and deep thinking.

## 2.4 Assessment of the safety training methods

Methods for safety training have been discussed above with the help of past literature. However, for assessment purposes, the pros and cons of each method will be mentioned below.

### 2.4.1 Training with the aid of Visual representations

Some of the advantages of training with the help of visual representations are discussed below:

- It allows the learners for better understanding the learning material and at their own pace by listening to instructors repeatedly by rewind forward option until they have fully understood the subject, while this comfort is not available in traditional classroom learning.
- Learning experience is also increased by swift access to random content access, which is effective for learner engagement (Alavi and Leidner, 2001; Zhang and Zhou, 2003).
- Since the traditional class room learning is more instructor-focused, with pre-determined teaching content, at controlled pace, students may lose attention if they fail to follow the instructor. However, in e-learning, each student has a customized curriculum resulting in more involvement and better learning.
- Provides location and time flexibility, resulting in cost and time savings for educational institutions (Athmika, 2017);
- Promotes self-paced and self-directed learning by enabling learner-centered activities;
- Links each learner digitally with other learners and experts creating a collaborative learning environment;
- Allows unlimited access to electronic learning material; and
- Allows knowledge to be updated and maintained in a more timely and efficient manner.

Few of the main drawbacks of visual learning as discussed by (Lewis and Orton, 2000; Sanderson, 2002; Klein and Ware, 2003; Nichols, 2003; Akkoyunlu, 2006; Hameed, Badii and Cullen, 2008; Algahtani, 2011) are mentioned below:

- Visual training as a method of education could lead to procrastination and lack of interaction with peers. Therefore, it requires a very strong motivation and time management skills in order to reduce such effects.
- Visual learning could lead to lack of socialization by limiting the role of instructors during the educational process.
- One issue with video learning is that once created, a video is mostly static. It’s a lot of work to edit and reissue a video if corrections are needed.

- Students often prefer direct instructions because they do not require them to do analysis or interpretation as that done in training through videos. (Bates, 2015).

### 2.4.2 Training with the aid of Simulation

(Xiannong, 2002; Banks *et al.*, 2010; Hammond, 2017) share some of the advantages of simulators in their studies:

- Simulators enable the learners to encounter the same environment without requiring years of training, education and work experience to have faced the same situation physically and in reality.
- Study the behavior of a system without actually producing it.
- It allows the researchers to provide with an active feedback instantly helping them to make changes in the real system instantly. This allows the designer to determine the correctness and efficiency of a design before the system is actually constructed
- Simulation models designed for training make learning possible without the cost disruption.
- Time can be compressed or expanded to allow for a speed-up or slow-down of the phenomenon
- "What if" questions could be answered.

(Gray, 2002; Moorthy, Vincent and Darzi, 2005; Brooks *et al.*, 2010) discuss some of the short-comings of simulators, and why are not they being implemented more comprehensively:

- Simulators are very expensive to build and they require constant maintenance from highly skilled technical staff.
- Simulators cannot always re-create accurate scenarios of the real-life situations
- Every trainee will learn from his/her own perspective which are variable for every human being.
- The time and cost taken for the staff to be trained on how to use the software and/or hardware makes it unfeasible for middle/low tier companies to use simulators.
- Since there are no real consequences for mistakes, it may result in students under performing and not being fully engaged in the training, thus generating inaccurate results.
- This individualized and learner specific approach is not possible in simulation based teaching. (Krishnan *et al.*, 2017)

### 2.4.3 Training with the aid of Lectures

Some of the advantages of training with the help of lectures are discussed below:

- In the presence of a teacher, a professor or a highly authoritative individual, the lesson is always shaped according to the course, keeping highly consistent and relevant, when it comes to what kind of information is delivered, and how it's delivered (Paris, 2014)
- There's not much effort needed for students during taking a lecture. They only need to pay attention, and take notes where they see fit. Because not much input is needed from the students, the information presented becomes clear, straightforward and uncomplicated. (Charlton, 2006)
- Students who are auditory learners may find that lectures appeal to their learning style. (Kelly, 2018)
- At time lectures prove to be the most economical training methods when compared with other educational means. (Phillips, 2005)
- They require minimum resources, just primarily a lecturer. (Freeman Herreid and Schiller, 2012)

Some of the drawbacks of training with the help of lectures are discussed below:

- A study from (Freeman *et al.*, 2014) finds that students in classes with traditional stand-and-deliver lectures are 1.5 times more likely to fail than students in classes that use more stimulating, so-called active learning methods.
- Due to lack of participation and involvement during a lecture, a student may be affected by boredom, losing focus and engagement, consequently making the lectures less purposeful (Bartsch and Cobern, 2003)
- The art of giving lecture depends on every teacher. The effectiveness is variable for every teacher.
- One downside is attending a lecture based course requires a long-term commitment to be in the required place at the directed time.

### 2.4.4 Group discussions

Some of the advantages of training with the help of group discussions are highlighted below:

- It helps classify thinking process which promotes relevant ideas. (Fay *et al.*, 2000)
- Makes learning more active and less isolating because the members exchange their own experiences and ideas.
- Allow members to assess their own knowledge and themselves with other members of the group which helps in character building. (Meleady *et al.*, 2013)
- An individual decision maker who will have a limited number of ideas is confined to his own knowledge only, while a group enables a number of members sharing their ideas and opinions which actually passes new information generating more new innovative thoughts. (Stajkovic *et al.*, 2009)
- There is generally an expert present in a group who have some background knowledge and experience related to the topic and he helps validate the suggestion and keeps the discussion on the point. They can be hired from outside to provide advices regarding the final decisions. (Bliese, 2000)

Some of the drawbacks of training with the help of group discussions are highlighted below:

- While group discussions are an important means of exchange of information, it shares some of the few disadvantages as well, as shared by (Chand, 2016).
- Assembling the right group, and a group reaching a common consensus can take too much time. And more time would be consumed as the size of the group increases.
- It is difficult to form a bond between the group members when the group size is large, leading to lower coordination and team-work (Bertucci *et al.*, 2010).
- In many instances, it is being observed that the participants in a group try to focus on their own ideas and interests and can give an unfair priority to them. These self-centered ideas and interests can lead to many conflicts between the groups which may hinder the efficiency and the quality of the process.
- In larger groups, dialogue decreases when certain speakers emerge and disproportionately dominate (Hamann *et al.*, 2012).

- There could be an element of social pressure if there are people belonging to different class groups within a discussion, with members may simply agree with the others for the sake of agreement and to conform and not to be the odd-man out. Thus the desire to be a good group member tends to silence disagreement and favors consensus. The social pressures can be very strong inducing people to change their attitudes, perceptions and behaviors. (Park and DeShon, 2018)
- A group may focus on one or a few alternatives based on current trends and may overlook other better alternatives. This is called "focus effect" which is common and it can lead to limiting ideas and choices.
- Sometimes a consensus can be detrimental to an organizational benefits. This can happen when a group may not always be in the accord with the objectives of their organization and the goal of individual and the goals of the group do not reinforce each other. (Fay *et al.*, 2000)
- (Ho and Dzeng, 2010) compared safety training through e-learning with other training methods and concluded that training through video or e-learning was the most effective method. They stated that an effective e-learning platform provides the labor with more exclusivity, and independence which is why the learners preferred e-learning compared to traditional learning methods.

In this chapter, multiple safety training methods were discussed along with their advantages and disadvantages. However, the selection of a specific method is done on the basis of requirements of the researcher. Due to this facts, visual learning is pursued considering the requirements of the target audience.

## 2.5 Use of digital technologies and softwares for training

Digital technologies are being introduced and implemented across different industries for various purposes. Construction industry is no exception, however, a limited research has been done to materialize the full potential of digital technologies in safety in construction industry to prevent work hazards. But in the past decade application of digital technologies in safety management have seen a growing interest among researchers. Some of the fine examples of such technologies include virtual reality, building information modeling, proximity warning, augmented reality, motion sensor, action/object recognition, laser scanning along with others. It could be argued that such technologies show great potential to improve construction safety because of its adaptability on individual level.

Mobile learning helps conventional learning by reaching inaccessible or remote learners (Traxler, 2005). From notebook computers to handheld and wireless devices, the combination of latest computing devices and rapidly improving internet capabilities have transformed the nature of higher education (Green, 2000). With a handheld device, the relationship between the owner and the device has become exclusive, ie. Location aware, personalized customization and always available (Homan *et al.*, 2003). Many industries like airlines, automobiles, manufacturing etc. are utilizing the use the digital learning for their distant employees and workers.

In earlier times, humans used to portray or document an event with the help of hand-made drawing, or sketching. With time, and new technologies, cameras were invented, later being upgraded with video features and the ability to record live movements of the subject. Animation could be described as a simulation of an activity created by presenting a series of pictures, or frames. Video animation can be 2-D (Two dimensional) and 3-D (Three dimensional). They can be prepared by a number of computer softwares (Autodesk Maya, Autodesk 3ds Max, Adobe Animate etc).

Education softwares help the audience with the purpose of self-learning. The concept of using computers in training and education dates back to the early 40s, when flight simulators were developed by American researchers to assist their pilots on better understanding airplanes. As the requirement of personalized and interactive softwares is growing, more startups and software houses are concentrating on developing programs that would cater the needs of teachers and students on learning different subjects (Sharon, 2017). Some of the softwares include TeachAIDS (Health), Number Munchers (History), DrGeo (Mathematics) and so on. Since educational multimedia software incorporates a variety of visualization techniques ranging from videos to pictures for aiding the knowledge of complex topics, it can be regarded as sustainable teaching method that is unexpected to become obsolete with time (Huk *et al.*, 2003).

Computer softwares could be used as a recreational tool, a vital component in offices for professional use, or in education. This could be in any form, such as video tutorials, simple animations generated with the help of computer softwares in the form of instructions, or in the case of children, computer games.

## 2.6 Softwares for creating 3D modules

According to Plaisant and Shneiderman (2005) animations could be a very effective teaching tool that involve a procedural action or process, particularly those that are difficult to visualize and imagined by the audience. For creation of animation in this study, Autodesk 3ds Max as shown in Figure 2.4 is used. Some of the salient features of this software are:

- 3D Modeling
- 3D Animation
- 3D Rendering & Imaging
- Dynamics & Effects

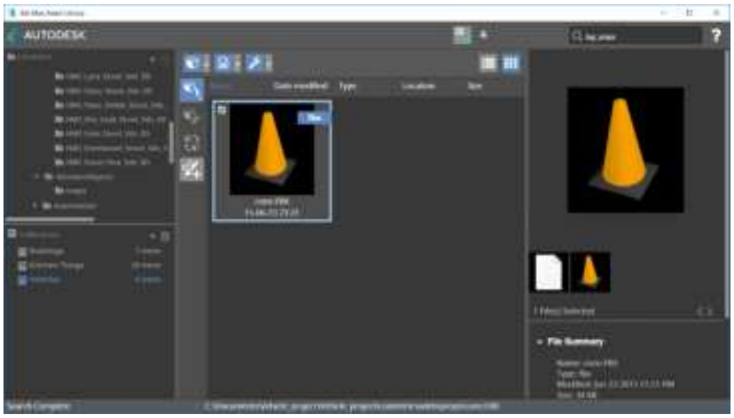


*Figure 2.4 Autodesk 3DS Max Interface*

Besides the software to create the safety animated scenes, an editing software is also used to incorporate the audio with the obtained scenes and add highlights. Adobe Premiere Pro as shown in Figure 2.5 is used to obtain the desired output.

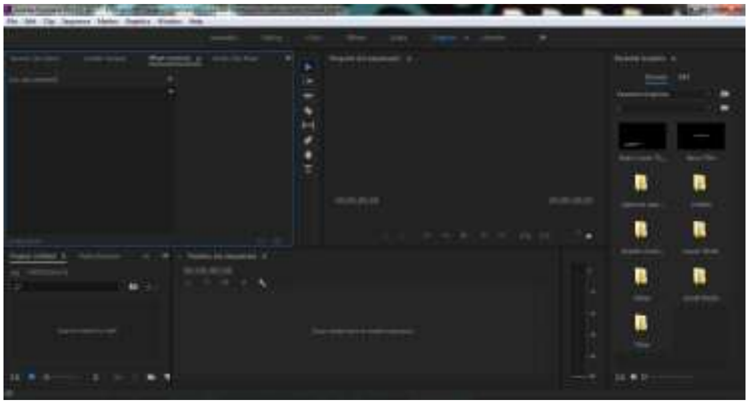


*Figure 2.5 Adobe Premiere Pro CC 2017*

## 2.7 Framework for the module development

A well-structured model demonstrating step-by-step pattern is considered before carrying out the developmental task of the safety modules. The framework in this research is formulated with the help of prominent ADDIE (Analyze, Design, Develop, Implement, and Evaluate) model along with the techniques adopted by various researchers in their respective studies. This study generates its own collective model namely ConSafe4All (Construction Safety for All) to fabricate a formal structure and process for creating computer generated 3D safety modules with a methodical thematic design integrating local languages. The ConSafe4All framework consists of three (03) main phases namely instructional design, development and assessment phase. Figure 2.6 represents the phases of the developed framework along with their processes.

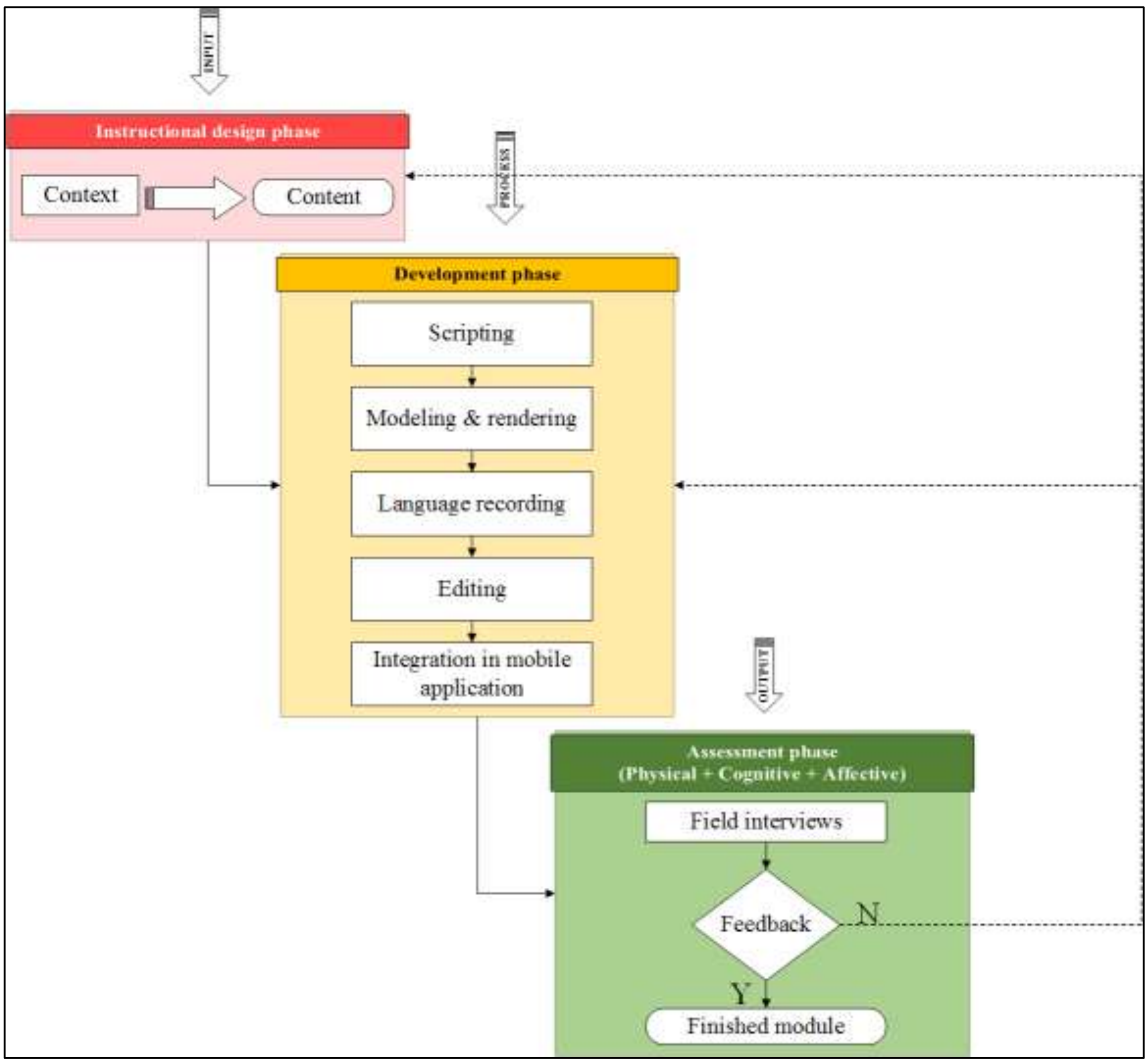



*Figure 2.6 ConSafe4All framework for module development*

### 2.7.1 Development of phases

#### 2.7.1.1 Instructional design phase

Instructional Design is the systematic development of instructional specifications using learning and instructional theory to ensure the quality of instruction. The process consists chiefly of determining the requirements and needs of the learner, defining the objective of instruction, and creating some interference to assist in the transition (Judith, 2016). Figure 2.7 shows the literature for instructional design phase.

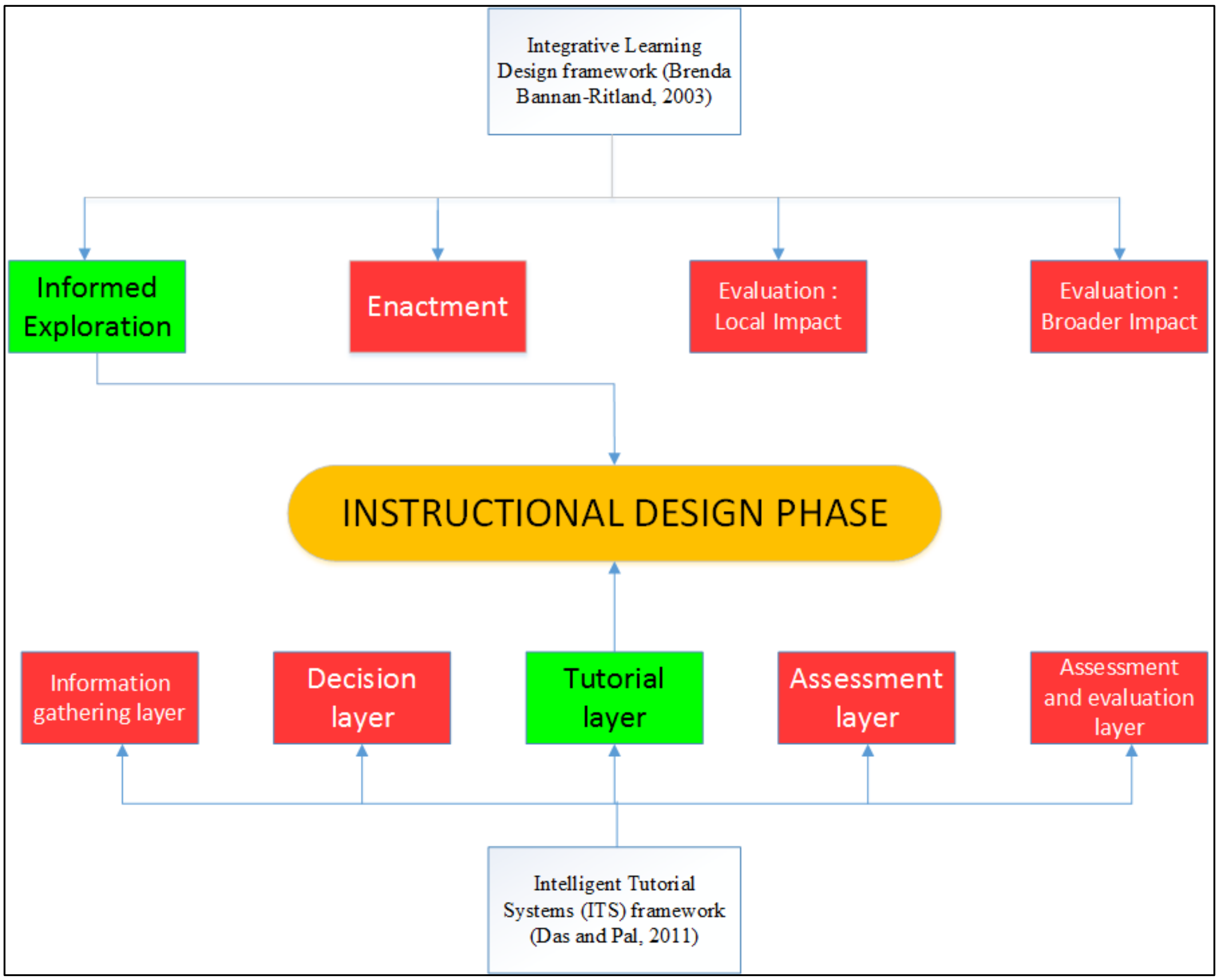



*Figure 2.7 Instructional Design Phase*

(Bannan-Ritland, 2003) proposed an integrative learning design (ILD) framework for effective learning by providing a comprehensive, yet flexible learning environments (using software and other artifacts) that allow trainers and learners to make education more effective. Extending the stages of (Ulrich and Eppinger, 2000) and drawing upon other design fields, the broad phases of the ILD frame- work are (a) Informed Exploration, (b) Enactment, (c) Evaluation: Local Impact, and (d) Evaluation: Broader Impact.

This phase of study adapts Informed Exploration shown in Figure 2.8, which studies the identifying and satisfying the needs of the intended users so that the mature innovation is successfully adopted and used to support its learning goals.

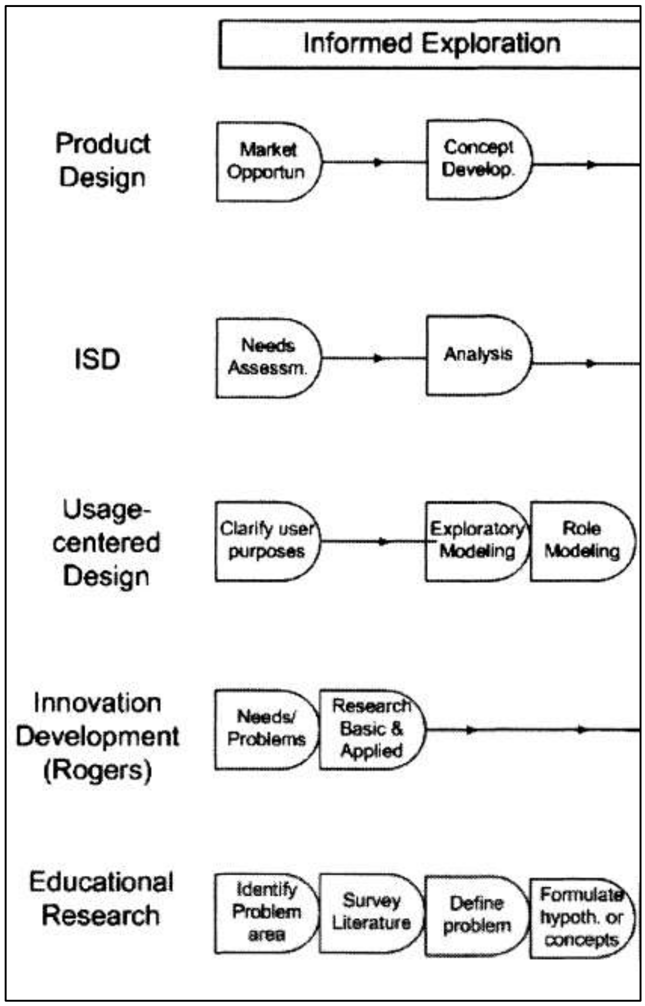



*Figure 2.8 Informed Exploration adapted in Bannan-Ritlan (2003)*

A framework of Intelligent Tutorial System developed by (Das and Pal, 2011) uses a layered architecture show in Figure 2.9 of adaptive learning to address some of the problem/drawbacks in traditional computer based learning system in conducting one-to-one learning. Pedagogy and intelligence are being tried to incorporate into the Intelligent Tutorial System.

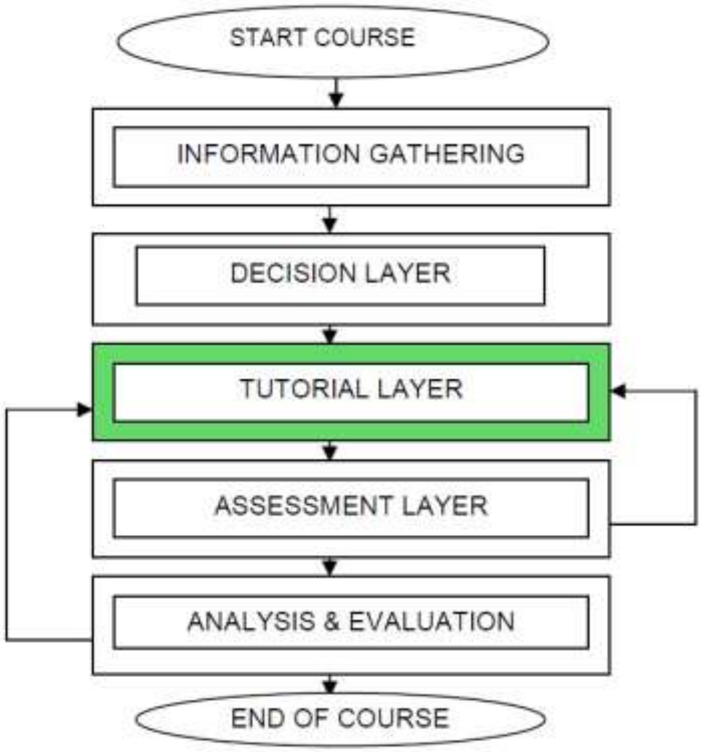



*Figure 2.9 Basic LAYER architecture of the proposed ITS*

Tutorial Layer which is also incorporated in this framework, discusses about the deliverable modules of learning material which are divided into number of frames. This layer serves the purpose of integrating relevant content and blend it in the study omitting all the extra information. The tutorial layer is directly tethered with evaluation layer; that is if the audience doesn't deem the content appropriate, the tutorial layer would be tailored.

Coherence Principle addresses an important topic of what information is to be included in a multimedia presentation. Essentially, this principle states that people learn better when extra or irrelevant information is excluded from a presentation (Mayer, 2009). It supports the concept that cognition is more difficult when extra information is presented. The extra information is interpreted as redundant and cause lesser learning to occur due to overloading of working memory.

One solution to this problem is a technique called "weeding"—the process of making the multimedia presentation as concise and coherent as possible, to reduce the amount of incidental processing that is required of the learner (Mayer and Moreno, 2002).

### 2.7.1.2 Development Phase

Development phase, Figure 2.10 which is the second phase of this study comes partially from the study of (Pedro *et al.*, 2015), which incorporated development phase by discussing about content development process in their VSES (Virtual Construction Safety Education System) framework.

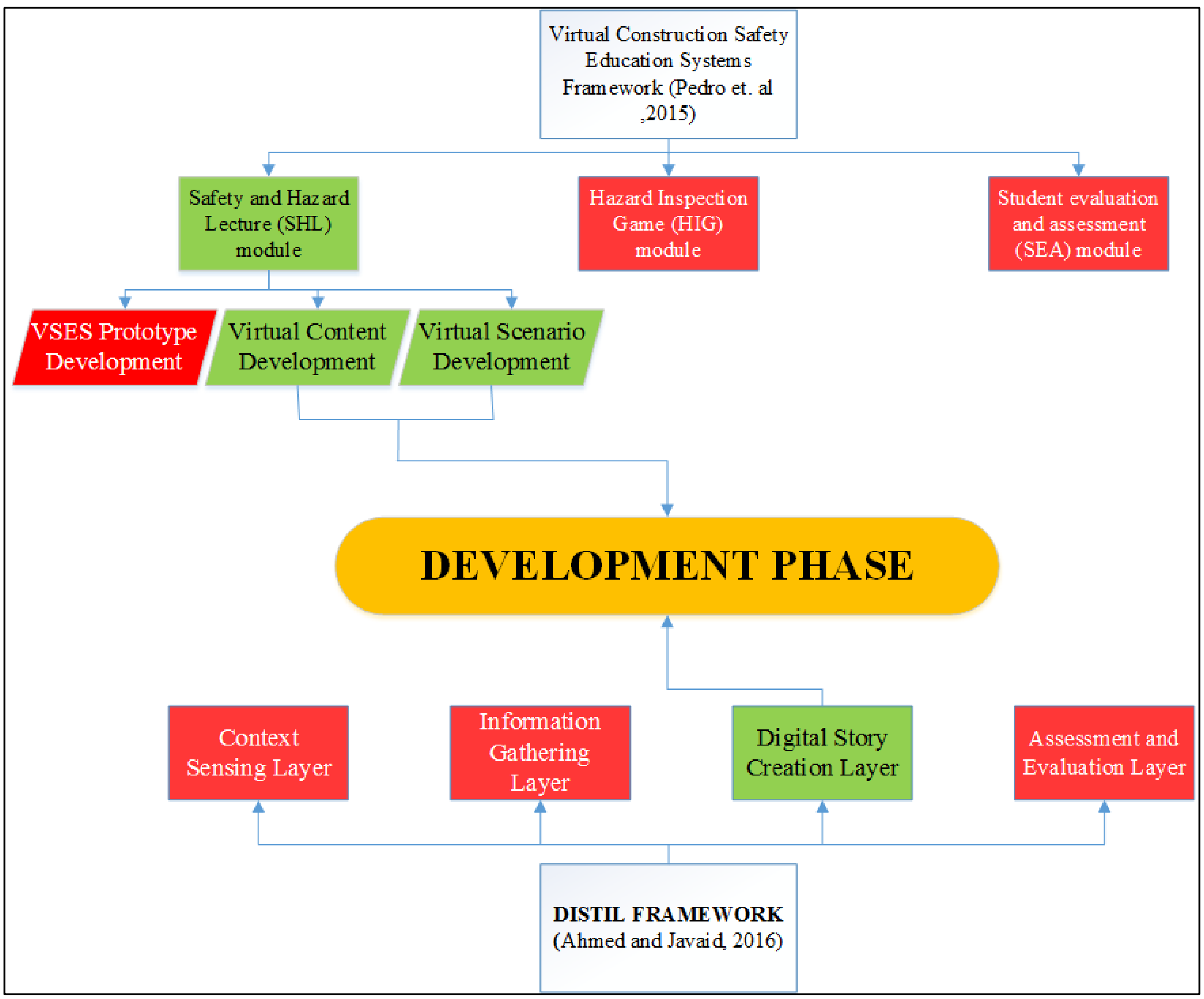



*Figure 2.10 Literature for development phase*

The prototype in VSES involved the development of a virtual environment and animation for their virtual game scenario based on construction processes.

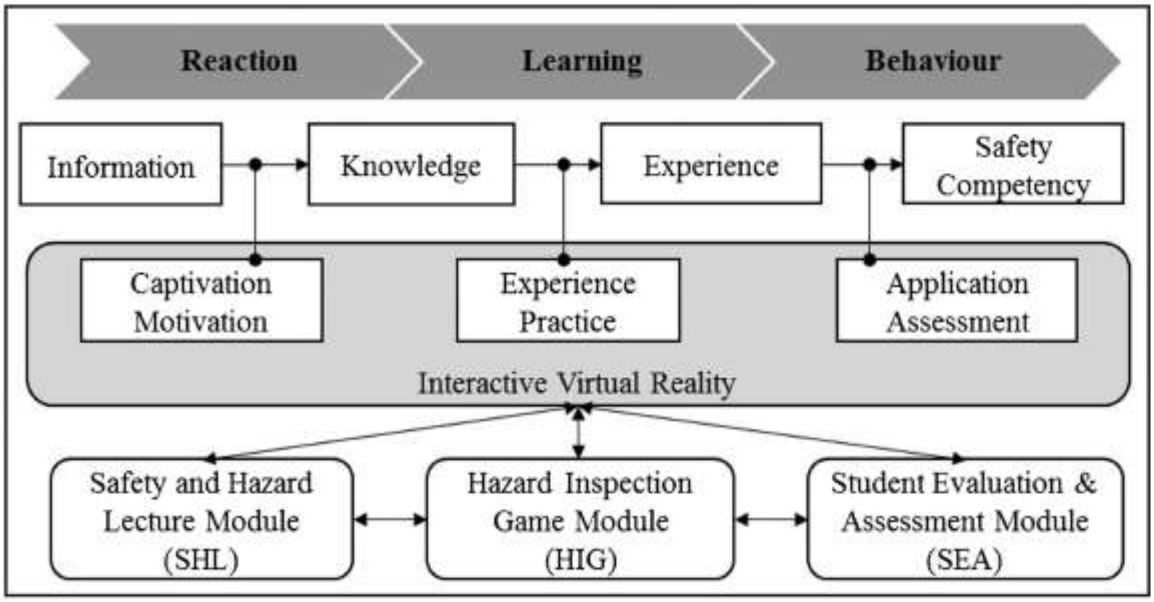



*Figure 2.11 VSES Framework (Pedro et al, 2015)*

A system shown in Figure 2.11 comprising of three modules is proposed, namely: (1) the safety and hazard lecture (SHL) module; (2) hazard identification game (HIG) module; and (3) student evaluation and assessment (SEA) module. Stimulating scenarios, examples and engaging games are created using these modules are according to the VSES learning model to enhance conventional construction safety education which facilitate experiential learning.

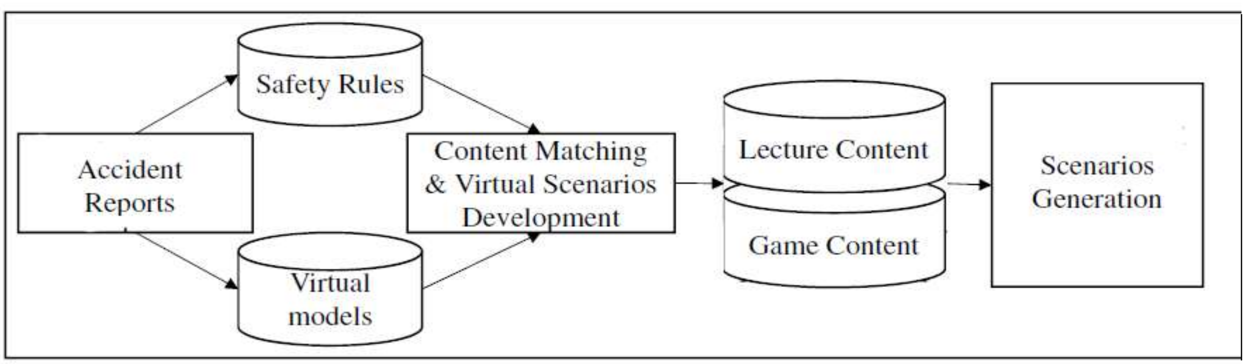



*Figure 2.12 VSES Content Development Phase (Pedro et al, 2015)*

The content development process shown in Figure 2.12 is incorporated in SHL (Safety and Hazard Lecture) module. Virtual Content Development and Virtual Scenario Development are the two main parts of SHL module. The study suggests that the scenarios generation is an extensive process. The process starts from gathering data related to accidents, their remedies, development of virtual models, and scenario development. After these pre-requisites, the content phase, which comprises of lecture content (what is the context) and game content (the final inclusion) in the module is included. These both contents merge to generate final scenarios for the audience to view.

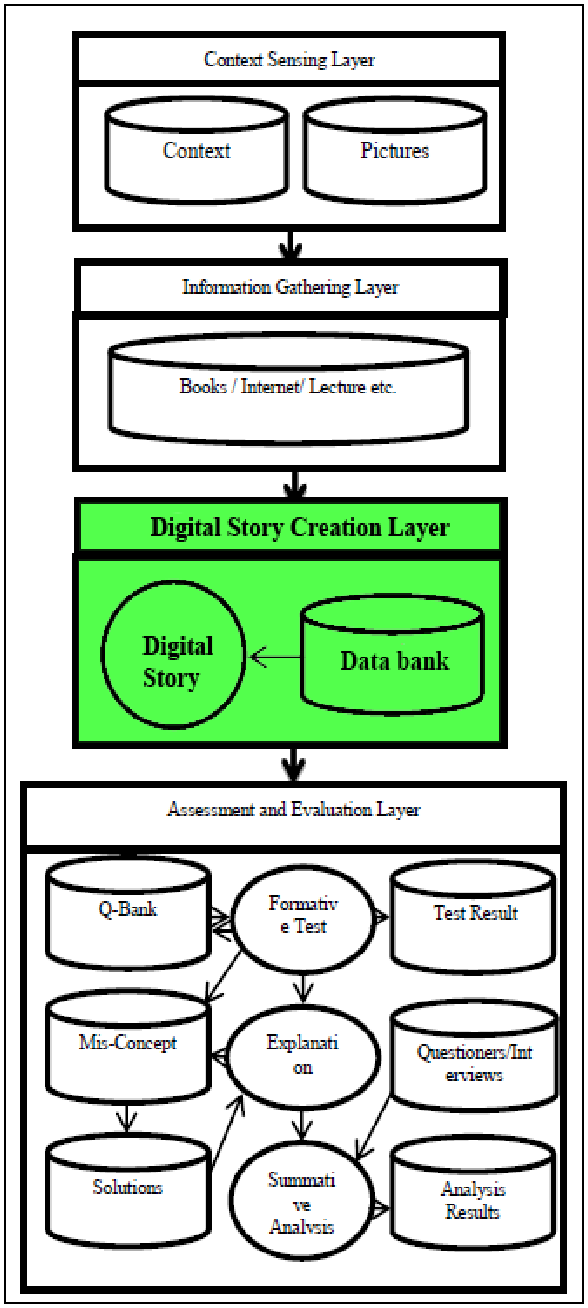



*Figure 2.13 DISTIL Framework (Ahmad and Javaid, 2016)*

Ahmed and Javaid (2016) incorporated Digital Story Creation Layer (DSCL), in their DISTIL framework Figure 2.13 in which they coupled the studies from (Hung *et al.*, 2013) and (Wei and Wei, 2010), which tells the art of storytelling by making use of moving pictures and audio for inquiry based learning activities.

Digital Story Creation Layer as in this study, states:

- Digital story creation can be text based in which information related to concerned picture is simply typed and displayed during presentation.
- Digital story creation can be audio based in which information or message related to concerned picture is recorded by the learner in his/her own voice.
- The path of tutoring is linear in lines with syllabus.

The digital story in this framework is video based with local language incorporated with simultaneous playback.

### 2.7.1.3 Assessment Phase

Assessment phase literature shown in Figure 2.14 is the backbone of any framework, as it confirms the validity of the entire model.

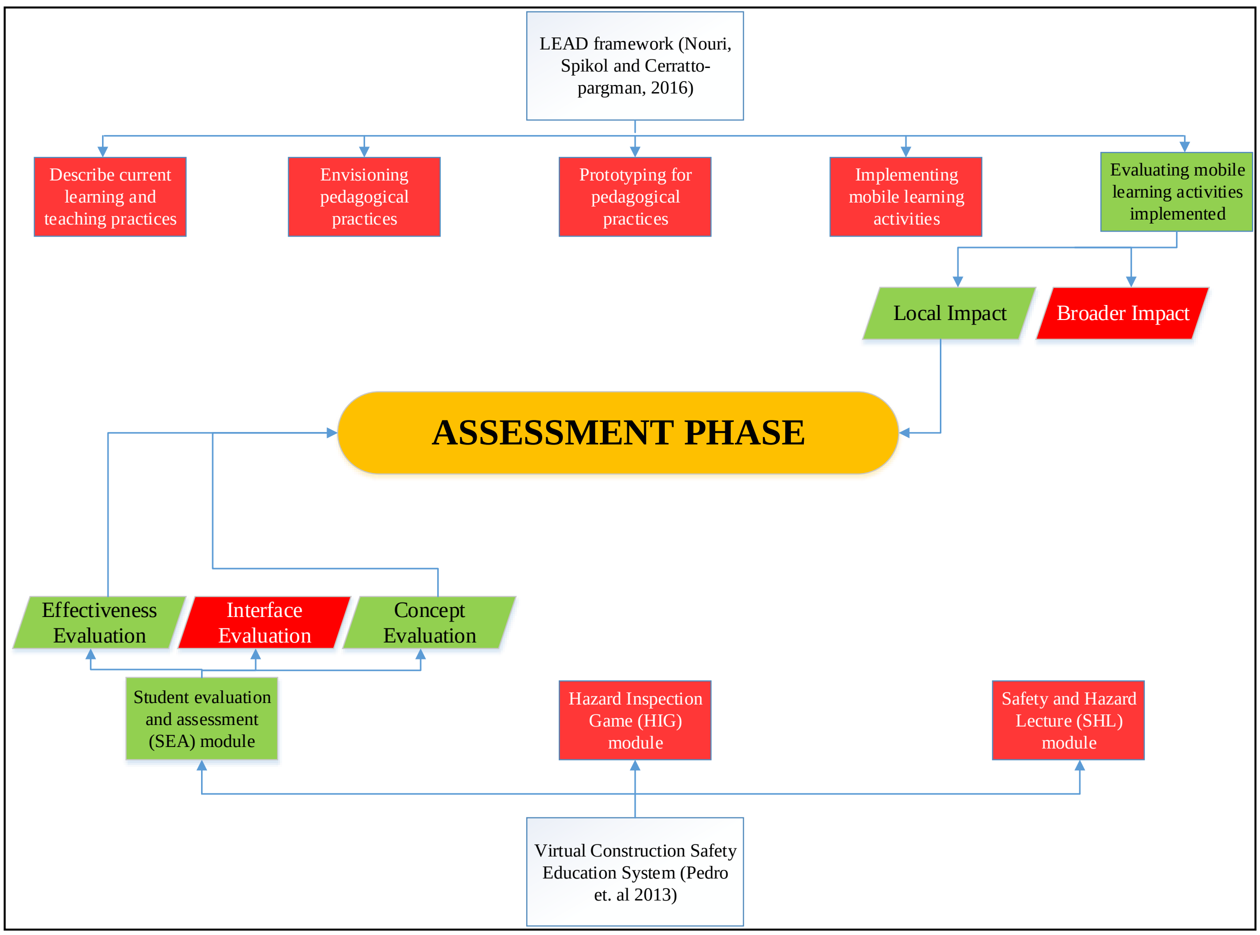



*Figure 2.14 Literature for assessment phase*

(Nouri *et al.*, 2016) employed Learning Activity Design (LEAD) framework for their model formed for the development and implementation of mobile learning activities in primary school.

Apart from the other four phases, their fifth and final phase comprises of evaluation which validate their study for mobile learning. These evaluations were based on the data collected in the studies comprising video, audio, survey data and interview.

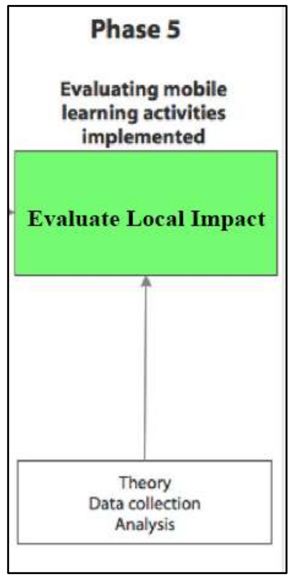



*Figure 2.15 Evaluation phase of LEAD framework (Nouri et al, 2013)*

The evaluation phase in the LEAD framework Figure 2.15 consists of two components, namely one evaluation of the local impact and an evaluation of the broad impact. The evaluations of the local impact comprise analysis of how well researchers' and designers' intervention satisfied the end-users. These evaluations were based on the data collected in the studies comprising video, audio, and interview and survey data.

Student Evaluation and Assessment (SEA) Figure 2.16 model was also applied and manipulated to mold into this study. The SEA model is designed to assess the safety knowledge and hazard recognition capabilities of students after the exhibition of the safety modules. The researchers in the above study performed "effective evaluation" which was based in interviews, questionnaires and feedback sessions. The purpose of effective evaluation is to measure the effectiveness of the 3D film on the target audience. Learners are evaluated with a novel approach using VR-based tests, exams, and assignments, whereby students can view 3D simulations of construction site processes. However, in this study the evaluation would take place in the form of field interviews.

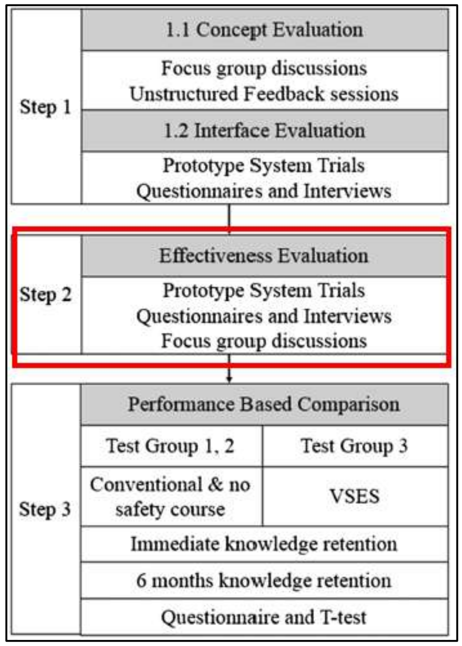



*Figure 2.16 Student Evaluation and assessment model (Pedro et al., 2015)*

SEA module is divided into three categories, Step 1 with Concept and Interface Evaluation. Step 2 with Effectiveness Evaluation, and Step 3 with Performance based comparison.

In this study, the phases of interface and effectiveness evaluation are selected. Interface evaluation focuses on the physical aspects of the module, while effectiveness evaluation validates the potency of the module. Physical aspect can cover the view ability, pace, duration, characters, or models in the module. Effectiveness evaluation covers the cognitive aspects like accuracy of the module, simplicity, or narration.

### 2.7.2 Definition of phases

#### 2.7.2.1 Instructional design phase

One of the key technologies required for efficient video processing is video content indexing, that is, how to effectively retrieve important information from redundant video data. A concise and informative video summary enables viewers to quickly figure out the overview contents of a video and decide whether the whole video program is what they want or not. (Ma *et al.*, 2005).

Important inputs regarding the selected construction hazards, and their responses for the given or required scenario are the contents or the subject matter that would be collected with the help of literature, books, internet and expert non-formal interviews. The “context” and “content” is defined as following:

*Context:* The top three accident types selected with the help of literature review.

*Content:* The remedies discussed in this section are based on the individual factors.

### 2.7.2.2 Development phase

Distribution of development phase Figure 2.17 which discusses the creation of graphical animated content, portrayal of construction workers, to demonstrate safety procedures. The main feature of this phase is the development of animated 3D modules, processed and generated with the help of computer softwares. With the help of a virtual environment, those demonstrations will be presented which would be easily understandable by the audience.

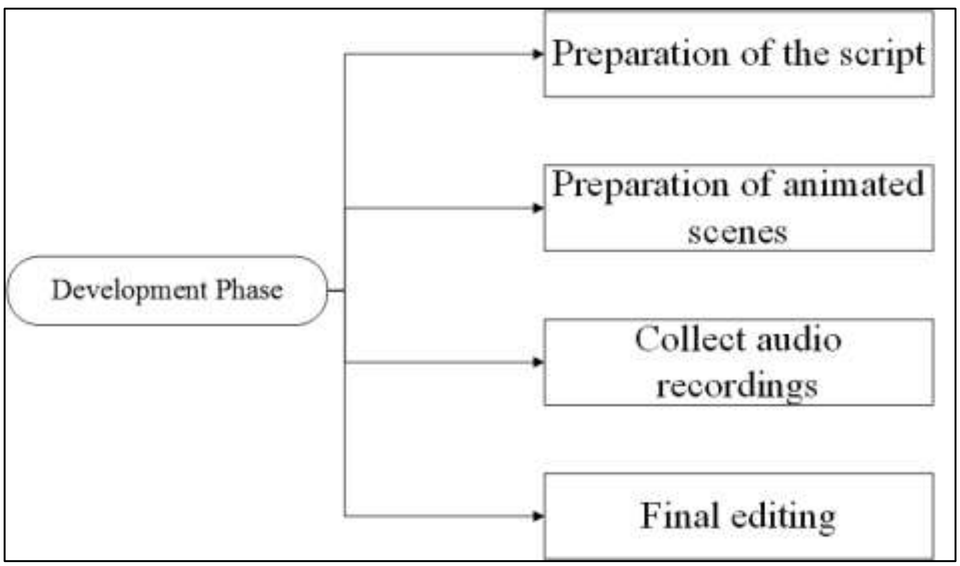



*Figure 2.17 Parts of development phase*

*Producing the script:* A script is a set of ideas written by the author on how to execute a desired storyline. A simple approach is followed to write a script, which consists of these basic steps:

- Outline the story. Start with a basic flow of the narrative
- Write the story on a paper or computer
- Add sequences
- Start writing scenes
- Cut away the excessive matter
- Show the finished work to friends or companions who can offer their opinions

- Revise your work as many times as necessary

After the script has been made, it's time to act upon it. In this case, the execution takes place inside AutoCAD 3ds Max computer animation software. All the imaginary data is being given a physical form for the audience to interpret and understand.

*Preparation of animated scenes:* Character modeling is the process which involves the generation of a two-dimensional or three-dimensional objects with the help of computer applications. It is mostly carried out in generating video games, simulators, animated movies, architectural designs, TV special effects and design visualization. The techniques and features used vary according to the software used and the nature of the project. Each frame which is designed, includes 3D animated objects, materials and subjects, shown in such a manner, that when combined together, creates a video that will achieve the desired result. The final product can be viewed in a smartphone, computers, projectors or similar devices.

*Collection of audio recordings:* Local regional languages that are to be used is being recorded in the form of normal audio files with the help of a recording software in a computer system. Volunteers recorded the narration after being provided with the audio script.

*Final editing*: The animated scenes and audio recordings obtained are then merged together to form a single clip playable through either mobile phone or a computer. This process also incorporates the addition of important highlights in the visual scenes.

**2.7.2.3 Assessment Phase:**

The assessment phase focuses on the assessment of the computer generated 3D safety modules. Evaluation could be regarded as a catalyst in deducing whether the product delivers expected results, in this case the product being the safety modules. Carliner (2000) proposed a framework for information design, which comprises of three main categories for evaluation, namely: physical, cognitive and affective design. Elements for these categories were picked by the studies from (Kay, 2014; Shirley *et. al*, 2014; Van Der Meij and Van Der Meij, 2014).

Physical design evaluation focuses on the concrete or tangible design of the safety module with the help of four variables: sound, pace, viewability, and duration. Sound measures volume and clarity of the narration. Pace measures the speed of the narration and animated scene. View-ability assesses the important objects and highlights in the module. Duration conforms if the duration of the module is suitable for the respondent.

Cognitive design evaluation primarily emphasizes the effectiveness of 3D safety modules with the help of six variables: similarity, understanding the module and narration, completeness, information processing, explain-ability, and increase in knowledge. Similarity confirms whether the audience has seen a similar video of the same or different topic before through any medium. Understanding evaluates the relevance of the narration (correction of language) and if the end-user understands the purpose of the module. Completeness is the depiction of how close the safety modules are to the real environment, if there are enough details and whether it contains any common errors that need rectification. Information processing ensures the simplicity and ease of understanding of the module. Explain-ability assesses if the respondent would be able to explain the module confirming the clarity of objectives. Increase in knowledge conforms if the safety module helped increase their knowledge relating to safety.

Affective design evaluation measures the amount of interest and engagement in the audience and whether they deem the videos worthwhile for future recommendation with the help of two variables: level of interest and future preference. Level of interest measures that while watching the safety module, did the viewer feel bored or experienced a loss of interest. Future anticipation or recommendation questions the respondent if they would like to view more videos on different safety topics by the same means confirming the effectiveness of the safety training modules.

*Steps to carry out the Evaluation phase*

At this mark, the 3D animated module has been developed. A final product has been generated which requires a general consensus. The next step is to test it on the target audience, who are construction workers in this case. Evaluation is carried out to confirm whether the module met the desired results. Figure 2.18 shows the phases to carry out assessment.

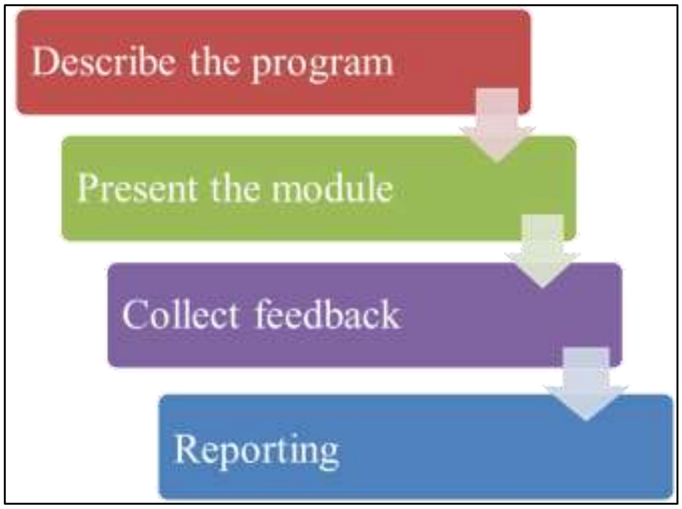



*Figure 2.18 Steps to carry out assessment*

1. *Describe the program*

The first step of evaluation phase is to describe the program to the audience. This includes explaining first what the study is about, building a perspective, present the objectives and the possible expectations of the study.

2. *Presenting the module*

This step includes the exhibition of the actual 3D animated video module which is prepared using computer software. This can be done via laptop, smartphone or other electronic device which supports audio and video playback. This study adopted the use of mobile phone.

3. *Collection of feedback*

An interview will be conducted from each individual which will be focused on the effectiveness of the module. Questions would be based upon visual and audio understanding, how clear the objectives were and whether the module was successful on achieving its desired results.

4. *Summarization of the results*

This is the final step of evaluation phase which comprises of forming the results on the basis of the feedback collected. Analysis will be performed and upon the final result, if positive, the study would be concluded.

*Chapter 3*

# RESEARCH METHODOLOGY

## 3.1 Introduction

This chapter discusses the research methodology carried out for this study. Research strategy shows how the researchers are going to carry out their study to achieve and answering research objectives (Saunders, Lewis and Thornhill, 2009). This research is conducted to investigate the effects of visual learning combined with local language to teach safety practices to construction workers. Schematic layout of the research methodology used in this research is given in Figure.

Research methodology Figure 3.1 shows how the researcher is going to carry out his study to achieve and answering research objectives. The methodology adopted for carrying out this research is described below:

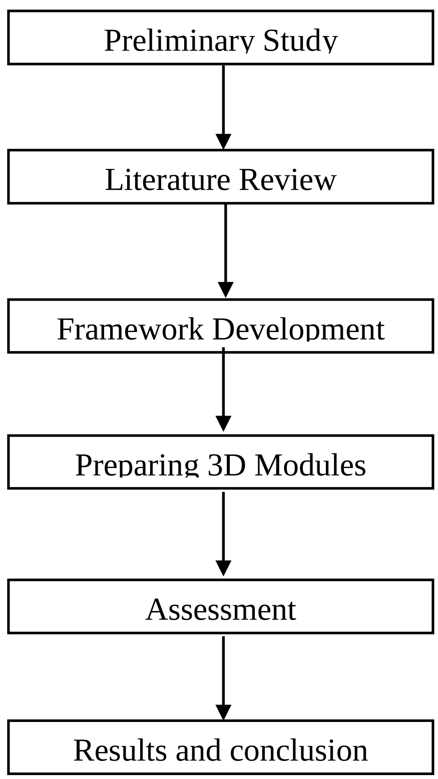



*Figure 3.1 Research methodology*

## 3.2 Preliminary study

A preliminary study was needed to inspect the current conditions of safety education designed for construction workers belonging to under developed areas. It was concluded that currently there is no proper channel to teach basic construction safety issues to illiterate workers originating mostly from rural areas or where there are less resources for education therefore the study was initiated to the next phase.

## 3.3 Literature Review

The next step of the study was to go through literature review. The purpose reading the past literature was to identify the most recurring accident types during a construction activity. Papers from different authors from all around the globe were studied and then the top most contributing factors were listed down with respect to their number of occurrences and their severity, upon which a literature score were given.

## 3.4 Framework Development

To create a systematic model to design a computer based 3D animated module, a framework was needed. For the creation of framework, different models and intense literature reviews was carried out. Framework will be in the design stage throughout the study.

## 3.5 Preparing 3D module

Figure 3.2 shows the graphical methodology for the preparation of 3D modules. This phase comprises of the actual development of computer generated 3D modules. There were three modules prepared, each for accidents due to falls, electric shocks and hit-by objects. The software used for this purpose are Autodesk 3ds Max for the modeling and creating animated scenes. Editing is done with the help of Adobe Premiere.

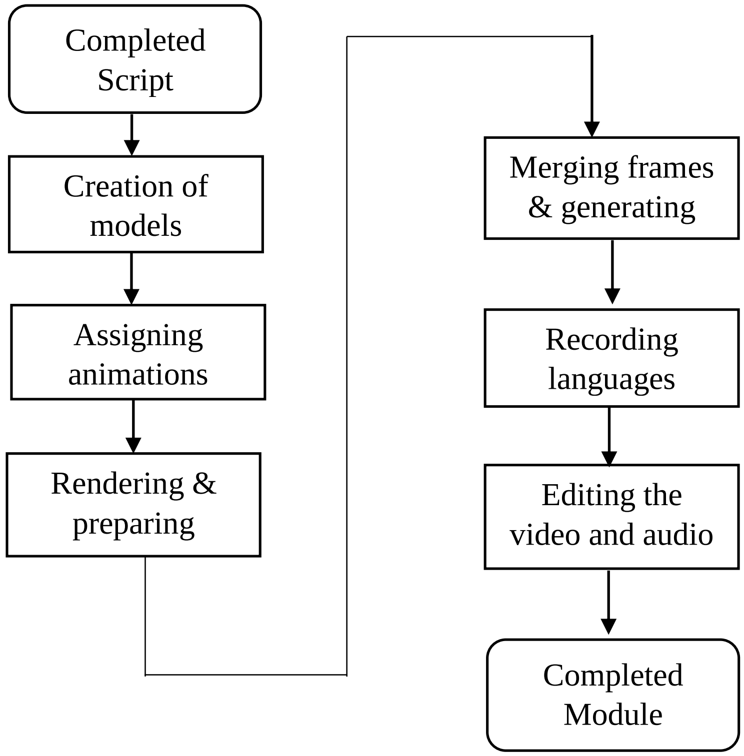



*Figure 3.2 Steps to develop animated scenes*

Before preparation of computer generated animations, a story-line was needed to aid the creation of the script for each module which was achieved with the help of literature studies discussed below:

### 3.5.1 Designing content

**1. Fall from height:**

According to (CPWR, 2008), falls are the leading cause of death and the third leading cause of non-fatal injuries in the construction industry. Ladders are the most common piece of equipment involved in fall fatalities (Bureau of Labor Statistics, 2017). After evaluating the worksites of 95 carpenters who fell while working at a residential site over a 3-year period, Lipscomb and colleagues determined that conventional fall protection could have prevented many of the falls (Lipscomb *et al.*, 2003), but such protection was rarely in place.

With the help of expert interviews, and with the references of the studies from (Rivara and Thompson, 2000; Chi, Chang and Ting, 2005; ROSPA, 2015; Evanoff *et al.*, 2016; Bunting *et al.*, 2017) Table 2 shows content was decided to be exhibited in the 3D modules catering the accidents caused due to falls:

*Table 2 Content in falls from height module*

| **Context** | **Content** |
|---|---|
| Accidents due to falls from height | 1. Accident: A worker falls down by losing balance as he tries to operate with a load while using ladder.<br>Remedy: Avoid carrying any load to ensure balance and safety.<br>2. Accident: A worker meets an accident trying to climb with the help of a broken ladder.<br>Remedy: Using fully functional ladder reduces such hazards.<br>3. Accident: Adjusting ladder onto different things to increase its height, causing a loss of balance and an accident.<br>Remedy: Using a proper ladder for the job with appropriate height eliminates such risks.<br>4. Accident: Walking near the edges of the buildings without any safety rail is extremely unsafe, a minor slip could lead to loss of life.<br>Remedy: Maintain at least 6' distance from the edge of the building.<br>5. Accident: Using a mobile device when falling into a ditch.<br>Remedy: Staying attentive of the surrounding, avoiding any form of distractions. |

## 2. Electrocution:

The costs from electrical injuries are severe not only economically but also physically. Most accidents involving electrical shocks are traumatic and cause severe tissue damage or even death (Zhao, Lucas and Thabet, 2009). The electrical injuries took as high as 15% of mortality rate, which resulted in roughly 1,000 deaths in the United States every year (Edlich *et al.*, 2005). Table 3 shows the content covered in Accidents due to electricity module with their remedies:

*Table 3 Content in electricity module*

| Context | Content |
|---|---|
| Accidents due to electrocution | 1. Accident: A worker gets electrocuted while working without a proper electrical safety equipment (Rubber gloves, and boots).<br>Remedy: Use of PPE (Personal protective equipment) should be mandatory.<br>2. Accident: Multiple connections and use of bare wires without proper plugs in a single power strip causes short circuit.<br>Remedy: Using proper power strips dedicated to each machinery with relevant power output minimizes such incidents.<br>3. Accident: A worker tries to lay down the erected ladder when he gets electrocuted from nearby power-lines.<br>Remedy: Asking for help from a co-worker, and laying down the ladder horizontally.<br>4. Accident: Crane boom gets in contact with power lines, causing the operator to be electrocute.<br>Remedy: A spotter is seen assisting the operator. |

### 3. Struck by / hit by an object:

According to OSHA, each year in the United States there are over 800 construction related deaths. Of these, more than 150 are caused by being struck by vehicles, construction equipment or other common workplace items. In fact, the so-called struck by accidents are the #1 cause of injuries on construction sites, and the second leading cause of death. Struck-by hazards exist any time a worker could be struck or hit by an object. Working or walking below elevated work surfaces may expose you to falling objects. Materials being moved overhead expose you to falling objects. (Ferraro, 2014; Copeland, 2016; Bachman, 2017) and on-field expert interviews suggested following content to over-come struck by accidents show in Table 4:

*Table 4 Content in hit-by module*

| **Context** | **Content** |
|---|---|
| Accidents due to hit-by objects. | 1. Accident: A worker is shown being hit by a suspended load.<br>Remedy: Safety cones and tape being deployed to denote safety distance.<br>2. Accident: A brick hits the worker who is working bare-foot.<br>Remedy: The worker is shown wearing safety boots and is indifferent to such hazards.<br>3. Accident: Due to improper house-keeping, a worker falls down hitting an object.<br>Remedy: A proper housekeeping minimizes such accidents.<br>4. Accident: A worker gets hit-by a passing car, as the driver is not able to view the worker due to lack of visibility.<br>Remedy: A reflective vest worn by the worker helps avoid this incident.<br>5. Accident: A worker is hit on head by an object while walking near the building.<br>Remedy: Wearing a hard hat minimizes the harm.<br>6. Accident: A driver near-misses a worker who is unaware of the vehicle.<br>Remedy: The driver uses a spotter who stops him before causing any harm to the worker. |

### 3.5.2 Creation of models and animations

Modeling in 3D is similar to sculpting. Many different techniques could be acquired to create the models in a scene. However, the technique used in this study is low-polygon modeling techniques. Polygon meshes are one of the major methods of modelling a 3D object for display by a computer. Polygons can, in theory, may have any number of sides but are commonly broken down into triangles for display. After creation of such models, they are assigned an animation, respective to their activity. For eg. A human climbing the ladder, a bucket hitting the ground. Today, most animations are made with computer-generated imagery (CGI). Commonly the effect of animation is accomplished by a quick series of sequential images that minimally vary from each other. Figure 3.3 shows the instance of 3D modeling.

*Figure 3.3 Modeling of a construction worker*

### 3.5.3 Recording local languages

The script prepared in the second step was furnished to the native speakers volunteering for the study. The volunteers participating were fluent in languages that the researcher pursues to incorporate in safety modules. There were a total of six languages recorded, namely (a) Urdu (b) Punjabi (c) Sindhi (d) Pashto (e) Balochi and (f) Saraiki. The final recorded audio clips would be combined with the visual scenes in the next step of the development phase.

### 3.5.4 Final editing and creation of media files

The files obtained from Autodesk 3ds Max and the voice recordings were two different entities that need to be brought together into a single video file. For this purpose, Adobe Premiere Pro CC

2017 shows in Figure 3.4 was used. Features like title screens, special effects, speed/duration of the clips were also adjusted with this software.

*Figure 3.4 Editing window*

The duration of each modules is shown in Table 5

*Table 5 Duration of the modules*

| **Accident type** | **Module No.** | **Duration** |
|---|---|---|
| Accidents due to struck-by objects | M-1 | 00:02:01 |
| Accidents due to falls | M-2 | 00:02:36 |
| Accidents due to electrocution | M-3 | 00:01:19 |

Figure 3.5 shows the screenshot from the animated modules

*Figure 3.5 Screenshot from module M-1 (left), M-2 (center), M-3 (right)*

### 3.5.5 Development of mobile-based application

A simple to use mobile application was required that would act as a medium to exhibit the safety training modules to the target audience. The app to be developed is catered for construction workers having minimal knowledge about handling the gadgets. Therefore, the interface of the app was kept as simple as possible requiring minimum number of clicks to navigating to the videos. Figure 3.6 shows the flow chart of mobile app execution.

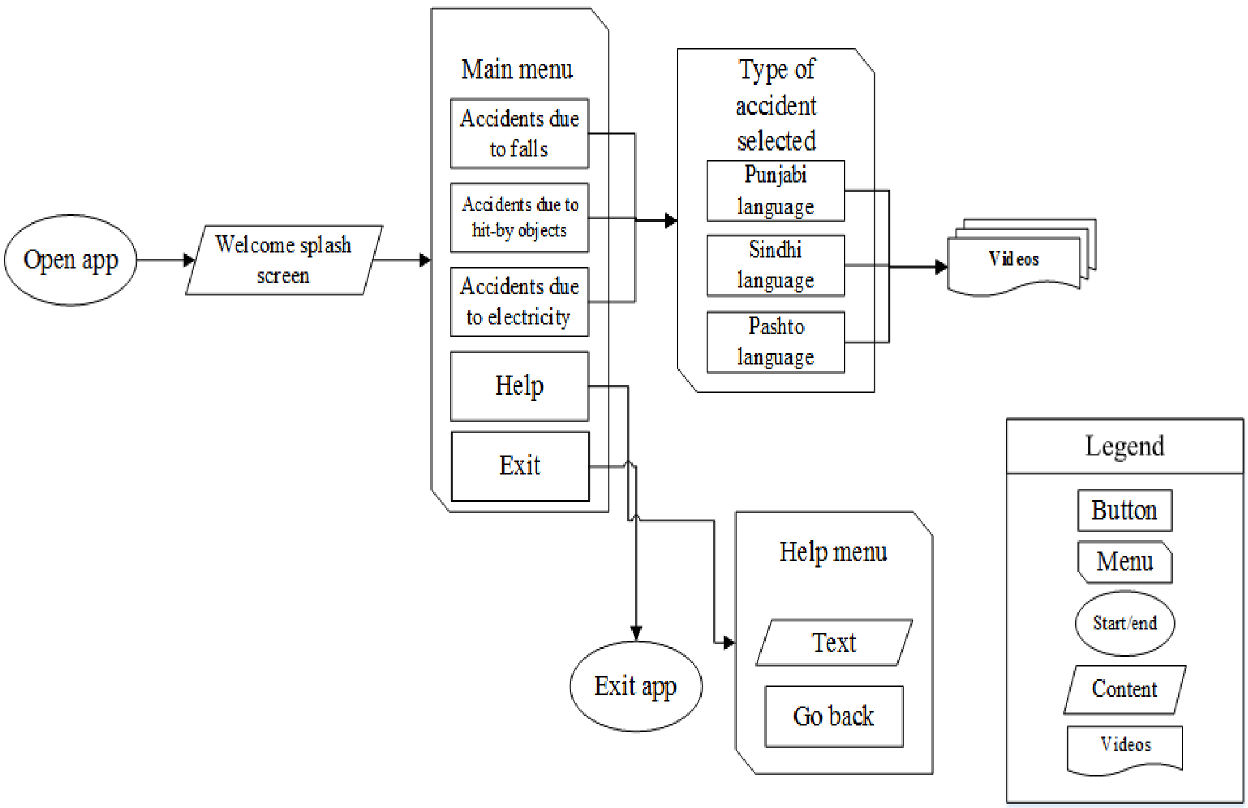



*Figure 3.6 Flow-chart of the mobile application*

The application first loads showing a splash screen in the background. Figure 3.7 shows the main screen which consists of 4 main buttons, namely: 1. Hit by 2. Electric 3. Heights 4. Help/About. Touching particular button proceeds to the next screen for tutorial videos. The icons on the respective buttons represent the language in which the module is based, making the selection process easier for someone who has difficulty understanding English language.

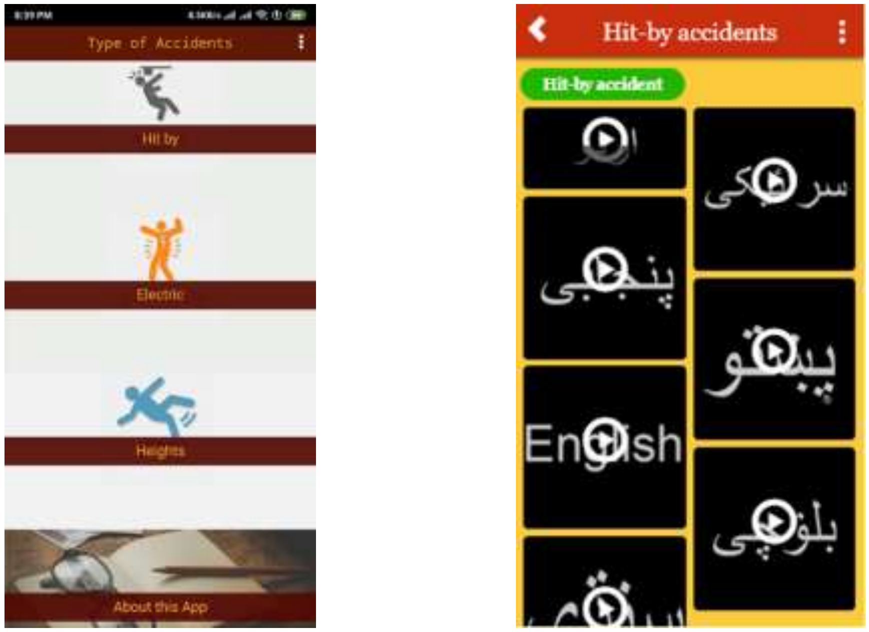



*Figure 3.7 Interface of the mobile application*

## 3.6 Assessment

After the development of mobile application, it was time for the evaluation to confirm its efficiency. A questionnaire based on three main categories, that are physical design, cognitive design and affective design was developed where only open ended questions were asked. Since the target audience mostly could not read or write, therefore the researcher was responsible to note down the responses individually. The details of the sites visited and the individuals interviewed are summarized in the following Table 6:

*Table 6 Location of the respondents*

| City | Project | Type of Construction | Size of the Construction | Number of interviewees |
|---|---|---|---|---|
| Peshawar | Total Parco<br>G+2 story house | Commercial<br>Residential | ~27000sq ft<br>4200 sq ft | 36 |
| Lahore | Head office AAP News Channel | Commercial | 6000 sq ft | 39 |
| Muzaffargarh | Construction and rehabilitation program for schools (UKAID) | Commercial (Non-profit) | 6500 government schools | 40 |

## 3.7 Results, conclusions & recommendations

After the interview, results would be summarized. Based on the results, conclusions will be summarized and recommendations for the future research would be proposed.

*Chapter 4*

# DATA COLLECTION & RESULTS

## 4.1 Introduction

This chapter parades through the data collected by one-on-one interviews. These interviews were conducted in order to assess whether the computer generated safety modules warrants any effectiveness for the learner and either it could be a reasonable alternative for the conventional safety training techniques.

## 4.2 Field Interview questions

Real life measures and experiences are gathered using with the help of interviews (Yin, 2003). There were a total of 42 open ended questions for the workers out of which 17 asked about the worker demographics, their working experience, their mode of communication, and whether they have faced or witnessed any accidents while working in the construction field. The entire questionnaire is attached in the Annexure - I. The questionnaire prepared was in dual language, English and Urdu. Workers who could not understand Urdu, a translator was used on-site who would translate the questions and their answers accordingly. Versatile data can be collected through questionnaire survey as it provides an access to extensive number of people so a broader concept can be gained.

## 4.3 Characteristics of the respondents

A total of 115 respondents from three different cities were evaluated. First they were asked some demographic questions, followed by exhibition of the safety modules. The researcher proceeded with younger respondents with lesser work experience and little to no educational background to achieve maximum positive output. All of the respondents were male, between the ages of 16-34.

## 4.4 Field interviews

Three cities, Lahore, Peshawar and Muzaffargarh were selected to carry out the field interviews. These three cities have workers who speak Punjabi, Pashto and Saraiki in majority along with a few other languages as well. The interviews were set up in casual manner. There are three safety modules; accidents due to heights, hit-by objects, and electric shocks. Therefore, majority of workers prone to such accidents were selected by default. That is, a professional working in folding is more vulnerable to fall as compared to tile fixer.

*Demographics of the respondents*

The age bracket of the respondents is reflected in Figure 4.1(a) 47 (41%) participants were aged between 15 to 21 years, 53 (46%) participants were aged between 22 to 28 years, 14 (12%) participants were aged between 29 to 35 years and only 01 participant was aged above 35 years. Moreover, as evident in Figure 4.1(b) 76 (66%) workers had 0-3 years of working experience. 33

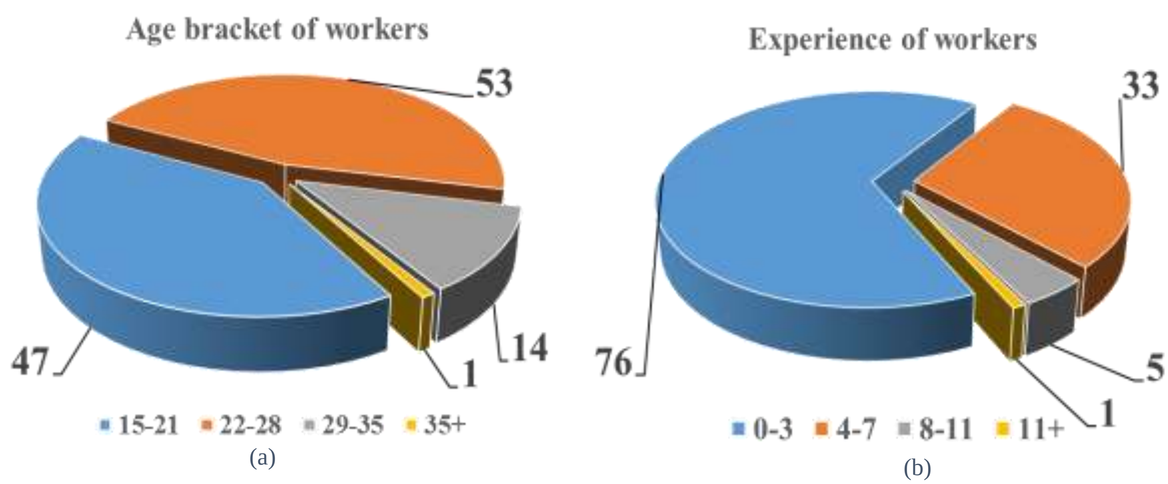
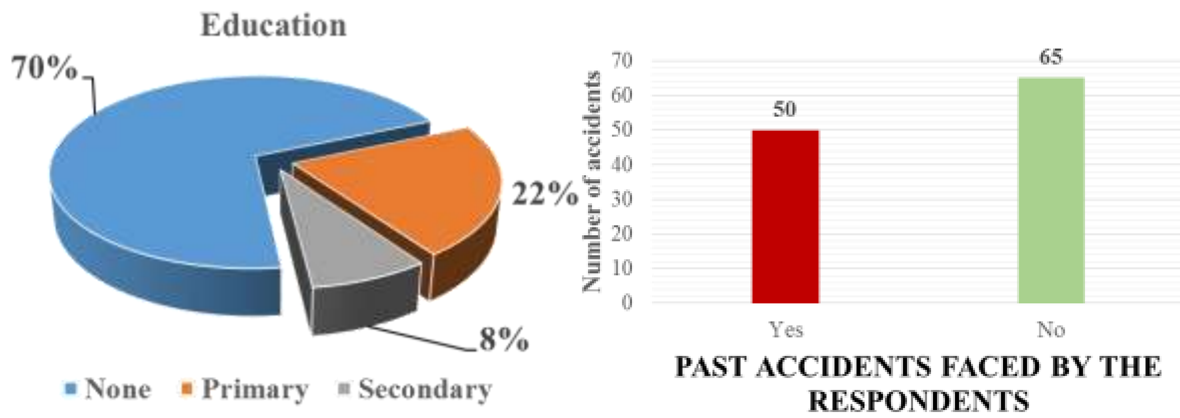



*Figure 4.1 (a) age & (b) experience of the workers*

(29%) workers had 4-7 years of working experience, 5 (4%) workers had 8-11 years and just one worker had experience of more than 11 years.

The education of the participants which is shown Figure 4.2(a) reflects that 81 (70%) of the workers had no educational background. 25 (22%) participants attended primary school, while 09 (8%) of them attended secondary school and none of them completed high-school or onwards. A series of questions related to past accidents were asked from the respondents.

As shown in the Figure 4.2(b) out of the total 115 respondents, 65 (57%) of them had experienced major to minor accidents in their workplace.




(a) (b)

*Figure 4.2 (a) education & (b) accidents faced by workers*

## 4.5 Results

The feedback collected from the respondents is shown. Table 7 represents results of the assessment carried for the safety training modules. M-1 denotes “Accidents due to falls”, M-2 denotes “Accidents due to struck-by/hit-by objects” and M-3 denotes “Accidents due to electricity”.

*Table 7 Assessment of the safety modules*

| Assessment type | Description | Module | Positive | | Neutral | | Negative | |
|---|---|---|---|---|---|---|---|---|
| | | | No. | % | No. | % | No. | % |
| Physical | Sound | M-1 | 43 | 100% | 0 | 0 | 0 | 0 |
| | | M-2 | 44 | 100% | 0 | 0 | 0 | 0 |
| | | M-3 | 28 | 100% | 0 | 0 | 0 | 0 |
| | Pace of the narration | M-1 | 43 | 100% | 0 | 0 | 0 | 0 |
| | | M-2 | 44 | 100% | 0 | 0 | 0 | 0 |
| | | M-3 | 25 | 89% | 0 | 0 | 3 | 11% |
| | Pace of the animation | M-1 | 43 | 100% | 0 | 0 | 0 | 0 |
| | | M-2 | 44 | 100% | 0 | 0 | 0 | 0 |
| | | M-3 | 23 | 82% | 0 | 0 | 5 | 18% |
| | View-ability | M-1 | 39 | 91% | 4 | 9% | 0 | 0 |
| | | M-2 | 39 | 89% | 5 | 11% | 0 | 0 |
| | | M-3 | 28 | 100% | 0 | 0 | 0 | 0 |
| | Duration | M-1 | 5 | 11% | 38 | 89% | 0 | 0 |
| | | M-2 | 3 | 7% | 41 | 93% | 0 | 0 |
| | | M-3 | 0 | 0 | 10 | 36% | 18 | 64% |
| Cognitive | Understanding | M-1 | 43 | 100% | 0 | 0 | 0 | 0 |
| | | M-2 | 44 | 100% | 0 | 0 | 0 | 0 |
| | | M-3 | 28 | 100% | 0 | 0 | 0 | 0 |
| | Information processing | M-1 | 31 | 72% | 12 | 28% | 0 | 0 |
| | | M-2 | 27 | 61% | 17 | 39% | 0 | 0 |
| | | M-3 | 27 | 96% | 1 | 4% | 0 | 0 |
| | Explanation | M-1 | 40 | 93% | 3 | 7% | 0 | 0 |
| | | M-2 | 37 | 84% | 7 | 16% | 0 | 0 |
| | | M-3 | 28 | 100% | 0 | 0 | 0 | 0 |
| | Similarity | M-1 | 43 | 100% | 0 | 0 | 0 | 0 |
| | | M-2 | 43 | 98% | 0 | 0 | 1 | 2% |
| | | M-3 | 23 | 82% | 0 | 0 | 5 | 18% |
| | Completeness | M-1 | 43 | 100% | 0 | 0 | 0 | 0 |
| | | M-2 | 44 | 100% | 0 | 0 | 0 | 0 |
| | | M-3 | 28 | 100% | 0 | 0 | 0 | 0 |
| | Increase in knowledge | M-1 | 34 | 79% | 4 | 9% | 5 | 12% |
| | | M-2 | 35 | 80% | 4 | 9% | 5 | 11% |
| | | M-3 | 16 | 57% | 0 | 0 | 12 | 43% |
| Affective | Level of interest | M-1 | 29 | 53% | 20 | 47% | 0 | 0 |
| | | M-2 | 24 | 55% | 20 | 45% | 0 | 0 |
| | | M-3 | 13 | 46% | 15 | 54% | 0 | 0 |
| | Recommendation | M-1 | 43 | 100% | 0 | 0 | 0 | 0 |
| | | M-2 | 44 | 100% | 0 | 0 | 0 | 0 |
| | | M-3 | 28 | 100% | 0 | 0 | 0 | 0 |

## 4.6 Discussion

The feedback shows that majority of the responses were positive for the developed safety modules with respect to the physical, cognitive and affective evaluation. The participants were contended with the volume quality and clarity of the narration which enhances the chances of comprehension in the cognitive domain as also envisaged by (Ashaver, 2013). Moreover, the added audio narrations have been reported as the major factor to understand the shown modules. The feedback for the pace of narration also shows that audio narrations were synchronized with the on-screen actions which mitigates the chances of straying from subject matter. The positive feedback received from majority of participants against view-ability and pace of animation shows that the participants were able to distinguish the on-screen objects with no difficulty due to their speedy movement as highlighted by (Clark and Mayer, 2012). Contrary to this, no feedback was received against the slow pace that could tempt the participants to skip and consequently miss the developed content as stressed by (Morain and Swarts, 2012). The neutral and negative responses received against the length of the module were due to the reason that the participants expressed their desire to increase duration to cover more number of accidents and their respective remedies.

For the case of cognitive assessment, the participants were majorly satisfied with related aspects of understanding, information processing and explanation even when they have not watched similar content previously. This satisfies the requirement suggested by (Bishop and Cates, 2001) that a viewer should not only watch the visual content but also be able to easily understand and elucidate the content. Under the affective domain, most of the participants suggested that they would like to watch and further recommend similar safety modules on more accident types, which shows their positive motivation and greater level of interest. The workers also believed that the developed modules have the potential to create safety awareness among newly recruited individuals on-site.

Besides the positive feedback, there have been some incidents where multiple amendments were suggested by the participants. These suggestions were mostly associated with the physical design thereby necessitating revisions in visual scenery of particular modules. The assessment for such modules were continued once all the amendments were incorporated. One of the examples is shown in Figure 4.3 wherein amendments were incorporated in the struck-by safety module. Figure 4.3(a) exhibits a scene before the changes were implemented. The participants raised difficulty in view-ability and suggested to increase brightness for better understanding. Figure 4.3(b) shows the corrected scene which received positive feedback in the assessment.

(a)

(b)

*Figure 4.3 (a) before and (b) after the revision of the modules*

*Chapter 5*

# CONCLUSION & RECOMMENDATIONS

## 5.1 Introduction

This section concludes the research and findings. Summary of data collection in previous chapters is presented. Recommendations based on study and results, along with future work is also suggested.

## 5.2 Conclusion

The study in the first step identified the potential of visual representation for knowledge transfer to construction workers pertaining to construction safety. The study develops a dedicated framework – ConSafe4All – to produce safety training videos for workers to train them in their preferred language of choice and overcome the language restrictions. The framework consists of three phases: instructional design, development, and assessment, which can facilitate the development of safety training videos for any working environment. To enhance understanding, the study also demonstrates all the phases under the ConSafe4All framework. The feedback of the construction workers in the assessment phase shows that the framework may be followed to develop training material to create awareness in newly recruited construction workers having little to no prior working experience. The framework may also be followed to cater the workers from other industries like manufacturing, agricultural, mining, etc. through development of safety tutorials. Other than the three accident types considered for the purpose of this study, there were many other types of accidents that occur quite frequently during construction works causing significant loss of human lives or leaving them with permanent injuries. Future research is also recommended to study the impact of the framework on safety record of a particular project through implementation in the execution phase.

## 5.3 Contribution for Academia

The study provides an extensive overview with respect to the current safety training methodologies. It was established with the help of previous literature that training with the help of visual representation is the most beneficial medium when other forms of pedagogical methods show lack of positive results under special circumstances. The study also signifies the importance of local languages in the training curriculum, exhibiting the compelling need of safety training where most of the audience cannot read or write in a common (English) language. Researcher also provides a framework for academic professionals to develop and replicate the safety training modules, instrumental for the workplace safety training and implementation in not just other countries, but other industries as well.

## 5.4 Contribution for Industry

During the assessment phase it was revealed that out of 115 participants who viewed the safety training modules, 50 of them faced workplace accidents in their life-time. These results were alarmingly high, uncovering the frightful conditions of construction industry and the lack of safety implementation protocols. This claim demonstrates the negligence from all the major stakeholders and insufficient safety enforcement procedures which instigates high number of workplace accidents especially in the developing countries. This study also highlighted probable workplace hazards that might transpire during a construction activity along with their remedies by providing computer generated animated modules. This emphasizes the importance of following workplace safety practices resulting in lesser injuries thus also inciting safety behavior within the audience, by exhibiting the consequences of the accidents and unsafe work behavior. Furthermore, these safety modules are portable, easily accessible and readily available. They provide a room for modification (change of languages, visual scenes), making them suitable for other industries as well. The safety modules are cost friendly alternative to conventional training techniques that are not audience centric, making them more vulnerable of becoming obsolete.

## 5.5 Recommendations

Out of the three, there were many other types of accidents that occurred quiet frequently during construction works causing significant loss of human lives or leaving them with permanent injuries. Due to time constraint, most of them could have not been made part of the mobile application which could still be included in the future. Future research is also recommended to study the impact of the framework on safety record of a particular project through implementation till the execution phase.

## REFERENCES


Ahmed, S. and Javaid, S. (2016) *A digital story telling framework for inquiry based learning activities*.

Akkoyunlu, B. (2006) ‘A Study on Students ’ Views On Blended Learning Environment’, *Tojde*.

Al-Humaidi, H. M. and Tan, F. H. (2010) ‘Construction safety in Kuwait’, *Journal of Performance of Constructed Facilities*, 24(1), pp. 70–77.

Alavi, M. and Leidner, D. E. (2001) ‘Research commentary: Technology-mediated learning—A call for greater depth and breadth of research’, *Information systems research*, 12(1), pp. 1–10.

Ale, B. J. M. *et al.* (2008) ‘Accidents in the construction industry in the Netherlands: An analysis of accident reports using Storybuilder’, *Reliability Engineering and System Safety*, 93(10), pp. 1523–1533. doi: 10.1016/j.ress.2007.09.004.

Algahtani, A. (2011) ‘Evaluating the Effectiveness of the E-learning Experience in Some Universities in Saudi Arabia from Male Students ’ Perceptions’, *Durham University E-Theses for the Degree of Doctor of Philosophy*.

Ali, T. H., Khahro, S. H. and Memon, F. A. (2014) ‘Occupational accidents: A perspective of Pakistan construction industry’, *Mehran University Research Journal of Engineering & Technology*, 33(3), p. 345.

Alinaitwe, H., Mwakali, J. A. and Hansson, B. (2007) ‘Analysis of Accidents on Building Construction Sites Reported in Uganda during 2001 - 2005’, pp. 1208–1221.

Arquillos, A. L., Romero, J. C. R. and Gibb, A. (2012) ‘Analysis of construction accidents in Spain, 2003-2008’, *Journal of safety research*, 43(5–6), pp. 381–388.

Arumugam, E and Thirumurthy, A. (2007) ‘Benchmarking Studies on Safety Management in Construction Industries of India’, *Master of Science Dissertation*.

Asanka, W. A. and Ranasinghe, M. (2015) ‘Study on the Impact of Accidents on Constructio Projects’, *6th International Conference on Structural Engineering and Construction Management 2015*, (August), pp. 58–67. Available at: http://www.civil.mrt.ac.lk/conference/ICSECM_2015/volume_4/Extract/SECM-15-088.pdf.

Ashaver, D. (2013) ‘The Use of Audio-Visual Materials in the Teaching and Learning Processes in Colleges of Education in Benue State-Nigeria’, *IOSR Journal of Research & Method in Education (IOSRJRME)*. doi: 10.9790/7388-0164455.

Athmika, T. (2017) *These Are The 7 Advantages of Using Videos in E-learning*. Available at: https://blog.commlabindia.com/elearning-design/7-advantages-of-using-videos-in-elearning (Accessed: 26 August 2018).

Ayomoh, M. K. O. and Oke, S. A. (2006) ‘A framework for measuring safety level for production environments’, *Safety Science*. doi: 10.1016/j.ssci.2005.09.006.

Bachman, S. (2017) *Tips to Avoid Struck-By Accidents on the Construction Site*. Available at: https://www.msblawkc.com/avoid-construction-struck-accidents/ (Accessed: 1 September 2018).

Banks, J. *et al.* (2010) ‘Discrete-Event System Simulation’, *PrenticeHall international series in industrial and systems engineering*. doi: 10.2307/1268124.

Bannan-Ritland, B. (2003) ‘The Role of Design in Research: The Integrative Learning Design Framework’, *Educational Researcher*. doi: 10.3102/0013189X032001021.

Barlas, B. (2012) ‘Occupational fatalities in shipyards: an analysis in Turkey’, *Brodogradnja: Teorija i praksa brodogradnje i pomorske tehnike*, 63(1), pp. 35–41.

Bartsch, R. A. and Cobern, K. M. (2003) ‘Effectiveness of PowerPoint presentations in lectures’, *Computers and Education*. doi: 10.1016/S0360-1315(03)00027-7.

BATES, A. W. T. (2015) *Teaching in a digital age, Open Web Source*. doi: 10.2498/cit.1002511.

Beaudin, B. P. and Quick, D. (1996) ‘Instructional video evaluation instrument’, *Journal of Extension*, pp. 9–17.

Bender, T. (2005) ‘Role Playing in Online Education: A Teaching Tool to Enhance Student Engagement and Sustained Learning’, *Innovate: Journal of Online Education*.

Bertucci, A. *et al.* (2010) ‘The impact of size of cooperative group on achievement, social support, and self-esteem’, *Journal of General Psychology*. doi: 10.1080/00221309.2010.484448.

Bishop, M. J. and Cates, W. M. (2001) ‘Theoretical foundations for sound’s use in multimedia instruction to enhance learning’, *Educational Technology Research and Development*. doi:

10.1007/BF02504912.

Bliese, P. D. (2000) ‘Within-group agreement, non-independence, and reliability: Implications for data aggregation and analysis’, *Multilevel theory, research, and methods in organizations: Foundations, extensions, and new directions*.

Brecht, H. D. and Ogilby, S. M. (2008) ‘Enabling a Comprehensive Teaching Strategy: Video Lectures’, *Journal of Information Technology Education*, 7, pp. 71–86.

Brooks, N., Moriarty, A. and Welyczko, N. (2010) ‘Implementing simulated practice learning for nursing students.’, *Nursing Standard*. doi: 10.7748/ns2010.01.24.20.41.c7454.

Brunvand, S. and Fishman, B. (2006) ‘Investigating the Impact of the Availability of Scaffolds on Preservice Teacher Noticing and Learning from Video’, *Journal of Educational Technology Systems*. doi: 10.2190/L353-X356-72W7-42L9.

Bunting, J. *et al.* (2017) ‘A national safety stand-down to reduce construction worker falls’, *Journal of Safety Research*. doi: 10.1016/j.jsr.2016.12.005.

Burke, M. J. *et al.* (2006) ‘Relative effectiveness of worker safety and health training methods’, *American Journal of Public Health*. doi: 10.2105/AJPH.2004.059840.

Camino López, M. A. *et al.* (2008) ‘Construction industry accidents in Spain’, *Journal of Safety Research*, 39(5), pp. 497–507. doi: 10.1016/j.jsr.2008.07.006.

Carliner, S. (2000) ‘Physical, cognitive, and affective: A three-part framework for information design’, *Technical Communication*.

Cha, M. *et al.* (2012) ‘A virtual reality based fire training simulator integrated with fire dynamics data’, *Fire Safety Journal*. doi: 10.1016/j.firesaf.2012.01.004.

Chand, S. (2016) *What are the Advantages and Disadvantages of Group Decision Making? – Explained!* Available at: http://www.yourarticlelibrary.com/management/what-are-the-advantages-and-disadvantages-of-group-decision-making-explained/3503 (Accessed: 20 August 2018).

Charlton, B. G. (2006) ‘Science school and culture school: Improving the efficiency of high school science teaching in a system of mass science education’, *Medical Hypotheses*. doi:

10.1016/j.mehy.2006.02.011.

Chen Yang, Zhao Yong, X. D. (2011) ‘An information structuring approach for group discussion’, *Advanced in Control Engineering and Information Science*, 15, pp. 1261 – 1265.

Cheng, C. W. *et al.* (2010) ‘Characteristic analysis of occupational accidents at small construction enterprises’, *Safety Science*. Elsevier Ltd, 48(6), pp. 698–707. doi: 10.1016/j.ssci.2010.02.001.

Chi, C. F., Chang, T. C. and Ting, H. I. (2005) ‘Accident patterns and prevention measures for fatal occupational falls in the construction industry’, in *Applied Ergonomics*. doi: 10.1016/j.apergo.2004.09.011.

Chi, S., Han, S. and Kim, D. Y. (2012) ‘Relationship between unsafe working conditions and workers’ behavior and impact of working conditions on injury severity in US construction industry’, *Journal of construction engineering and management*, 139(7), pp. 826–838.

Chong, H. Y. and Low, T. S. (2014) ‘Accidents in Malaysian construction industry: Statistical data and court cases’, *International Journal of Occupational Safety and Ergonomics*, 20(3), pp. 503–513. doi: 10.1080/10803548.2014.11077064.

Clark, R. C. and Mayer, R. E. (2012) *e-Learning and the Science of Instruction: Proven Guidelines for Consumers and Designers of Multimedia Learning: Third Edition*, *e-Learning and the Science of Instruction: Proven Guidelines for Consumers and Designers of Multimedia Learning: Third Edition*. doi: 10.1002/9781118255971.

‘CONSTRUCTION RELATED INJURIES AND FATALITIES  As of December 31, 2014’ (2017), p. 2017.

Cooper, J. B. and Taqueti, V. R. (2008) ‘A brief history of the development of mannequin simulators for clinical education and training’, *Postgraduate Medical Journal*. doi: 10.1136/qshc.2004.009886.

Copeland, J. (2016) *Top 4 Causes of Construction Deaths: Steps to Prevent These Tragedies*. Available at: https://www.arbill.com/arbill-safety-blog/top-4-causes-of-construction-deaths-steps-to-prevent-these-tragedies (Accessed: 1 September 2018).

CPWR (2008) *The construction chart book: The US construction industry and its workers*. Cpwr-The Center for Construction Research and Training. Available at: refhub.elsevier.com/S0022-4375(16)30510-2/rf0020.

Crosthwaite, D. (2000) 'The global construction market: A cross-sectional analysis', *Construction Management and Economics*. doi: 10.1080/014461900407428.

Das, B. K. and Pal, S. (2011) 'A framework of intelligent tutorial system to incorporate adaptive learning and assess the relative performance of adaptive learning system over general classroom learning', *International Journal of Multimedia and Ubiquitous Engineering*.

Dėjus, T. (2007) 'Accidents On Construction Sites And Their Reasons', pp. 1–7.

Dumrak, J. *et al.* (2013) 'Factors associated with the severity of construction accidents: The case of South Australia', *Australasian Journal of Construction Economics and Building*, 13(4). doi: 10.5130/ajceb.v13i4.3620.

Edlich, R. F. *et al.* (2005) 'Modern concepts of treatment and prevention of electrical burns.', *Journal of long-term effects of medical implants*. doi: 10.1615/JLongTermEffMedImplants.v15.i5.50.

Enerpac (2017) 'TOOL SAFETY TRAINING GOES ON-SITE TO CUT DOWNTIME', August, p. 1. Available at: https://www.industryupdate.com.au/article/tool-safety-training-goes-site-cut-downtime.

Evanoff, B. *et al.* (2016) 'Results of a fall prevention educational intervention for residential construction', *Safety Science*. doi: 10.1016/j.ssci.2016.06.019.

Evia, C. (2011) 'Localizing and Designing Computer-Based Safety Training Solutions for Hispanic Construction Workers', *Journal of Construction Engineering and Management*, 137(6), pp. 452–459. doi: 10.1061/(ASCE)CO.1943-7862.0000313.

Farooq, U. (2012) *Lecture Method of teaching, Definition, Advantages & Disadvantages*. Available at: http://www.studylecturenotes.com/social-sciences/education/382-lecture-method-of-teaching-definition-advantages-a-disadvantages- (Accessed: 28 August 2018).

Farrow, S. and Hayakawa, H. (2002) 'Investing in safety an analytical precautionary principle.', *Journal of safety research*. doi: 10.1016/S0022-4375(02)00023-3.

Fay, N., Garrod, S. and Carletta, J. (2000) 'Group Discussion as Interactive Dialogue or as Serial Monologue: The Influence of Group Size', *Psychological Science*. doi: 10.1111/1467-9280.00292.

Ferraro, T. (2014) *Struck by Accidents in Construction*. Available at: https://blog.creativesafetysupply.com/struck-accidents-construction/ (Accessed: 1 September 2018).

Freeman Herreid, C. and Schiller, N. a. (2012) 'Case studies and the flipped classroom', *Journal of College Science Teaching*. doi: doi.org.proxy2.lib.umanitoba.ca/10.1.

Freeman, S. *et al.* (2014) 'Active learning increases student performance in science, engineering, and mathematics.', *PNAS Proceedings of the National Academy of Sciences of the United States of America*. doi: 10.1073/pnas.1319030111.

Gaba, D. M. (2004) 'The future vision of simulation in health care', *Quality and Safety in Health Care*. doi: 10.1136/qshc.2004.009878.

Gray, W. D. (2002) 'Simulated Task Environments: The Role of High-Fidelity Simulations, Scaled Worlds, Synthetic Environments, and Laboratory Tasks in Basic and Applied Cognitive Research', *Cognitive Science Quarterly*. doi: citeulike-article-id:8050468.

Green, K. C. (2000) 'Technology and instruction: compelling, competing, and complementary visions for the instructional role of technology in higher education. Retrieved November 11, 2006 fromhttp://www. campuscomputing. net/archive/papers/tech_and_instruction. pdf'.

Gürcanli, G. E. and Müngen, U. (2013) 'Analysis of construction accidents in Turkey and responsible parties.', *Industrial health*, 51(6), pp. 581–95. doi: 10.2486/indhealth.2012-0139.

Gürcanli, G. E., Müngen, U. and Akad, M. (2008) 'Construction equipment and motor vehicle related injuries on construction sites in Turkey.', *Industrial health*, 46, pp. 375–388. doi: 10.2486/indhealth.46.375.

Halvani, G. *et al.* (2012) 'A survey on occupational accidents among construction industry workers in Yazd city: Applying Time Series 2006-2011', *JOHE spring*, 1(1), pp. 1–8. doi:

10.18869/acadpub.johe.1.1.1.

Hamann, K., Pollock, P. H. and Wilson, B. M. (2012) ‘Assessing Student Perceptions of the Benefits of Discussions in Small-Group, Large-Class, and Online Learning Contexts’, *College Teaching*. doi: 10.1080/87567555.2011.633407.

Hameed, S., Badii, A. and Cullen, A. J. (2008) ‘Effective e-learning integration with traditional learning in a blended learning environment’, in *European and Mediterranean Conference on Information Systems*.

Hammond, K. (2017) *Advantages & Disadvantages of Simulation*. Available at: https://itstillworks.com/12599408/advantages-disadvantages-of-simulation-games (Accessed: 30 August 2018).

Hartsell, T. and Yuen, S. C.-Y. (2006) ‘Video Streaming in Online Learning’, *AACE Journal*.

Haslam, R. A. *et al.* (2005) ‘Contributing factors in construction accidents’, *Applied Ergonomics*, 36(4 SPEC. ISS.), pp. 401–415. doi: 10.1016/j.apergo.2004.12.002.

Hinze, J. (2008) ‘Construction safety’, *Safety Science*. doi: 10.1016/j.ssci.2007.07.003.

Hinze, J., Huang, X. and Terry, L. (2005) ‘The nature of struck-by accidents’, *Journal of construction engineering and management*, 131(2), pp. 262–268.

Ho, C. L. and Dzeng, R. J. (2010) ‘Construction safety training via e-Learning: Learning effectiveness and user satisfaction’, *Computers and Education*. Elsevier Ltd, 55(2), pp. 858–867. doi: 10.1016/j.compedu.2010.03.017.

Homan, SR and Wood, K. (2003) ‘Taming the mega-lecture: wireless quizzing’, *SYLLABUS-SUNNYVALE THEN CHATSWORTH*, 17(3), pp. 23–27.

Hoover, D. S. (2006) ‘Popular Culture in the Classroom: Using Audio and Video Clips to Enhance Survey Classes.’, *History Teacher*. doi: Article.

Huang, X. and Hinze, J. (2006) ‘Owner ’ s Role in Construction Safety’, *Journal Construction and Engineering Management*. doi: 10.1061/ASCÊ0733-93642006132:2164.

Huk, T., Steinke, M. and Floto, C. (2003) ‘Helping Teachers Developing Computer Animations for Improving Learning in Science Education’, in *Proceedings of Society for Information*

*Technology & Teacher Education International Conference 2003*.

Hung, P. H. *et al.* (2013) 'Seamless connection between learning and assessment- applying progressive learning tasks in mobile ecology inquiry', *Educational Technology and Society*.

Im, H. J. *et al.* (2009) 'The characteristics of fatal occupational injuries in Korea's construction industry, 1997-2004', *Safety Science*. Elsevier Ltd, 47(8), pp. 1159–1162. doi: 10.1016/j.ssci.2008.11.008.

Jackson, S. A. and Loomis, D. (2002) 'Fatal occupational injuries in the North Carolina construction industry, 1978-1994', *Applied Occupational and Environmental Hygiene*, 17(1), pp. 27–33.

Judith, C.-C. (2016) *What is Instructional Design?* Available at: https://www.ef.com/blog/general/what-is-instructional-design/ (Accessed: 25 July 2018).

Juneja, P. (2017) *What is Group Discussion and How is it Different from a Debate*. Available at: https://www.managementstudyguide.com/group-discussion-and-debate.htm (Accessed: 30 August 2018).

Kay, R. H. (2014) 'Developing a Framework for Creating Effective Instructional Video Podcasts', *International Journal of Emerging Technologies in Learning (iJET)*, 9, pp. 22–30. doi: 10.3991/ijet.v9i1.3335.

Kelly, M. (2018) *Lectures in Schools: Pros and Cons*. Available at: https://www.thoughtco.com/lecture-pros-and-cons-8037 (Accessed: 30 August 2018).

Klein, D. and Ware, M. (2003) 'E-learning: New opportunities in continuing professional development', *Learned Publishing*. doi: 10.1087/095315103320995078.

Krishnan, D. G., Vasu Keloth, A. and Ubedulla, S. (2017) *Pros and Cons of Simulation in Medical Education: A Review, International Journal of Medical and Health Research*. Available at: http://www.medicalsciencejournal.com/download/481/3-6-15-916.pdf.

De Leng, B. A. *et al.* (2007) 'How video cases should be used as authentic stimuli in problem-based medical education', *Medical Education*. doi: 10.1111/j.1365-2929.2006.02671.x.

Lewis, N. J. and Orton, P. (2000) 'The Five Attributes of Innovative E-Learning', *Training &*

*Development*.

Li, R. Y. M. and Poon, S. W. (2009) 'Future motivation in construction safety knowledge sharing by means of information technology in Hong Kong', *Journal of Applied Economic Sciences*, 4(3), pp. 457–472. doi: 10.1007/978-3-642-35046-7.

Ling, F. Y. Y., Liu, M. and Woo, Y. C. (2009) 'Construction fatalities in Singapore', *International Journal of Project Management*. Elsevier Ltd and IPMA, 27(7), pp. 717–726. doi: 10.1016/j.ijproman.2008.11.002.

Lipscomb, H. J. *et al.* (2003) 'Falls in residential carpentry and drywall installation: Findings from active injury surveillance with union carpenters', *Journal of Occupational and Environmental Medicine*. doi: 10.1097/01.jom.0000083037.56116.d4.

Ma, Y.-F. M. Y.-F. *et al.* (2005) 'A generic framework of user attention model and its application in video summarization', *IEEE Transactions on Multimedia*. doi: 10.1109/TMM.2005.854410.

Manu, P. *et al.* (2010) 'An approach for determining the extent of contribution of construction project features to accident causation', *Safety Science*, 48(6), pp. 687–692.

Mayer, R. E. (2009) *Multimedia Learning*. 2nd edn. Cambridge University Press. doi: 10.1017/CBO9780511811678.

Mayer, R. E. and Moreno, R. (2002) 'Aids to computer-based multimedia learning', *Learning and Instruction*. doi: 10.1016/S0959-4752(01)00018-4.

Van Der Meij, H. and Van Der Meij, J. (2014) 'A comparison of paper-based and video tutorials for software learning', *Computers and Education*. Elsevier Ltd, 78, pp. 150–159. doi: 10.1016/j.compedu.2014.06.003.

Meldrum, A., Hare, B. and Cameron, I. (2009) 'Road testing a health and safety worker engagement tool-kit in the construction industry', *Engineering, Construction and Architectural Management*. doi: 10.1108/09699980911002601.

Meleady, R., Hopthrow, T. and Crisp, R. J. (2013) 'Simulating social dilemmas: Promoting cooperative behavior through imagined group discussion', *Journal of Personality and Social*

*Psychology*. doi: 10.1037/a0031233.

Mohammed, Y. D. and Ishak, M. B. (2013) ‘a Study of Fatal and Non-Fatal Accidents in Construction Sector’, *Malaysian Journal of Civil Engineering*, 25(1), pp. 106–118.

Mohan, S. and Zech, W. C. (2005) ‘Characteristics of worker accidents on NYSDOT construction projects’, *Journal of Safety Research*. doi: 10.1016/j.jsr.2005.06.012.

Moorthy, K., Vincent, C. and Darzi, A. (2005) ‘Simulation based training.’, *BMJ (Clinical research ed.)*. doi: 10.1136/bmj.330.7490.493.

Morain, M. and Swarts, J. (2012) ‘Yoututorial: A framework for assessing instructional online video’, *Technical Communication Quarterly*. doi: 10.1080/10572252.2012.626690.

N.Aniekwu (2007) *Accidents and safety Violations in the Nigerian construction industry, Journal of science and technology*. doi: 10.4314/just.v27i1.33027.

Nichols, M. (2003) ‘A theory for eLearning’, *Educational Technology and Society*. doi: 10.2307/jeductechsoci.6.2.1.

Nouri, J., Spikol, D. and Cerratto-pargman, T. (2016) ‘A Learning Activity Design Framework for Supporting Mobile Learning’, *Designs for Learning*. doi: 10.16993/dfl.67.

Oishi, L. (2007) ‘Did you see that? Online video sites can jumpstart lessons.’, *Technology & Learning*.

Paris, C. (2014) *Lecture Method: Pros, Cons, and Teaching Alternatives*. Available at: https://blog.udemy.com/lecture-method/ (Accessed: 30 August 2018).

Park, G. and DeShon, R. P. (2018) ‘Effects of group-discussion integrative complexity on intergroup relations in a social dilemma’, *Organizational Behavior and Human Decision Processes*. doi: 10.1016/j.obhdp.2018.04.001.

Pedro, A. *et al.* (2015) ‘Framework for Integrating Safety into Construction Methods Education through Interactive Virtual Reality’, *Journal of Professional Issues in Engineering Education and Practice*, 142(2), pp. 1–10. doi: 10.1061/(ASCE)EI.1943-5541.0000261.

Pérez-Alonso, J. *et al.* (2012) ‘Accidents in the greenhouse-construction industry of SE Spain’, *Applied Ergonomics*. Elsevier Ltd, 43(1), pp. 69–80. doi: 10.1016/j.apergo.2011.03.007.

Perttula, P. *et al.* (2003) 'Accidents in materials handling at construction sites', *Construction Management and Economics*. doi: 10.1080/0144619032000087294.

Perttula, P. *et al.* (2006) 'Improving the Safety and Efficiency of Materials Transfer at a Construction Site by Using an Elevator', *Journal of Construction Engineering and Management*. doi: 10.1061/(ASCE)0733-9364(2006).

Phillips, R. (2005) 'Challenging The Primacy Of Lectures: The Dissonance Between Theory And Practice In University Teaching', *Journal of University Teaching and Learning Practice*.

Pinto, A., Nunes, I. L. and Ribeiro, R. A. (2011) 'Occupational risk assessment in construction industry - Overview and reflection', *Safety Science*. doi: 10.1016/j.ssci.2011.01.003.

Plaisant, C. and Shneiderman, B. (2005) 'Show me! guidelines for producing recorded demonstrations', in *Proceedings - 2005 IEEE Symposium on Visual Languages and Human-Centric Computing*. doi: 10.1109/VLHCC.2005.57.

Rahim, A. *et al.* (2008) 'Causes of Accidents At Construction Sites', *Malaysian Journal of Civil Engineering*, 20(202), pp. 242–259.

Rivara, F. P. and Thompson, D. C. (2000) 'Prevention of falls in the construction industry: evidence for program effectiveness', *American journal of preventive medicine*, 18(4), pp. 23–26.

ROSPA (2015) *Working at Height e-book*. Available at: safety.rospa.com/safetymatters/info/working-at-height-ebook.pdf%0A%0A.

Rubio, M. C. *et al.* (2008) 'Role of the civil engineer as a coordinator of safety and health matters within the construction sector', *Journal of Professional Issues in Engineering Education and Practice*, 134(2), pp. 152–157.

Salas, E., Wildman, J. and Piccolo, R. (2009) 'Using simulation-based training to enhance management education', *Academy of Management Learning and Education*. doi: 10.5465/AMLE.2009.47785474.

Sampaio, A. Z. *et al.* (2010) '3D and VR models in Civil Engineering education: Construction, rehabilitation and maintenance', *Automation in Construction*. doi: 10.1016/j.autcon.2010.05.006.

Sanderson, P. E. (2002) 'E-Learning: strategies for delivering knowledge in the digital age', *The*

*Internet and Higher Education*. doi: 10.1016/S1096-7516(02)00082-9.

Saunders, M., Lewis, P. and Thornhill, A. (2009) *Research methods for business students*. Pearson education.

Setareh, M., Bowman, D. A. and Kalita, A. (2005) ‘Development of a virtual reality structural analysis system’, *Journal of architectural engineering*. American Society of Civil Engineers, 11(4), pp. 156–164.

Sharon, N. (2017) *What You Need To Know About Educational Software*. Available at: https://elearningindustry.com/use-lms-reports-improve-elearning-product-6-ways-can (Accessed: 26 July 2018).

Shephard, K. (2003) ‘Questioning, promoting and evaluating the use of streaming video to support student learning’, *British Journal of Educational Technology*. doi: 10.1111/1467-8535.00328.

Sherratt, F., Farrell, P. and Noble, R. (2013) ‘UK construction site safety: discourses of enforcement and engagement’, *Construction management and economics*, 31(6), pp. 623–635.

Shirley Mrs., A. C., Chijioke, O. P. and Chukwumaijem, O. B. (2014) ‘Development and Evaluation of Brick/Block Laying and Concreting (B/Bc) Instructional Video’, *Journal of Engineering and Architecture*, 2(2), pp. 217–227. doi: 10.15640/jea.v2n2a16.

Singh, A. B. (2011) *What Are Simulators*. Available at: https://www.sooperarticles.com/technology-articles/what-simulators-376534.html (Accessed: 28 August 2018).

Smallwood, J., and Haupt, T. . (2000) ‘Construction safety and health management’, in *Construction Safety and Health Management, New Jersey: Prentice Hall*, pp. 223–34.

Solís-Carcaño, R. G. and Arcudia-Abad, C. E. (2013) ‘Construction-Related Accidents in the Yucatan Peninsula, Mexico’, *Journal of Performance of Constructed Facilities*, 27(2), pp. 155–162. doi: 10.1061/(ASCE)CF.1943-5509.0000300.

Stajkovic, A. D., Lee, D. and Nyberg, A. J. (2009) ‘Collective Efficacy, Group Potency, and Group Performance: Meta-Analyses of Their Relationships, and Test of a Mediation Model’, *Journal of Applied Psychology*. doi: 10.1037/a0015659.

Suraji, A., Duff, A. R. and Peckitt, S. J. (2001) 'Development of causal model of construction accident causation', *Journal of construction engineering and management*, 127(4), pp. 337–344.

Traxler, J. (2005) 'Defining mobile learning', *IADIS International Conference Mobile Learning*, (September 2004), pp. 261–266.

Tversky, B., Morrison, J. B. and Betrancourt, M. (2002) 'Animation: Can it facilitate?', *International Journal of Human Computer Studies*. doi: 10.1006/ijhc.2002.1017.

Ulrich, K. T. and Eppinger, S. D. (2000) 'Product design and manufacturing'. The McGraw-Hill Inc., ISBN 0-07-229647-X.

Wang, Y. *et al.* (2002) 'A study of construction site accident statistics', in *Proceedings of Triennial Conference CIB W*, pp. 223–227.

Wei, D. and Wei, W. (2010) 'Design of E-learning platform by SQL', in *ICCET 2010 - 2010 International Conference on Computer Engineering and Technology, Proceedings*. doi: 10.1109/ICCET.2010.5486364.

Whatley, J. and Ahmad, A. (2007) 'Using video to record summary lectures to aid students' revision', *Interdisciplinary Journal of E-Learning and Learning Objects*, 3(1), pp. 185–196.

Williams, O. S., Adul Hamid, R. and Misnan, M. S. (2018) 'Accident Causal Factors on the Building Construction Sites: A Review', *International Journal of Built Environment and Sustainability*, 5(1), pp. 78–92. doi: 10.11113/ijbes.v5.n1.248.

Williams, Q. *et al.* (2010) 'The impact of a peer-led participatory health and safety training program for Latino day laborers in construction', *Journal of Safety Research*. doi: 10.1016/j.jsr.2010.02.009.

Winge, S. and Albrechtsen, E. (2018) 'Accident types and barrier failures in the construction industry', *Safety Science*. Elsevier, 105(February), pp. 158–166. doi: 10.1016/j.ssci.2018.02.006.

Wong, F. K. W. *et al.* (2009) 'Findings from a research study of construction safety in Hong Kong: Accidents related to fall of person from height', *Journal of Engineering, Design and Technology*, 7(2), pp. 130–142.

Xiannong, M. (2002) *Advantages and Disadvantages of Simulations*. Available at: https://www.eg.bucknell.edu/~xmeng/Course/CS6337/Note/master/node3.html (Accessed: 21 August 2018).

Yilmaz, F. (2015) 'Monitoring and Analysis of Construction Site Accidents by Using Accidents Analysis Management System in Turkey', *Journal of Sustainable Development*, 8(2), pp. 57–65. doi: 10.5539/jsd.v8n2p57.

Zhang, D. and Zhou, L. (2003) 'Enhancing e-learning with interactive multimedia', *Information Resources Management Journal (IRMJ)*, 16(4), pp. 1–14.

Zhao, D., Lucas, J. and Thabet, W. (2009) 'Using virtual environments to support electrical safety awareness in construction', in *Proceedings - Winter Simulation Conference*. doi: 10.1109/WSC.2009.5429258.

## Annexure I – Questions for assessment

# Annexure I -Questions for assessment

| **Background Information / General Questions** |
|---|
| 1. Name<br>2. Education<br>3. Where do you belong from? (City/Village name)<br>4. Experience<br>5. Field of work<br>6. Any disability?<br>7. Mother tongue<br>8. Any other languages?<br>9. Mode of communication between other workers?<br>10. Mode of communication with supervisor?<br>11. Are you able to read?<br>12. Have you ever met an accident in your work life?<br>13. If yes, what was the type of accident?<br>14. Have you ever witnessed any accident in your work life?<br>15. If yes, what was the type of accident?<br>16. Are you given any safety education before starting on a new work?<br>17. If yes, in what form? |

| **Physical Design of the Application** |
|---|
| 18. Please give your feedback about the volume/sound of modules?<br>19. What are your reviews about the narration? Were they effective and appropriate for instructional purposes? (Used correct terminologies, language)<br>20. Describe the pace of the narration. |

21. Share your views with regard to the speed of the animation/videos?
22. Did you notice any highlighted regions? What were they indicating?
23. Comment about the animations/graphics (Whether were they easy to understand)
24. Can you distinguish important objects in the module?
25. What should be the ideal duration of the videos?
26. Was the presentation adequate? Was it missing anything?

**Cognitive Design of the Application**

27. What was the purpose of the video shown?
28. Have you seen any similar video before?
29. Discuss any mistakes or errors in the videos shown if you have noticed.
30. Highlight any ambiguities in the video that you did not understand?
31. How much time did it take you to process or understand the message in the video?
32. Elaborate the hazards of accidents that you just saw.
33. What are your views about the remedies shown for the hazards? Do you have any better idea?
34. Did the video module in any way, help increase your knowledge that you did not have before?
35. Anything specific that caught your attention in the video? Why?
36. What are the things that you would like me to add in the video?
37. If asked, would you be able to remember and explain the contents of the video shown after a few days?
38. Would you recommend these videos to your colleagues? Why?

| Affective Design of the Application |
| --- |
| 39. Share your experience while watching the video?<br>40. How much mental effort did you need to understand the videos?<br>41. Discuss anything that you found boring or of lesser interest in the video.<br>42. If given, would you prefer to watch more similar videos on different topics? |