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Effect Of Construction Worker Demographic On E-Learning With Hazard Communication Standard

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EFFECT OF CONSTRUCTION WORKER DEMOGRAPHICS ON E-LEARNING WITH HAZARD COMMUNICATION STANDARD TRAINING

by

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DEDICATION

Dedicated to my Family...

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1 : INTRODUCTION

1.1 Overview

This section gives background information about the study and it covers the demographic information of workers in U.S. construction industry followed by basic statistical information on construction safety leading to Hazard Communication Standard, which is the focus of the study. Afterwards, costs associated with accidents are mentioned and safety and health training is introduced as a means to reduce such costs. Finally, the problem addressed in the study is stated and objectives of the study are laid out.

1.2 Demographic Information of the Construction Industry in the United States

There are 9.27 million construction workers in the United States according to the U.S. Bureau of Labor Statistics, 2013. This number represents approximately 6.4 % of all U.S. workers and makes the construction industry one of the largest industries in the United States. Worker demographics in the construction industry can be represented by age, union status, education level, ethnic background, native languages, experience level, working sector, gender, etc.

The age distribution of workforce in construction industry is seen in Figure 1 (www.bls.gov). According to the figure, 25-34, 35-44 and 45-54 age groups for construction have the highest portions and each has more than 2 million workers. Number of people who are older than 55 is 1.8 million. However, according to labor force projections by the Bureau of Labor Statistics, the number of workers older than 55 will increase due to the large birth cohort between 1946 and 1964 in 2022 (http://www.bls.gov/news.release/ecopro.t01.htm). Another reason for this increase is growing number of employees who are planning to have longer working careers (Silverstein, 2008).

	Total, 16 years and over	16 to 19 years	20 to 24 years	25 to 34 years	35 to 44 years	45 to 54 years	55 to 64 years	65 years and over	Median age
Total, all industries	143,929	4,45	13,59	31,242	30,650	32,52	23,776	7,681	42,4
Agriculture, forestry, fishing, and hunting	2,130	100	175	369	355	389	400	341	46.9
Mining, quarrying and oil and gas extraction	1,065	18	86	288	221	247	173	33	41.5
Construction	**9,271**	**144**	**652**	**2,127**	**2,233**	**2,312**	**1,440**	**364**	**42.8**

Figure 1: People employed by industry and age, 2013 annual mean (Numbers in thousands)

Statistics prepared by the Electronic Library of Construction Occupational Safety and Health (Elcosh) indicate that there were 2.7 million Hispanic workers in the construction industry in 2008 and construction industry had the highest percentage of foreign-born workers of any industry sector.

In addition to age and ethnicity, union status is another factor frequently mentioned as part of worker demographics in the literature. According to Bureau of Labor Statistics reports, 14.1 % of the construction workers were members of union in 2013 and 14.9 % of them were represented by unions. (http://www.bls.gov/iag/tgs/iag23.htm#workforce). The percentage of workers who were union members fell sharply, from 25 % in 1977 to 14.1 % in 2013 (Baldwin, 2003). There are different opinions about this decline in union membership. However, the most frequently argued cause is the changing composition of employment. This can be supported by the decrease in the percentage of non-agricultural employment in the industries of mining, construction manufacturing, and transportation (Neumann and Rissman, 1984). Global investment opportunities may also induce employers to seek union-free or decentralized bargaining environment to have more flexibility and expectation of lower wages. Another reason might be the effect of globalization on governments competition policies and made them weaken the union bargaining strength and legal voice in the workplace (Lange and Scruggs, 1998). Being a union member may affect the safety climate in the workplaces and most union workers view their workplace safety more favorably. However, in both union and non-union workplaces, safety climate measures need to be improved. (Gillen et al., 2001)

There are also some women workers in the construction industry. According to OSHA statistics, there were 818,000 women workers in the construction industry in 2010. As seen in Figure 2, the number of women workers in the construction industry reached the highest value in 2007 between years 1985 and 2010. However, the number of women workers in construction industry is less than the other industries as shown in Figure 3.

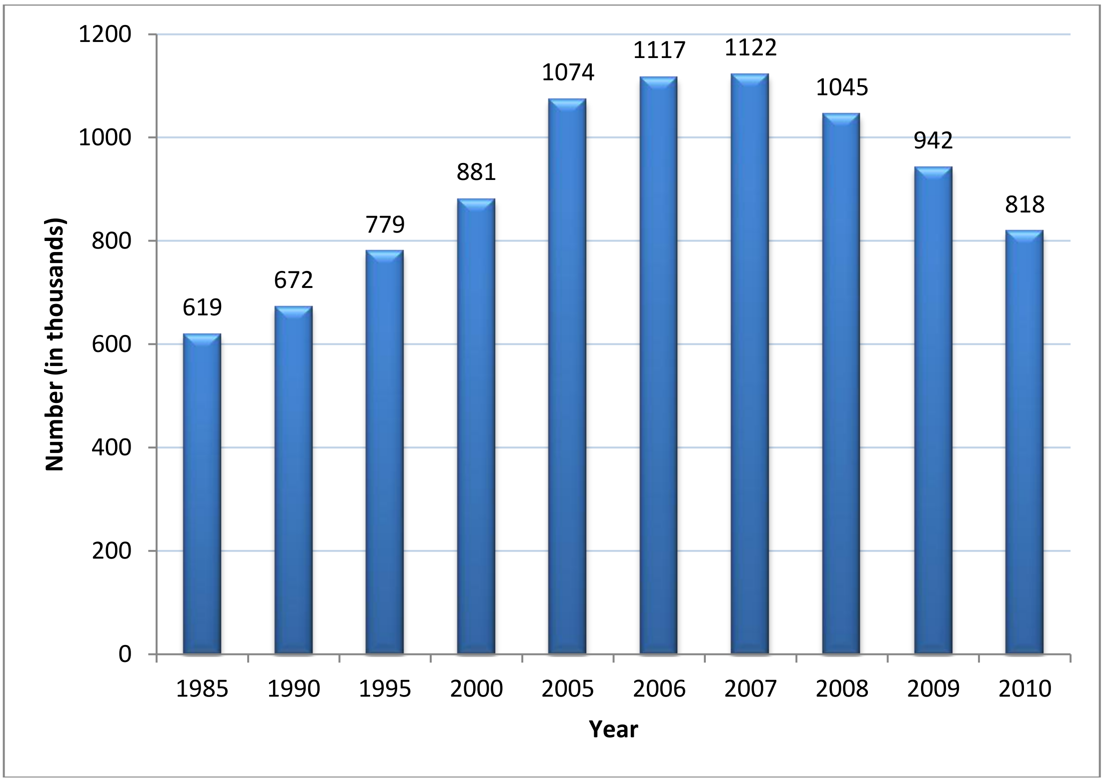


Figure 2: Number of women workers in construction industry, each year

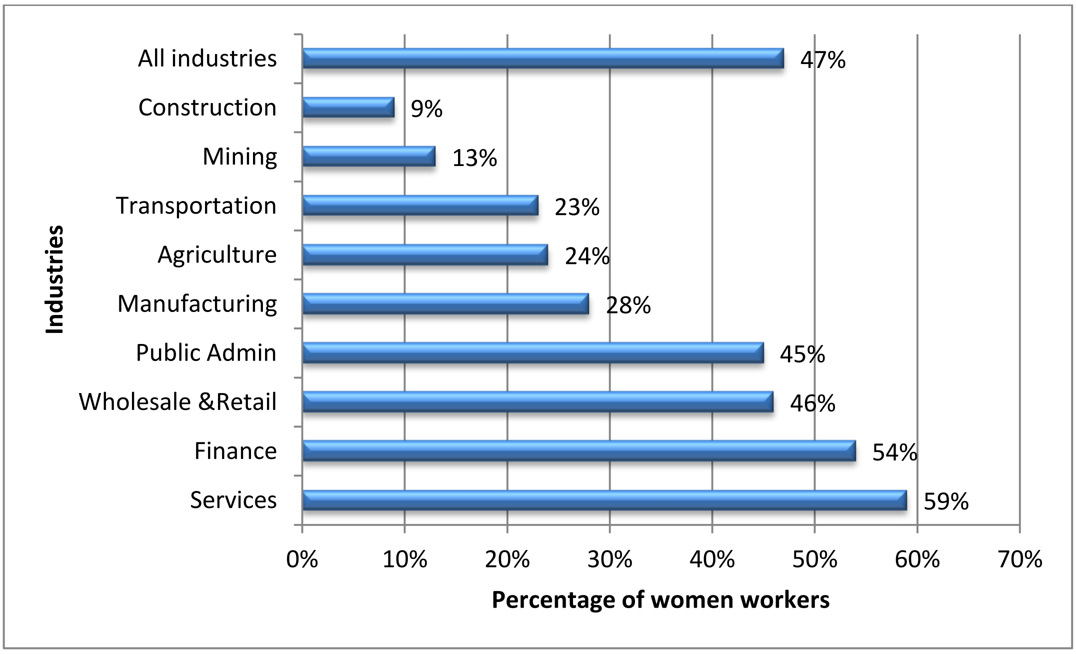


Figure 3: Percentage of women workers in construction industry, and other industries

1.3 Facts About the U.S. Construction Industry

Construction is not only one of the largest and diverse industries, but also is one of the most dangerous occupations. Construction workers find themselves facing complex and dangerous situations every day in their workplaces. Therefore, the accidents in this occupation are common. It can be seen in Figure 4 that 806 out of the 4628 work related fatalities occurred in construction industry in 2012. This number is equal to 17 % of the total fatal work injuries U.S. industrywide. Fatal work injury rate in the construction industry is 9.9 per 100,000 full-time equivalent (FTE) workers, which is higher than the average of all industries. In addition, nearly 3.8 million nonfatal workplace injuries and illnesses were reported in 2012, and construction industry had 183 thousand of the recorded nonfatal accidents (http://www.bls.gov).

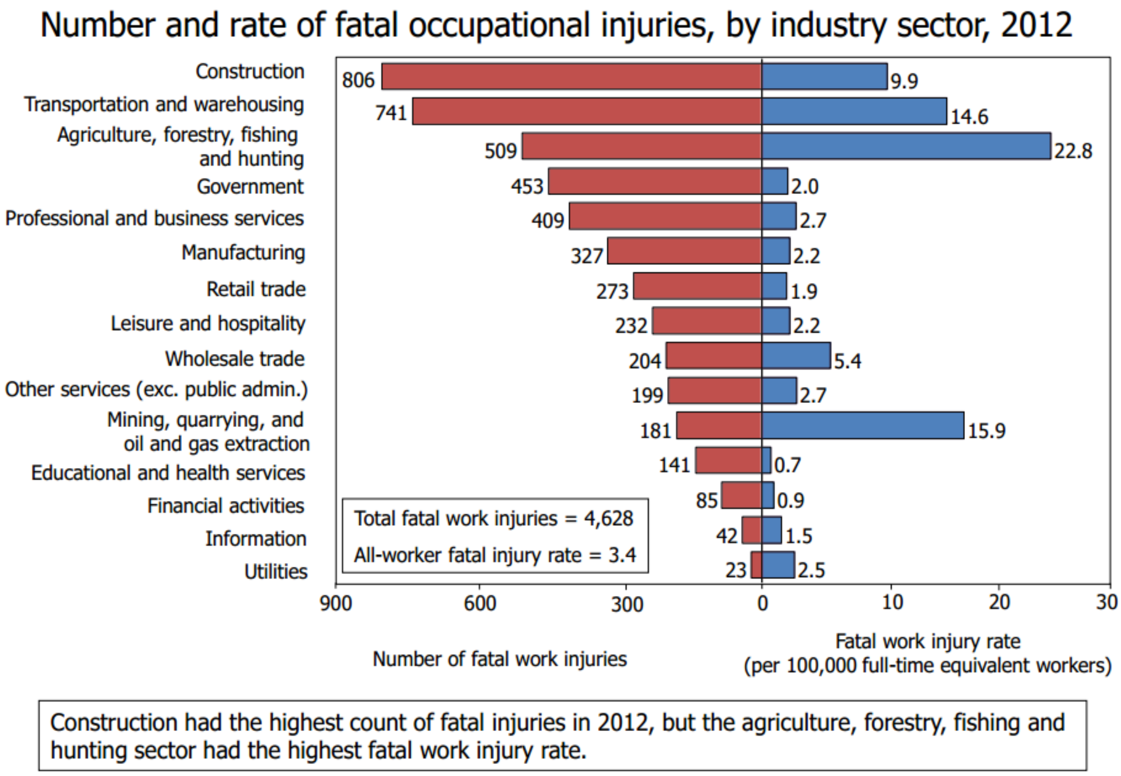


Figure 4: BLS Fatality Statistics, 2012

Construction is a physically demanding industry presenting many safety challenges, and construction workers experience chronic illnesses over time, as well. Compared to younger workers, older workers have been considered at increased risk of injury (Schwatka et al., 2012 ;Dong et al., 2011). On the other hand, statistics show that there is an increase of fatal work injuries for workers under 16 years of age. The number of fatal work injury for workers under the age of 16 rose to 19 in 2012 from 10 in 2011 (http://www.bls.gov/news.release/cfoi.nr0.htm). On the other hand, workers under age of 25 had a higher nonfatal injury rate than the overall rate. The same study also showed that young workers experienced lower fatality rate compared to the older group (Salminen, 2004). Distribution of fatal work injury rates by age group is seen in Figure 5 (http://www.bls.gov/news).

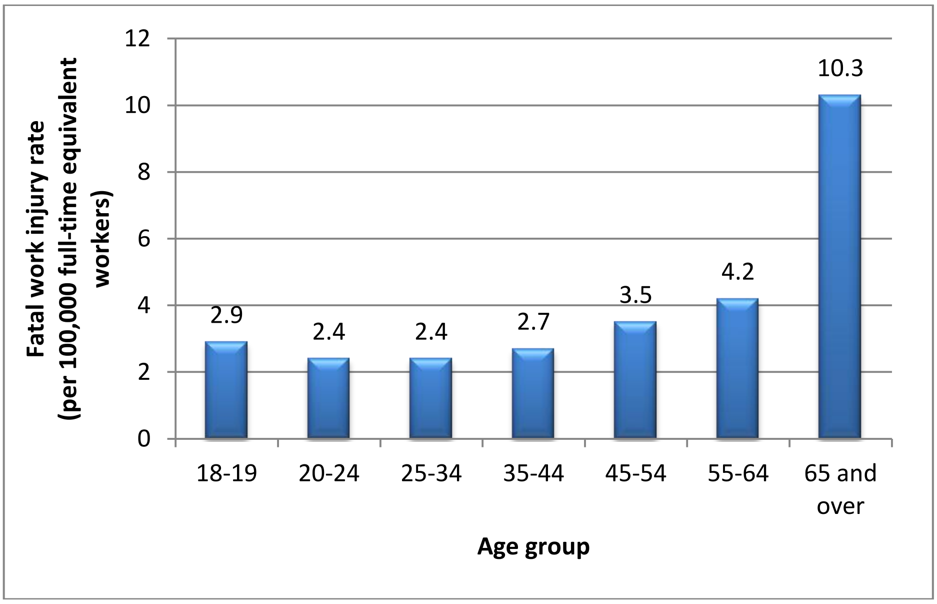


Figure 5: Fatal work injury rates, by age group, 2012 (all workers average fatal injury rate is 3.4)

When the accidents were investigated according to the ethnic background of workers, it was observed that 331 white, 48 African American, and 151 Hispanic or Latino workers became victims of fatal accidents in 2011(http://www.bls.gov).

Most of the developed countries have been addressing occupational safety and health challenges for over 100 years, resulting in the promulgation of various laws and regulations (Hamalainen, et al., 2009). In the U.S., the OSH Act was signed on December 29, 1970. According to this Act every employer in the U.S. had the responsibility of protecting their employees. This act created OSHA, Occupational Safety & Health Administration, which formally came into existence in 1971. OSHA's mission is to protect employees, and to accomplish this, the agency works together with approximately 100 million employees and 8 million employers. Developing safety and health standards, maintaining record keeping system to track injuries that are happened in the workplaces and providing training programs to increase the knowledge about health and safety are some of the things that OSHA does to carry out its mission. As a result of this and other factors, worker deaths in America have been reduced (on average) from about 38 worker deaths a day in 1970 to 12 a day in 2012. Worker injuries and illnesses have also shown a downward trend; namely, from 10.9 incidents per 100 workers in 1972 to 3.4 per 100 in 2011 (www.osha.gov).

OSHA does not only develop safety and health standards but also schedules site visits for inspecting the implementation of safety and health standards in the workplaces. In these site visits, or based on employee-provided accident data and reports, OSHA can cite the violation of a standard. Most frequently cited violations in 2013 are presented in Figure 6. It is observed that Hazard Communication Standard (in bold), which is central to this research, is very highly ranked in this list.

OSHA's 2013 TOP TEN Most Frequently Cited Violations	
1) Fall protection	6) Powered industrial trucks
2) Hazard communication	7) Ladders
3) Scaffolding	8) Lockout/ tagout
4) Respiratory protection	9) Electrical: systems design
5) Electrical : wiring	10) Machine guarding

Figure 6: OSHA's 2013 TOP TEN Most Frequently Cited Violations

1.4 Hazard Communication Standard

Hazard Communication Standard (HCS) is one of the standards developed by OSHA to decrease the number of injuries and illnesses and to ensure employee's right to be informed about hazardous chemicals in the workplace. This standard is therefore also known as the "Right to Know" standard; it was first enacted on November 25, 1983. It includes both physical and health hazards and requires employers to inform and train their workers about hazardous chemicals, as well as possible hazards that can happen in the workplace. Under this standard, employers must;

- provide information and training about chemicals in the workplace in a language that workers can understand;
- keep a current list of hazardous chemicals in the workplace;
- make sure that container labels are appropriate; and
- make available to workers the Safety Data Sheet (SDS) for each chemical product, their effect, preventive information, and emergency treatment in case of exposure.

Since HCS was enacted, it has been used as the primary standard about training and informing workers about possible hazards. Employers used the labels and materials in the format which they desired as long as it covered all required information. HCS was recently revised to align with the United Nations' Globally Harmonized System of Classification and Labeling of Chemicals (GHS). It was first introduced in 2012 and will be fully implemented by 2016. After incorporating GHS in HCS, all employers will use the same format for labels and SDSs. This will improve understanding and safety of hazards. It will help to prevent injuries and illnesses, and it will decrease costs for American businesses that periodically update labels and revise SDSs.

With the adoption of GHS, there are some changes in the framework, exemptions and scope of the standard. Some parts of HCS were improved and some terminologies were changed. For instance the term "Hazard Determination" became "Hazard Classification", "Material Safety Data Sheet" became "Safety Data Sheet". In addition, some new information was added to the standard. Hazard determination which was in the old form of HCS, was the process of evaluating the scientific evidences of chemical product to show if it was pursuant to the standard. The evaluation were showing both physical and health hazards. In the revised HCS, the hazards of a chemical are defined as a chemical that meets the definition of a health hazard class. In other words, and employer is not supposed to test the chemical; s/he can instead make a review of the scientific literature and use the old records or information to show that the chemical meets OSHA's requirements.

The hazard classification process includes the following steps:

- Identify the relevant data regarding the hazards of the chemical
- Review the data to ascertain the hazards associated with the chemical
- Determine if the chemical is hazardous based on its physical, health, and other hazards
- Identify each of the hazard classes that apply to each chemical
- Where appropriate, identify the appropriate hazard category within each class for the chemical being classified. (The hazard categories are divisions within each hazard class which identify the severity within the hazard class).

1.5 Cost of Accidents In the Industry

Accident can be defined as an unplanned, undesirable, unexpected, and uncontrolled event. An accident can result in an injury, damage to equipment and materials. (Hinze, 1997). There are some direct costs and indirect costs of these accidents. Direct costs can be defined as those actual, contractor cash flows that can be directly attributable to injuries and fatalities. On the other hand, loss of productivity, disruption of schedules, administrative time for investigations and reports, training of replacement personnel, wages paid to the injured workers and others for time not worked, cleanup and repair, adverse publicity, and third-party liability claims can be listed as indirect costs of an accident (Business Roundtable Report, 1982). Indirect cost of the accidents can be found by multiplying the direct cost of the accident by an indirect cost multiplier. The range of this multiplier may vary between 2 and 20; generally it is used as 4 (Everett and Frank, 1996).

According to a National Academy of Social Insurance (NASI) report published in 2011, the workers' compensation programs managed by 50 states, the District of Columbia and federal government paid $ 60.2 billion in benefits which was $58.2 billion in 2010. In the same year, medical payments to health care providers increased by 4.5 percent to $29.9 billion and benefits to injured workers became $30.3 billion. Compensation costs of workers including benefits to employers increased by 7.1 % to reach $77.1 billion in 2011. Accordingly, accidents are a heavy burden for both the employers and the government. This signifies that focused attention should be paid to safety and health training to decrease the number and cost of accidents (http://www.nasi.org/research/2013/report-workers-compensation-benefits-coverage-costs-2011).

1.6 Safety and Health Training

According to Ridley (1986), 99 % of the accidents are caused by either unsafe acts or unsafe conditions or both, and as such, they are preventable. Research shows that, the causes of accidents include lack of awareness and enforcement of safety regulations, lack of proper training, unsafe site conditions, poor regard for safety by people involved in construction projects, engaging incompetent personnel, mechanical failure of construction machinery and equipment, physical and emotional stress, chemical impairment, not using provided safety equipment (Lubega et al., 2000; Toole, 2002; Tam et al., 2004). According to Kazan (2013), who studied causal factors for construction heavy equipment accidents, not having an OSHA required safety program in the workplace increases the odds of fatal injury by 1.45 times compared to the presence of a safety program prepared in accordance with OSHA training requirements. It can be stated that safety and health training, which is an essential component of an effective safety and health program, has an important effect on workplace accidents. Training helps both the management and the employees in identifying the safety and health hazards at the site along with their mitigation and control leading to accident prevention (https://www.osha.gov).

Such training can be delivered through different methods such as traditional learning, e-learning, and blended learning.

1.6.1 Traditional Learning

Traditional learning, also known as classroom learning, centers on instructors who have control over class content and learning process. Traditional learning gives students the opportunity to get immediate feedback, and become familiar with both the instructor and other students. However, besides being instructor centered, there are time and space constraints. According to Zhang et al., (2004), it is also more expensive when compared to e-learning. In traditional learning, the teacher is the authority in the class and conducts the lesson according to the study program. Information provided by a 2013 Training Industry Report, indicated that 44 % of the training overall was delivered by a stand-and-deliver instructor in a classroom setting.

1.6.2 e-learning

Clark and Mayer (2008) defined e-learning (online) as training delivered on a digital device such as a smart phone or a laptop computer that is designed to support individual learning or an organizational performance goal. E-learning has become more important nowadays because it provides expediency for learners to study and learn their knowledge without constraints of time and space. In addition, e-learning may decrease the internal training cost for some enterprises and it can be used as an alternative self-training for assisting or improving the traditional classroom teaching (Chao and Chen, 2009). According to the 2013 Training Industry Report, 25.9 % of the training was delivered via online or computer based technologies. Approximately 1.9 % of the training hours nationwide were delivered via mobile devices, up from 1 % from 2012. Social learning also increased to 3 % from 1.1 % from the previous year (http://www.trainingmag.com/2013-training-industry-report).

There are two main types of e-learning: synchronous (virtual classroom, webinar) learning and asynchronous (self study). Synchronous learning allows students from different places to attend an online class taught by an instructor in a specified time. On the other hand, asynchronous learning is typically self paced, allowing individual learners to access the training content at any time or location on their own. (Clark and Mayer, 2011)

1.6.3 Blended Learning

Blended learning is the integration of traditional (classroom, face-to-face) learning with e-learning (Garrison and Kanuka, 2004). According to Martyn (2003), blended learning gives teacher the opportunity of face-to-face meetings with students, synchronous chat, online assessments, asynchronous online threaded discussions, online quizzes, and immediate feedback. This training method is used to find the optimum training program for the audience. It uses many different forms of e-learning with an in class training method (Bersin, 2004). According to Garrison and Kanuka (2004), blended learning integrates the strengths of traditional and online learning. Using technology and the internet can make the blended learning more effective and efficient when compared to traditional learning method, and in 2013, 28.3 % of training was delivered with blended learning techniques.

1.7 Training Expenditures

According to the 2013 Training Industry Report, the cost of industry training programs, including payroll and spending on external products and services, decreased from $55.8 billion to $55.4 billion last year. At the same time, training payroll itself increased substantially (from $36.4 billion to $39.9 billion), while spending on outside products and services decreased significantly (from $7.4 billion to $5.7 billion) (http://www.trainingmag.com/2013-training-industry-report). It is commonly agreed that safety training decreases total direct and indirect cost of accidents by decreasing the number of occupational accidents. Survey results presented in this publication suggested that, on average, for every dollar spent for improving workplace safety, return on investment was about $4.41.The median was $2; see Figure 7 (http://www.asse.org). Huang et al., (2006), listed other benefits of effective workplace safety training program as increased productivity, increased retention and better employee morale.

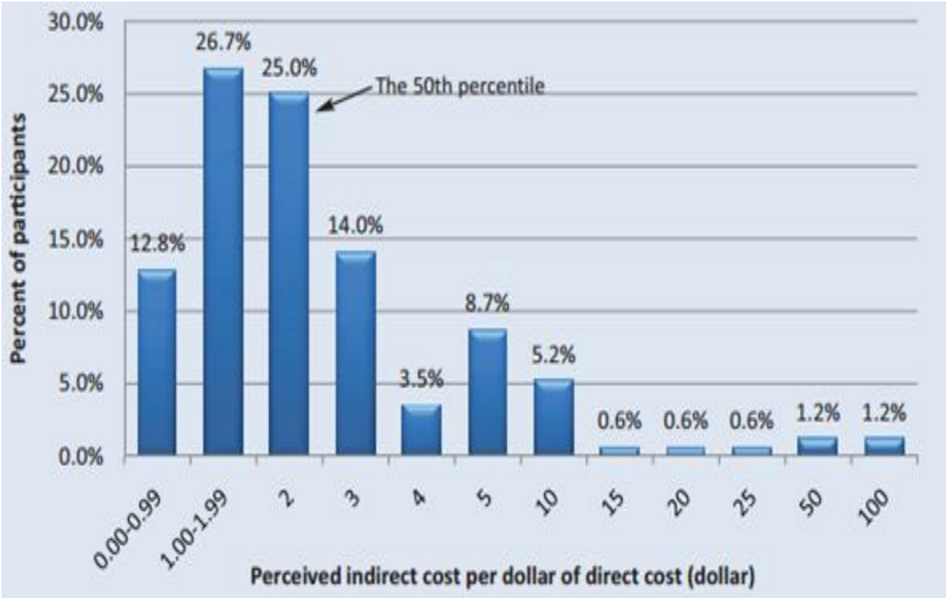


Figure 7: Perceived Dollar Return on Each Dollar Spent Improving Workplace Safety

1.8 Problem Statement

OSHA mandates that all employers have to assure safe and healthful conditions for their workers and train them about possible workplace hazards and their prevention. It is the legal right of the employees to know of the possible hazardous conditions on the jobsite and get proper training about them (https://www.osha.gov/Publications/osha3021.pdf). The requirements for safety training can be frequently found in OSHA standards (29 CFR Part 1926) and under training guidelines on OSHA website. It is important to recognize, however, that even in large companies where safety training programs are well established and documented, there are still occurrences of accidents and injuries (Killingsworth et al., 2014).

In specific reference to the Hazard Communication Standard, according to OSHA, the purpose of the standard is to ensure that the hazards of all chemicals produced or imported are classified, and that information concerning the classified hazards is transmitted to employers and employees. Employers are required to train employees on hazardous chemicals in their work area at the time of their initial assignment, and whenever a new physical or health hazard the employees have not previously been trained about is introduced into their work area. Training type might change according to OSHA requirements and worker's age, experience level, ethnicity, etc. to gain higher benefit from the training. Therefore, the characteristics of the workers should be considered before preparation of the training materials and delivery system.

Constant technological improvement and innovation about new equipment and chemicals have increased the incidence rates of occupational injury and illness. A relatively new approach the companies have started to implement is e-learning via the internet (Ho and Dzeng, 2010). In regard to the effectiveness of e-learning, Rehberg (2003) found that there is no significant difference between the knowledge scores of two groups of college students who got trained by e-learning and the traditional method. Zang et al. (2004) suggested that e-learning can be at least as effective as traditional learning among undergraduate students, but it is hard to claim that e-learning can replace the traditional learning method. Park, Lee and Cha (2008) studied the effectiveness of e-learning with Korean high school students. They proposed that there is no significant difference between traditional learning and e-learning. Kirtman (2009) did a study to explore the issues of learning in online courses vs. traditional courses in master's degree program. She also found no significant difference between two groups of students. Cho and Zeng (2010) studied the effectiveness of e-learning and factors affecting learning effectiveness. They used data gathered from different construction project workers who had different types of training. They concluded that e-learning method is more effective than the blended learning and traditional learning methods according to average pass rate, degree of satisfaction and total number of unsafe behavior observed. In view of these research findings there is strong evidence in favor of the effectiveness of e-learning. However, there is insufficient information on which factors impact the effectiveness of e-learning to what degree. Different demographic characteristics of trainees may have different effects on the benefits gained from e-learning, while this has been studied and documented only to a limited extent.

1.9 Objectives of the Study

The main purpose of this study is to measure training effectiveness and compare the effects of construction worker demographic factors on online self-paced training using Hazard Communication Standard as the training medium. In other words, this study will show how groups with different characteristics benefit from e-learning. The trainees included in this study are operating engineers and representatives of other construction trades.

Traditionally the effectiveness of safety training has been measured by the improvement of posttest performance over pretest performance. In this research we introduce an additional metric, training success, based on the posttest score meeting or exceeding a minimum threshold value (70 %). So, a secondary objective is to incorporate training success in the evaluation of overall training effectiveness.

A final objective is to gain insights into possible relationships between the demographic factors (variables) considered in this research. This requires formulation of pertinent research questions and generating answers through statistical analyses.

Studies have been limited on evaluating the reaction of workers in the construction industry to online construction safety training; consequently, this research will aim at expanding the knowledge about how people benefit from online safety training. The findings of this study should be useful to the people who are responsible for training delivery as well as workers receiving training on various activities and tasks they are supposed to perform.

CHAPTER 2: LITERATURE REVIEW

2.1. Overview

The goal of this chapter is to provide additional background information on all aspects of e-learning effectiveness and usage of e-learning in construction safety. This review helped to identify e-learning usage in other industries and educational institutions, impact of human characteristics on e-learning effectiveness and safety applications which are used to improve safety in workplaces. In order to gain this knowledge, all relevant journals and governmental websites were searched. Published papers and completed statistical analysis were reviewed in order to expand our knowledge and understanding on construction safety and health, safety and health training methods, effectiveness evaluation, and training effectiveness.

The literature covers the topics of construction safety and health, construction safety training, training effectiveness evaluation, e-learning effectiveness and available safety apps since the study focuses on mobile based training. The aim of covered topics is to reveal information to improve the quality of the study.

2.2 Construction Safety and Health

In the United States, 139 million people, including 9 million construction workers, go to work every day, working as full time or part time employee. These workers face with serious of accidents, injuries, illnesses and even death during their hours of work on the job. Therefore, safety becomes an important issue to prevent accidents, injuries and illnesses in construction industry and decrease the number of fatal and nonfatal accidents.

Jaselskis et al. (1996) conducted a research on construction safety and stated that there is an interest in improving construction safety for humanitarian purposes and because of rising cost of OSHA fines and compensation costs. There are different ways to increase the safety in the workplaces. In some companies, they hired full time safety coordinators, increased number of inspections, developed safety training programs and implemented "back to work" program for injured workers. They recommended that construction safety is one of the most important issues that companies should focus on to decrease the number of incidence and experience modification rate (EMR). There should be more supportive actions towards safety such as increased time to devoted safety, more formal meetings with supervisors and contractors, increased number of safety inspections and more budget to safety awards.

Sawacha, Naoum and Fong (1999) did a study on factors contributing to accidents and stated that accidents at work occur either due to lack of knowledge or training, lack of supervision, or lack of means to carry out the job safely. In addition, carelessness, diversity and complexity of the size of the organization, lack of controlled working environment also have effect on construction accidents. However, unsafe behavior is the most effective contributor of site accidents and poor safety culture. Productivity bonus pay kind of payments, which make people work faster than usual, increase the number of unsafe behaviors. Safety trainings and talks, safety policy, care for personal safety, relationship with workers and having a safety representative are the factor that have positive effect in safety performance.

Mohamad (2001) also indicated that the major causes of accidents in construction can be directly attributed to unsafe site practices. To decrease the number of unsafe behavior in the workplaces, which is consequence of existing safety climate, there are some issues to pay attention such as management commitment to safety, safety rules and procedures, supportive environment. On the other hand pressure on the workers has negative effect on workers such as using tight schedule to complete the job. In such situations, workers use shortcuts and increase the number of unsafe behaviors.

Huang and Hinze (2006) stated that construction is one of the industries with the poorest safety. To increase safety performance in construction, there are two key factors which are having a full time safety representative at workplace and requirement of submitting the resumes of key safety personnel of the contractor to the owner for the approval. Safety training, site specific safety plan and safety policy of the firm are also additional requirements which have effects on safety and health.

2.3 Construction Safety and Health Training

It is understood that safety is an important issue to decrease the number of unsafe acts in the workplaces. According to OSHA, employers shall instruct their employees in the recognition and avoidance of unsafe activities and regulations applicable to their work to control and eliminate any hazards or any other exposure to prevent injury and illnesses. Therefore each employer has to have a safety program including education and training for preventing the unsafe condition, and improve safety in the working environment.

Goldenhar et al. (2001) studied the health and safety training in open-shop construction companies. They interviewed with contractors about their safety performance at their workplaces. Most of the contractors who have safety program in their workplaces stated that safety training increased employee productivity, morale, safety and health of the work environment and quality of the product. After trainings, workers feel safer and cared, they are more aware of safety issues, and there is an increase in using personal protective equipments.

Weahrer and Miller (2009) conducted a study on construction safety training effect on workplace injuries and they used 1993 BLS Survey on Employer-Provided Training information in their analysis which is gathered by mailed surveys to private non-agricultural establishments. They stated that formal safety program is positively associated with reporting of injuries and illnesses. It reduces the number of toxic exposure events in manufacturing establishments but does not have positive effect on overexertion incidents. It also has positive effect in decreasing the number of days away work injuries, cost of injuries and illness rates in large firms. However, having a safety program increases number of days away from work injuries in small sized establishments while decreasing injury rate. The increase in number of days away from work seems unreasonable but it can be a reason of increase in reporting the accidents.

Arditi and Demirkesen (2011) stated that accidents generally happen in unsafe workplaces, because of carelessness, inadequate labor force, low education level and unsafe acts. Therefore, construction safety training becomes an important issue to provide a safer workplace. In construction safety trainings, the purpose of the training should be clearly defined, and the ability, capability, education level and language skills of trainees should be considered. Training method also has effects on quality of the trainings. Nowadays, on site trainings are the most used training method. However, online training is cheap, has flexibility and ease of accessibility.

Kazan (2013), in his study on factors associated with the fatalities and nonfatal injuries resulting from construction accidents involving earthmoving equipment, stated that only 53 % of the victims of accidents had adequate safety training while the remaining 47 % did not have adequate or any safety training. According to the results, equipment operators who were not trained according to OSHA guidelines are 3.74 times more likely to be a victim of a fatal accident and on foot workers are who were not trained according to OSHA guidelines are 2.35 times more likely to be a victim of an accident resulting in fatality.

2.4 Training Effectiveness Evaluation

There are different methods to evaluate the effectiveness of the training to make sure that it improves the knowledge of trainees. Kirkpatrick's classical evaluation model is one of the methods used to evaluate the training effectiveness. According to the American Society of Training and Development (ASTD) reports, over 60 % of organizations that evaluate their training programs currently use the Kirkpatrick model. By using this model, any training can be evaluated at four progressive levels. According to Donald L. Kirkpatrick (1967) if the evaluation is broken into logical steps, it changes from a complicated elusive generality into clear and achievable goals. Kirkpatrick defines the steps as follows:

1) Reaction
2) Learning
3) Behavior
4) Results

Kirkpatrick (1967) defines the reaction (Level 1) as how well the trainees liked the training program. In the reaction evaluation step, the purpose is to measure the feeling of trainees. It does not measure any training that takes place. In reaction step, it is important to ask questions to the trainees about the training they attend. There may be questions about the training institute, training delivery system, frequency of the training, instructor, etc.

Learning (Level 2) is about the principles, facts, and techniques that are understood and absorbed by trainees. Trainers try to find how much the skill, and knowledge of the trainee changed after the training. To measure learning both pretest and posttest are given to trainees to determine how much they learned as a direct result of the training program.

Behavior (Level 3) measures the ability of workers to transfer and apply what they have learned to their jobs. In other words, it is the visibility of learning in practical works. However, it takes long time to measure because it is needed to observe the changes in trainer's behavior. In construction, this measure might be the error, injury rate of the worker.

Level 4 is the final result of the training for organization. It shows whether the outcomes are good for business, employees and bottom line of the company. It is the most complicated part of the evaluation since it is difficult to identify which results, benefits are linked to the training. Outcomes of the training may include: increased productivity, reduced waste, higher quality, increased customer satisfaction, etc.

Since, evaluation level 3 and level 4 takes long time, only level 1 and level 2 were analyzed in this study.

2.5 E-learning Effectiveness

It is known that with the developing technology, companies started to change their training types to increase the productivity and decrease the expenses. IBM saved $200 million in 1999, Ernst & Young reduced their training expenditures by 35 % and Rockwell Collins reduced by 40 % by adopting online training to their existing trainings. There are also companies adopted online training but have not received the desired benefits (Strother, 2002). More than $156 billion was spent on employee training in 2012 and 77 % of corporations were using e-learning in the U.S. in 2011. The market for mobile education products which is a part of online training created $ 4.4 billion portion of the training expenditures in 2012 (e-learning magazine, 2013).

Online learning is not only used in industry for employee training but also it is used in educational institutions. It is still discussed whether e-learning acceptance and effectiveness change from person to person based on different criteria. Age, level of education, gender, union status, experience are some of the factors that may affect the acceptance and the effectiveness of e-learning.

Ong and Lai (2004) conducted a study on gender difference in e-learning acceptance and stated that men's ratings of perceptions with respect to computer self-efficacy, perceived usefulness, perceived ease of use, and behavioral intent to use e-learning are higher when it is compared to women. Understanding better the gender differences in users' attitudes toward e-learning can help developers to design and develop their e-learning theories in the future. To increase the e-learning effectiveness, it is important for men to perceive that the system is useful to enhance their job performance or productivity. For women, it is important for companies to make them familiar with computing technologies and increase their self-efficacy.

Wallen and Mulloy (2006) indicated that aging results in number of changes that makes it more difficult to learn from computer based training. In their study, they created three different modules; text, text with pictures and text with pictures and audio narration. It was found that young learners are better than old learners overall. Old learners who got training with narration, pictures, and animation did better than the old workers who read the text only version. This can be because of loss of cognitive function throughout the adult lifetime, not being familiar to technology as much as young people and having difficulty when something is new, unpracticed and unusual. However, it can be said that when text is supported with narration, pictures and animations is the best option for both young and old learners.

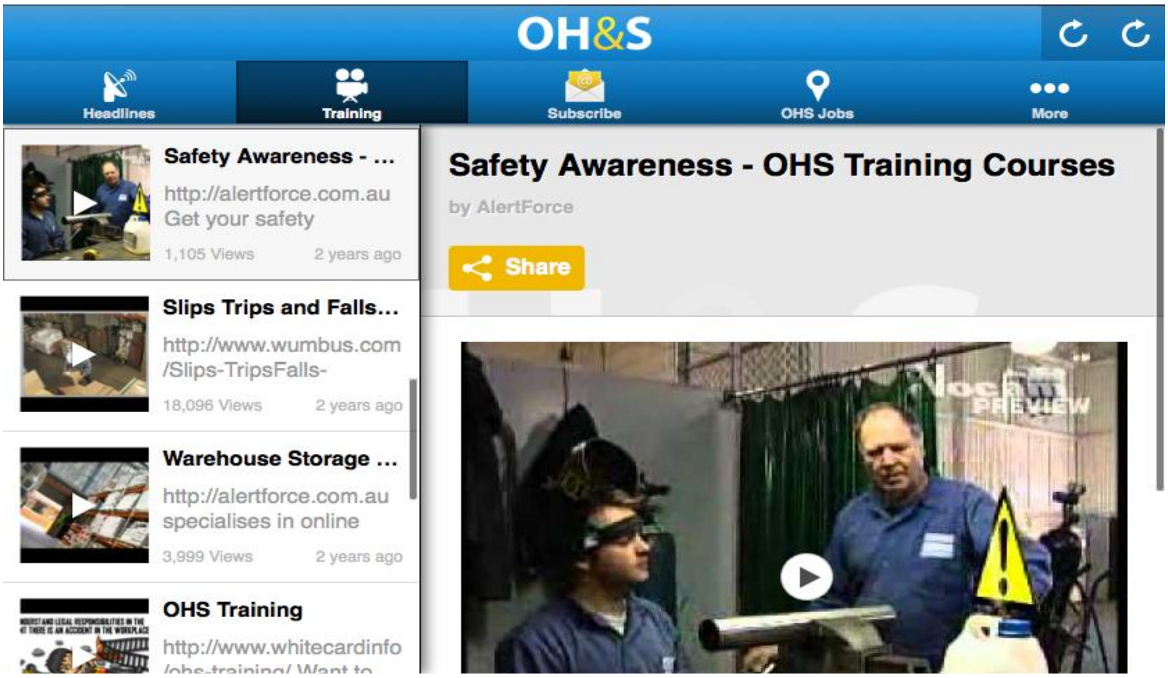
Ho and Dzeng (2010) conducted a study on effectiveness of safety education to prevent falls in Taiwan. They used each one of the different training methods which are e-learning, blended learning, and traditional learning in three different construction sites and compared them according to average pass rate, satisfaction degree and total number of unsafe behaviors. Workers who got trained with e-learning method had the highest satisfaction degree and pass rate, also the lowest error rate. However, all training types are effective when they are used properly no matter education degree, age and information accomplishment of labor. A good training mode can reduce unsafe behavior and increase the overall safety in the construction sites.

According to Islam et al. (2011), e-learning is an effective tool in education and it has positive effects on learning process. However, these effects may change with respect to learner characteristics. Gender, and level of education have significant effect on the e-learning effectiveness in a higher learning institution in Malaysia. According to the results obtained, men get more benefits from e-learning type of training while they are more interested in technology. Students with higher level of education have a broader knowledge on the use of technology. Therefore, as level of education increases, students become more likely to update their knowledge through e-learning. Nevertheless, race and marital status were found to have no significant effect on e-learning effectiveness.

2.6 Safety Apps

2.6.1 Occupational Health and Safety

Occupational Health and Safety (OHS) mobile application features the latest discussions, webinars and topics from featured experts and publishers about occupational health, workplace safety, occupational health and safety training and tutorials, YouTube videos of experts, Facebook and Twitter discussions. It is also possible to find some job opportunities across Australia, the USA, UK and Canada. Figure 8 shows the screenshots of the safety app.



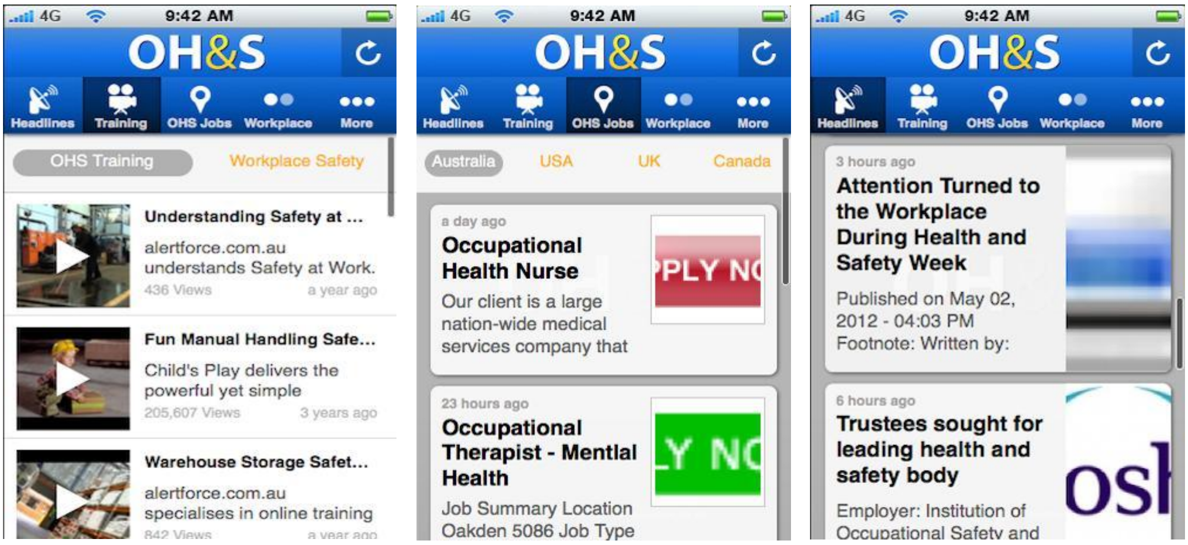


Figure 8: Screenshots of the Occupational Health and Safety application

2.6.2 OSHA Heat Safety Tool

The application allows workers and supervisors to calculate the heat index for their worksite, and the risk level of that heat index to workers. It also gives information about protective measures that should be taken to protect workers from heat related illness. These protective measures can be drinking enough fluids, scheduling breaks, planning for and knowing what to do in an emergency, gradually building up the workload for new workers, training on heat illness signs and symptoms, and monitoring each other for signs and symptoms of heat related illness. Screenshots of the app are shown in Figure 9.

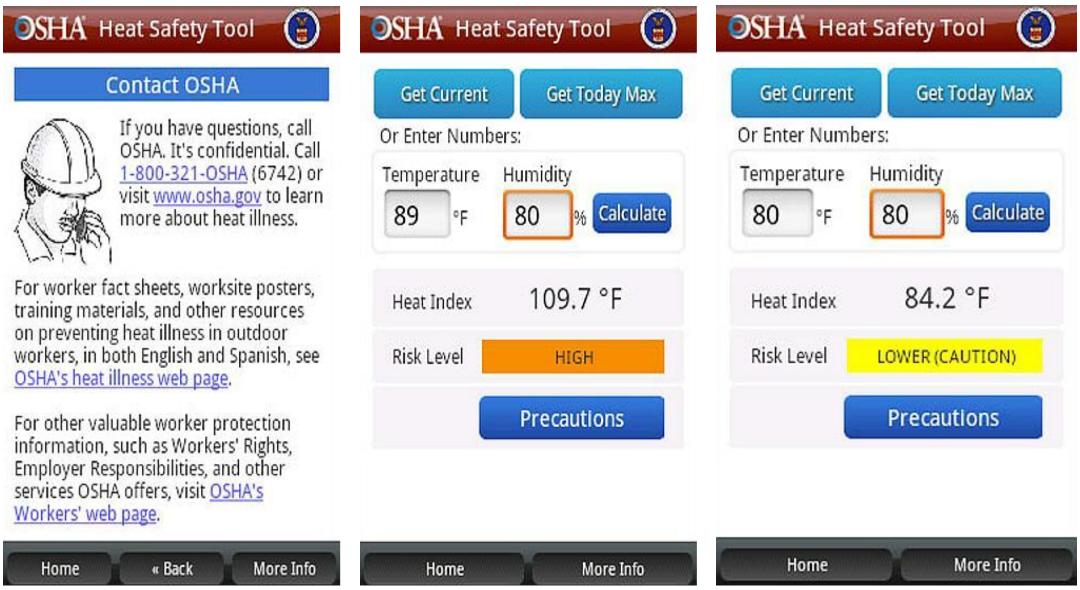


Figure 9: Screenshots of the Occupational Health and Safety application

2.6.3 Safety Meeting App

This application allows contractors to record and track OSHA required safety meetings, accidents, incidents, employee records, etc.

The Safety Meeting Application can be used to:

- Access different safety meeting topics related to more than 15 specific trade categories, and previous class and employee records,
- Collect photo of attendees for proof,
- Record jobsite accidents and incidents,
- Generate proof for OSHA inspections,
- Prepare list of employees in the company.

Screenshots of the app are shown in Figure 10.

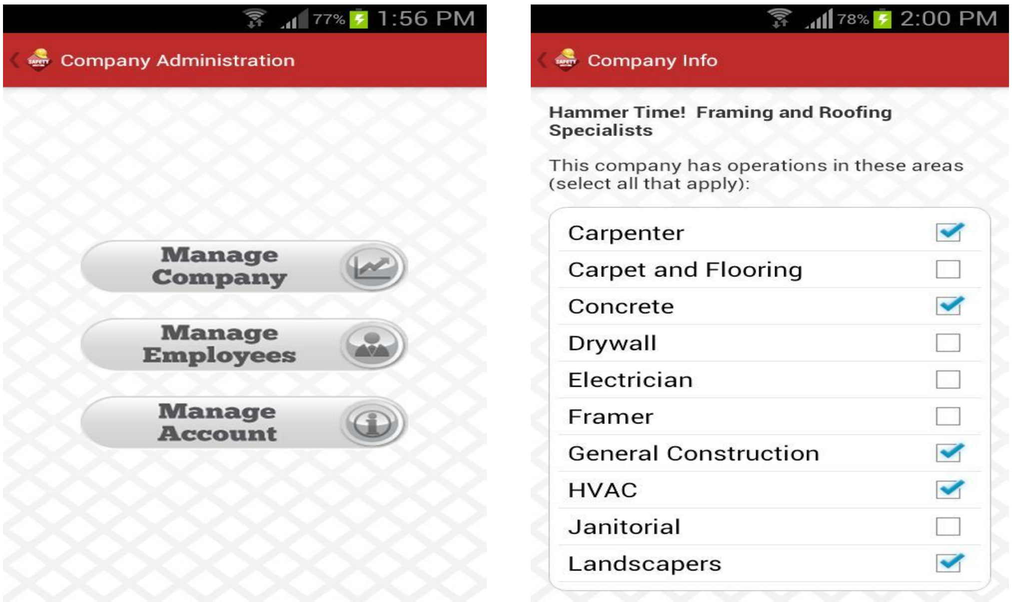


Figure 10: Screenshots of the Safety Meeting application

2.6.4 Safety Talks - Construction

Safety Talks application is an illustrated training aid, covering all the main safety related topics for many industries. It gives information about safe stacking on site, use of hand tools, demolition works, vibration, excavation, fumes, underground services, working close to water, confined spaces, asbestos. This application can be found in different languages. Figure 11 shows the screenshot of the safety app.

Figure 11: Screenshot of the Safety Talk application

2.6.5 HazCom : Worker Rights

This app is created for better understanding of newly adopted symbols and labels for dangerous chemical and it includes brief information about workers rights, new adopted pictograms, summary of potential hazards and possible protections. There is a puzzle game to help workers to get familiar with newly adopted symbols. Contact information for U.S. Department of Labor can also be found on this application. Screenshots of the app are shown in Figure 12.

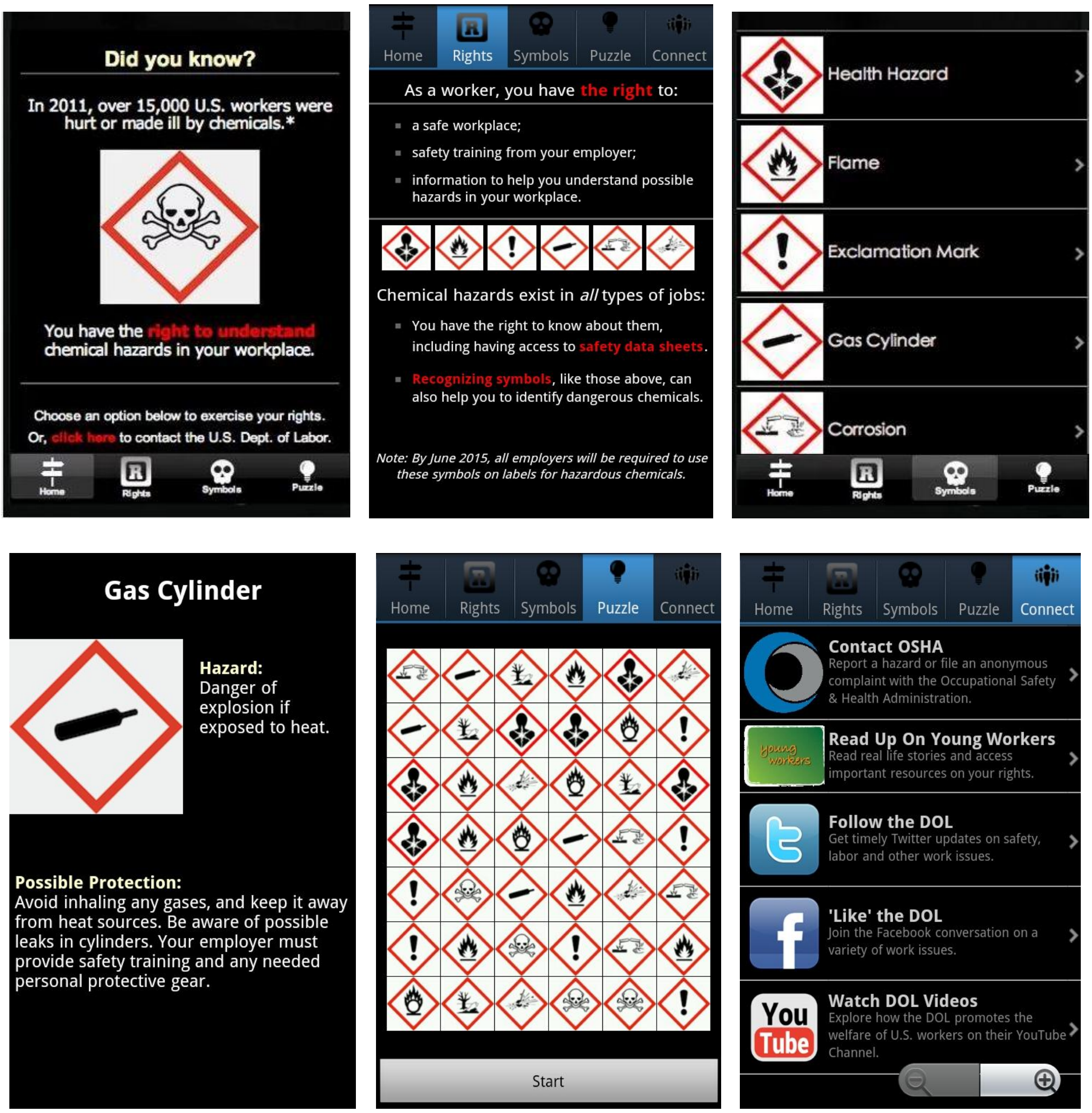


Figure 12: Screenshots of the HazCom: Worker Rights application

2.6.6 GHS Pictogram Reference

GHS pictogram reference application gives information about newly adopted GHS symbols. It gives the possibility of accessing and using GHS related information where and when it is needed. Figure 13 displays the screenshots of the GHS pictogram reference app.

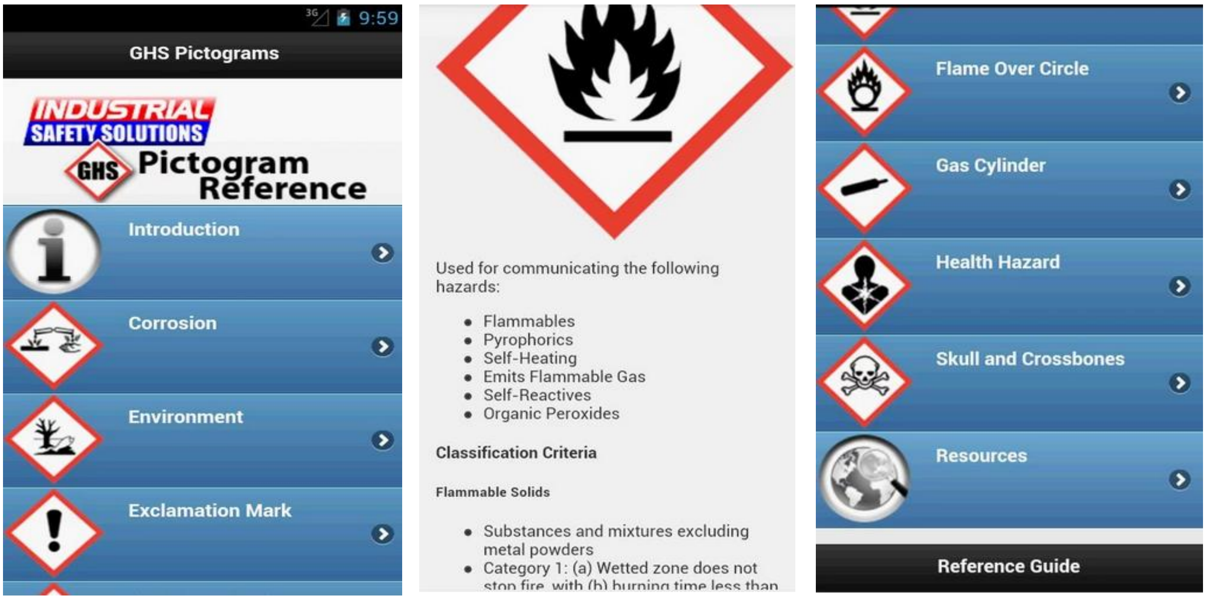


Figure 13: Screenshots of the GHS Pictogram Reference application

2.6.7 Material Safety Data Sheet

This application displays MSDS information related to chemicals, their hazards and possible protections. After adoption of GHS to the Hazard Communication Standard, name of MSDS was changed as SDS and MSDS is not used anymore. However, this application may still be useful for getting information about the chemical in the workplace. Screenshots of the app are shown in Figure 14.

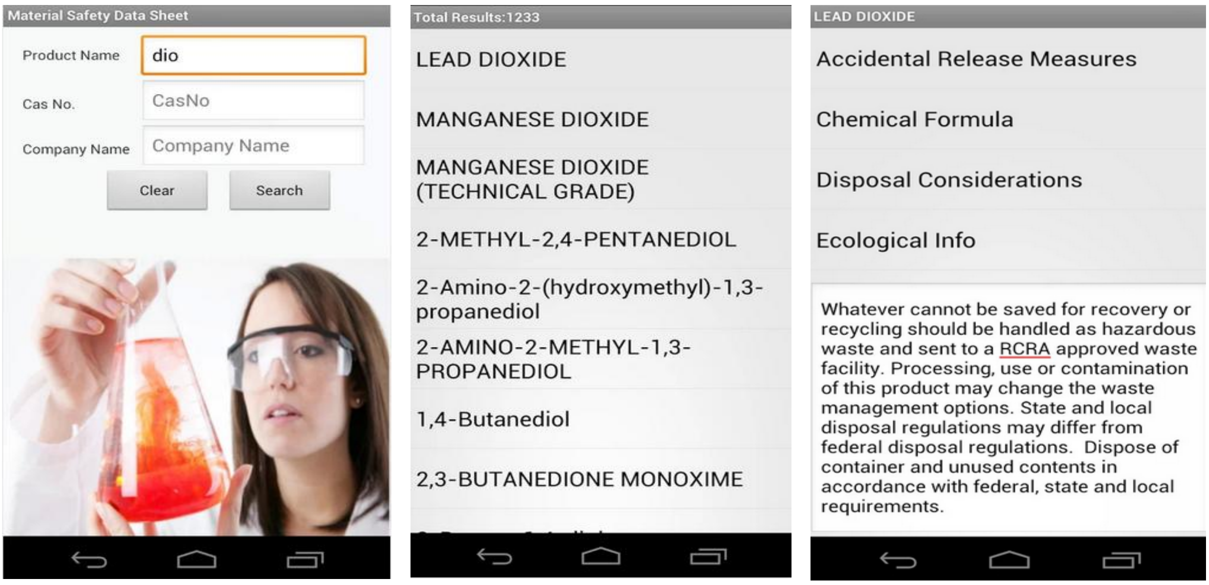


Figure 14: Screenshots of the Material Safety Data Sheet application

2.6.8 Ladder Safety

The ladder safety application was developed by National Institute for Occupational Safety and Health (NIOSH) to ensure the safety of extension-ladder users. This app uses visual and sound signals to assist the user in positioning an extension ladder at an optimal angle. Furthermore, it helps workers find reference materials, safety guidelines and checklists for extension ladder selection, inspection, accessorizing, and use.

2.6.9 NIOSH Pocket Guide to Chemical Hazard

Pocket Guide to Chemical Hazard application is developed by NIOSH and it gives industrial hygiene information on several hundred chemicals/classes for workers, employers, and occupational health professionals. It represents the data in tabular form for chemical substance groupings (e.g. fluorides, manganese compounds) that are found in the environment and it helps users recognize and control occupational chemical hazards.

2.6.10 Safety Inspector

The safety inspector application is used to perform safety inspections and pre-start checks. It applies ISO and OSHA standards for prevention of possible accidents. In this application, inspection templates that suits the workplaces can be found, photos and voice can be added to demonstrate compliance issues, drawing feature can be used to add detail to images or site illustrations, completed inspection can be sent to colleagues, etc. With additional installs, this application let employers install their own information, questionnaires and materials to the application.

2.6.11 SDS Binder Works Mobile

SDS Binder Works Mobile application is used by employers to make their Safety Data Sheets available to employees. It gives employees the flexibility of accessing to company's SDSs anytime and anywhere. Employer can update, add or delete the SDS anytime.

2.7 Research Need and Justification

Reviewed references for this study show that there are several studies on e-learning effectiveness and effect of worker demographics on e-learning effectiveness. Since this method is newly introduced to educational institutions and industry, there are limited studies on this field. This study is focused on effect of worker demographics on e-learning effectiveness and it is conducted to provide additional information to the literature. Two independent variables were defined in this study which are posttest/pretest ratio and training success determined by minimum threshold in the posttest. In the literature, effectiveness of the training is generally analyzed with posttest and pretest scores. In this study, additionally training success of the workers which was not studied before is also analyzed and results are presented.

CHAPTER 3 : METHODOLOGY

3.1 Overview

This chapter covers the methodology of the study with data acquisition including training delivery system and data analysis including univariate analysis, cross tabulation and analysis of variance (ANOVA). At the end the hypotheses of the study are introduced.

3.2 Data Source, Data Acquisition

3.2.1 Data Source

This study was primarily conducted with Operating Engineers Local 324 trainees in two locations at downtown Detroit, Michigan and Howell, Michigan. Additional training sessions were held that Wayne State University Office of Environmental Health and Safety Department, and some other construction companies. Training materials were developed by the researcher, and a proprietary mobile phone/tablet based training delivery system developed by CIS IT and Engineering Company, Southfield, Michigan was employed in the study. The integrated system was presented to the safety directors and trainers of the Local 324 training and education centers, Wayne State University Environmental Health and Safety Department, and local construction companies. The data required for analysis were collected by using the training delivery system throughout the training sessions incorporated in the study. In all training sessions, a QR code was provided to the trainees and they were asked to log onto the training delivery system by scanning the QR code. Throughout the self-paced training sessions, trainees used their cell phones and tablet computers. After the training sessions were completed, the collected data were analyzed by using the Statistical Package for the Social Sciences (SPSS). The results obtained were listed in tabular and graphical format.

The participants were construction workers working in industry. A total of 146 construction workers received this training. Because some of the trainees logged out of the system without completing the training, it was possible to obtain complete datasets on only 96 trainees. Detailed information about the data and trainees will be presented in Section 3.2.

3.2.2 Data Acquisition

3.2.2.1 Training Delivery System Development

Data used in this research were acquired by a web based training delivery system, the URL of which is "esafetyinfo.com". The system was developed before the training sessions and it was used in both training and data collection processes. The QR code which is shown in Figure 15 was provided to the trainees at the beginning of the training sessions.

Figure 15: QR Code

During the training, trainees were required to complete all 6 steps of the training delivery system which is shown in Figure 16.

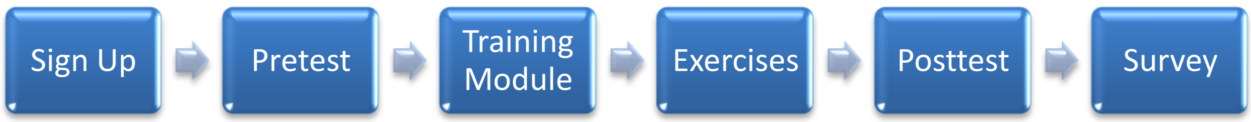


Figure 16: Training Delivery System flow chart

In the "Sign up" process trainees used their personal information to create an account. The system recorded their names, surnames, e-mail addresses, age, gender, ethnic background, industry sector, experience level, job classification, years in industry, union status and education level. Trainees were required to fill these areas to log onto the training delivery system. The information and variables which were used in this study were acquired in this section.

Once they submitted their information, the system directed them to the homepage and to the other sections. The "Pretest" section was completed before the training module to measure trainee's knowledge about the training topic prior to the training. A total of 13 questions were asked to each trainee in this section. After they completed the pretest, they studied training module which was about the Hazard Communication Standard (HCS). Module was prepared on HCS since the standard was aligned with Globally Harmonized System (GHS) of classification and labeling of chemicals and all workers were required to be trained on the revised standard. This section was studied by trainees and there was not a time limitation in this step. After they completed the self-paced training module, the system directed them to participate in two exercises to improve their knowledge with real case field scenarios which were prepared from information provided on real accidents on the OSHA website. There were two questions for the trainees on each scenario. Encountered with a decision point in implementing a field task, the employee needed to find relevant hazard and prevention information from the Safety Data Sheets (SDSs) for the chemicals involved. After completing the exercises, trainees were directed to the posttest which was prepared with same questions from the pretest but presented in a different order. The last section of the training delivery system was the "Survey", which was designed to capture information on the trainee's past safety training history, and their reactions to end thoughts on the QR code usage and the training delivery system.

Type of data collected in each step is illustrated in Figure 17.

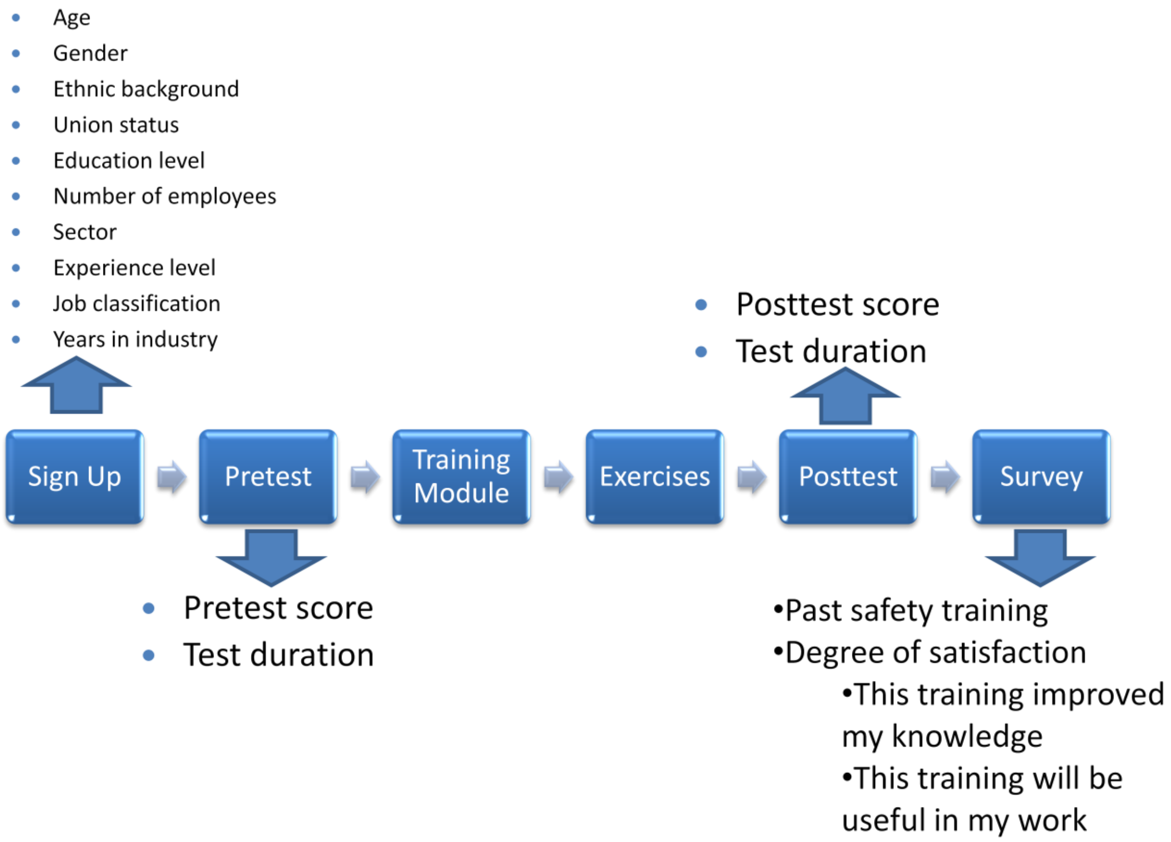


Figure 17: Type of data collected in each step

Images (screenshots) of the training delivery system can be found in the Appendix A.

3.2.2.2 Variables

Demographic information of the workers were acquired in the sign up and survey sections. They submitted information about their age, experience and past safety and health training. In addition to that in pretest and posttest sections were developed to measure their knowledge before and after the training. Figure 18 summarizes the variables included in this study.

Figure 18: Collected variables

- **Age:** There were different age group created in the system. Workers who took the training had to submit their age during the sign up process to take the training. Created age groups in the system were:
    - 18-29
    - 30-39
    - 40-49
    - 50-59
    - 60+
- **Gender:** Gender is used as another variable during the analysis. During the sign up process, trainees were asked to select their gender.

- **Ethnic Background:** U.S. construction industry employs people with different ethnic backgrounds. This information was also asked to the trainees while creating an account for training delivery system. Provided choices were :
    - White
    - Native American
    - African American
    - Asian American
    - Hispanic
- **Union Status:** To analyze the effect of being a union member or being represented by a union, it was needed to submit union status prior to the training to create an account. They were required to choose one of the three choices:
    - Union
    - Non Union
- **Education Level:** Education level of the trainees was also taken as an independent variable for analysis. There were five different education level categories in the training delivery system
    - High School
    - Some College Courses (No Degree)
    - Associates Degree
    - Bachelors
    - Graduate
- **Number of Employees:** Another factor that may affect the effectiveness of the training is number of employees working in the trainee's company. This data is not a worker characteristic but it was collected to analyze whether the companies that

employs high number of trainees have more effective training policy. Therefore, the trainees were provided different range of employee numbers:

- 1-10
- 11-50
- 51-100
- 101-200
- 200+

- **Sector :** Another variable used in the analysis is sector of the trainee. Five different sectors were defined in the system and asked the trainees to choose their sector during the sign up process:
  - Highway / Transportation
  - Commercial
  - Residential
  - Industrial
  - Institutional
- **Experience Level:** Experience level of trainees was another factor used as variable in this study. The trainees were asked to state their experience level and five alternatives were provided to them:
  - Apprentice
  - Foreman (Supervising)
  - Foreman (Working)
  - Journeyman
  - Other

- **Job Classification:** The workers who participated in the training were doing different jobs in the construction sector. Their job classification was also used as a variable and three different choices were given to the trainees. Since the trainee groups were not known before the system development, the "other" option was also added to the system.
    - Civil / Hoisting
    - Stationary Engineer
    - Other
- **Years in Industry:** This variable gives information about the time that trainee spent in construction industry. It is a continuous variable but it was changed to categorical number during the system development phase to be used in the analysis easily. Six different experience ranges were provided to the trainees and they were required to choose one of them during the sign up process.
    - Less Than 1 Year
    - 1-5
    - 6-10
    - 11-15
    - 16-20
    - 20+
- **Past Safety Training:** Participants were asked to provide information about whether they were previously trained. There are two different category values under this category.
    - Previously Trained
    - Previously Not Trained

- **Test Duration:** The duration that each trainee spent for pretest and posttest was recorded during the training. The difference in duration between the posttest and pretest is taken and the effect of increase and decrease was analyzed. The defined category values are:
    - Increase
    - Decrease

Table 1 shows the previously described variables and their category values.

VARIABLE	CATEGORY VALUES and CODES
Age	18-29 (1) 30-39 (2) 40-49 (3) 50-59 (4) 60+ (5)
Gender	Male (1) Female (2)
Ethnic Background	White (1) African American (2) Asian American (3) Hispanic (4) Native American (5)
Union Status	Union (1) Non Union (2)
Education Level	High School (1) Some College Courses (No Degree) (2) Associates Degree (3)

	Bachelors (4) Graduate (5)
Number of Employees	1-10 (1) 11-50 (2) 51-100 (3) 101-200 (4) 200+ (5)
Sector	Highway / Transportation (1) Commercial (2) Residential (3) Industrial (4) Institutional (5)
Experience Level	Apprentice (1) Foreman (Working) (2) Foreman (Supervising) (3) Journeyman (4) Other (5)
Job Classification	Civil / Hoisting (1) Stationary Engineer (2) Other (3)
Years in Industry	Less Than 1 Year (1) 1-5 (2) 6-10 (3) 11-15 (4) 16-20 (5) 20+ (6)
Past Safety Training	Previously Trained (1) Previously Not Trained (2)

Test Duration	Increase (1)
	Decrease (2)

Table 1: Variables and Category Values

3.3 Data Analysis

Univariate analysis was performed as the first step of the analysis for data overview and data classification. Multivariate analysis and analysis of variance (ANOVA) were performed to clarify the relationship between the variables. MS Excel and Statistical Package for Social Sciences (SPSS) software were used for analysis.

3.3.1 Univariate Analysis

The first step to understand a data set is to look at each variable, one at a time, using univariate statistics. Even if it is planned to carry the analysis further to explore the relationship and linkages between two or more variables, it is helpful to look carefully at the distribution of each variable on its own (Fielding and Gilbert, 2006).

Univariate analysis is the simplest form of quantitative analysis and involves describing the case in terms of single variables. In this study, univariate analysis is used to screen the demographics of the trainees who participated in the training sessions and logged onto the system. In other words, the frequency distribution of each independent variable listed in Table 1 were established and the results are shown in the results chapter.

3.3.2 Multivariate Analysis using Cross Tabulation

After conducting univariate analysis, multivariate analysis can be performed to study the relationship between the independent variables and dependent variables.

Multivariate analysis is used for observation and analysis of more than one statistical outcome variable at a time. This data may be correlated with each other and this statistical dependence may be taken into account while analyzing the data. As previously mentioned, the main thrust of this study is to evaluate the knowledge gain by training through e-learning and the effect of demographics on e-learning training results. Multivariate analysis in this study is performed using the cross tabulation method.

Cross tabulation analysis (contingency table analysis), is generally used to analyze categorical (nominal measurement scale) data. A cross-tabulation is a two (or more) dimensional table that records the frequency of respondents that have the specific characteristics described in the cells of the table. Cross tabulation tables provide information about the relationship between the variables.

After creating the table and recording the frequency, it is important to test the statistical significance of the variables. This significance can be analyzed with chi-square (χ^2) analysis to determine if there is a statistical relationship between the variables or not (Michael, 2002).

Before performing the chi-square (χ^2) test, developed by Karl Pearson, there are some assumptions that have to be met and hypotheses have to be defined. These assumptions include the following:

- Random sampling is not required but the best way to insure that the sample is not biased is random selection.
- Each person's response is independent from other's responses. In other words the responses of people do not affect each other. Observations are also independent if the sampling of one observation does not affect the choice of the second observation.
- Mutually exclusive row and column variable categories that include all observations. The chi-square test cannot be conducted when categories overlap or do not include all of the observations.
- Chi-square test works best when the expected frequencies are large. No expected frequency should be less than 1, and no more than 20 % of the expected frequencies should be less than 5 (Michael, 2002).

The hypotheses include;

- Null Hypothesis (H_0) : There is not a statistically significant association between independent variable and dependent variable
- Alternative Hypothesis (H_A) : There is a statistically significant association between independent variable and dependent variable

When any of these assumptions is not met, exact test is used additionally to provide more reliable results. Exact tests provide two additional method which are the exact and Monte Carlo methods, and they provide means for obtaining accurate results when the data fails to meet any of the assumptions.

The formula of chi-square (χ^2) analysis :

$$\chi^2 = \sum_{i=1}^{n} \frac{(E-O)^2}{E}$$

- E_i is the expected frequency for i^{th} cell
- O_i is the observed frequency for i^{th} cell
- n is the number of cells in the table

The general formula for each cell's expected frequency:

$$E= \frac{Ti \times Tj}{N}$$

- Ti is the total number of counts in the i^{th} row.
- Tj is the total number of counts in the j^{th} column.
- N is the total number of counts in the table.

After calculating the frequency and chi-square values , also degree of freedom and "p" value and should be calculated. Degree of freedom is the number of variables which may vary in the final calculation. In general, the degrees of freedom is calculated by subtracting the number of estimated parameters from number of independent observations.

Degree of freedom = *df* = (number of rows-1) x (number of columns - 1)

The p value is a measure of probability that is used for testing the hypothesis. P value is used to find whether the result is significant. Significance level is generally taken as 0.05 and if p value is less than 0.05, it can be stated that there is a significant relationship between the variables. In this situation, the researcher can reject the null hypothesis which states that there is no significant relationship between the independent and dependent variables.

After accepting that there is a significant relationship between the variables, it is needed to determine the significance level. For this purpose, Phi or Cramer's V analysis are used. These are measures of strength of relationship between the variables. Phi analysis is used for 2x2 contingency tables in which there are two categorical variables and each variable has two categories. It is calculated by taking the chi-square value and dividing it by the sample size and then taking the square root of this value (Field, 2009).

Equation of phi value:

$$\varphi = \sqrt{\frac{\chi^2}{N}}$$

- χ^2 = chi-square value
- N = sample size

Cramer's V is used when one of the categorical values include more than two categories. Because in this kind of situation phi fails to reach 0 which is its minimum value. Cramer's V value is calculated as:

$$V = \sqrt{\frac{\chi 2}{N(k-1)}}$$

- χ^2 = chi-square value
- N = sample size
- k = number of columns or rows in the contingency table (which is less)

The strength of the relationship values range between 0 and 1. 0 means there is no association and 1 means perfect association. Rea and Parker (1992) defined the scale of phi and Cramer's V as:

- 0 and under 0.1 Negligible association
- 0.1 and under 0.2 Weak association
- 0.2 and under 0.4 Moderate association
- 0.4 and under 0.6 Relatively strong association
- 0.6 and under 0.8 Strong association
- 0.8 to 1 Very strong association

In this study, contingency table is used to determine the correlation between independent and dependent variables. Dependent variables are e-learning posttest/pretest ratio and training success and cross tabulation analysis will show how independent variables are correlated with these two dependent variables. Cramer's V and phi results will determine the strength of relationship between the variables. The results of cross tabulation analysis, Cramer's V and phi analysis are presented in the results chapter.

3.3.3 Analysis of Variance (ANOVA)

Analysis of Variance (ANOVA) is a statistical method used to test differences between two or more means**.** ANOVA can be used to determine whether any observed difference between the pretest and posttest means is statistically significant .

In ANOVA, the term sum of squares (SSQ) is used to indicate variation. The total variation is defined as the sum of squared differences between each score and the mean of all subjects. The mean of all subjects is called the grand mean (GM). The total sum of squares is defined as:

$$SSQ = \sum (X - GM)^2$$

which means to take each score, subtract the grand mean from it, square the difference, and then sum up these squared values.

$$\text{SSQcondition} = n\sum (\text{M1}-\text{GM})^2 + (\text{M2}-\text{GM})^2 + (\text{M3}-\text{GM})^2 + \cdots + (\text{Mk}-\text{GM})^2$$

- where n is the number of scores in each group,
- k is the number of groups,
- M1 is the mean for Condition 1, M2 is the mean for Condition 2, M3 is the mean for Condition 3 and Mk is the mean for Condition k.

If there are unequal sample sizes, the following formula which is similar to previous one is used:

$$\text{SSQcondition} = \sum \text{n1}(\text{M1}-\text{GM})^2 + \text{n2}(\text{M2}-\text{GM})^2 + + \cdots + \text{nk}(\text{Mk}-\text{GM})^2$$

- where ni is the sample size of the ith condition.

The sum of squares error is the sum of the squared deviations of each score from its group mean:

$$\text{SSQerror} = \sum (\text{Xi1}-\text{M1})^2 + \sum (\text{Xi2}-\text{M2})^2 + \cdots + \sum (\text{Xik}-\text{Mk})^2 +$$

- Xi1 is the ith score in group 1
- M1 is the mean for group 1,
- Xi2 is the ith score in group 2
- M2 is the mean for group 2, etc.

The sum of squares error can also be computed by:

$$SSQ_{error} = SSQ_{total} - SSQ_{condition}$$

Once the sums of squares have been computed, the mean squares (MSB and MSE) can be computed easily. The formulas are:

$$MSB = SSQ_{condition}/dfn$$

- dfn is the degrees of freedom numerator and is equal to k - 1. Similarly,

$$MSE = SSQ_{error}/dfd$$

- where dfd is the degrees of freedom for the denominator and is equal to N - k.

After applying ANOVA Test, post hoc techniques are used when the homogeneity or normality assumptions are violated or to confirm where the differences occurred between groups. When the data meet the variance assumptions, in other words when there is no significant difference between variances of the population, generally Tukey test is used since it is more powerful when testing large number of means (Field, 2009). If the data do not meet the homogeneity of variances assumption, Games Howell test which is generally recommended should be used.

In this study, the ratio of posttest scores to pretest scores and the training success of the trainees are used as dependent variables and it was analyzed that whether any of the independent variables affect these two dependent variables. Results of the analysis are presented in the results chapter.

3.4 Hypotheses of the Study

In this study there are two different characteristics effects of which will be analyzed. For each characteristic, there are two different hypothesis: a) null hypothesis (H_0) and b) alternative hypothesis (H_A).

Hypotheses for Posttest/Pretest Ratio:

Age:

H_0: There is no significant relationship between age of construction workers trained on construction safety and health and online self-paced training posttest/pretest ratio.

H_A: There is a significant relationship between age of construction workers trained on construction safety and health and online self-paced training posttest/pretest ratio.

Gender:

H_0: There is no significant relationship between gender of construction workers trained on construction safety and health and online self-paced training posttest/pretest ratio.

H_A: There is a significant relationship between gender of construction workers trained on construction safety and health and online self-paced training posttest/pretest ratio.

Ethnic Background:

H_0: There is no significant relationship between ethnic background of construction workers trained on construction safety and health and online self-paced training posttest/pretest ratio.

H_A: There is a significant relationship between ethnic background of construction workers trained on construction safety and health and online self-paced training posttest/pretest ratio.

Number of Employees:

H_0: There is no significant relationship between number of employees in the company of workers trained on construction safety and health and online self-paced training posttest/pretest ratio.

H_A: There is a significant relationship between number of employees in the company of construction workers trained on construction safety and health and online self-paced posttest/pretest ratio.

Sector:

H_0: There is no significant relationship between working sector of construction workers trained on construction safety and health and online self-paced training posttest/pretest ratio.

H_A: There is a significant relationship between working sector of construction workers trained on construction safety and health and online self-paced training posttest/pretest ratio.

Experience Level:

H_0: There is no significant relationship between experience level of construction workers trained on construction safety and health and online self-paced training posttest/pretest ratio.

H_A: There is a significant relationship between experience level of construction workers trained on construction safety and health and online self-paced training posttest/pretest ratio.

Job Classification:

H_0: There is no significant relationship between job classification of construction workers trained on construction safety and health and online self-paced training posttest/pretest ratio.

H_A: There is a significant relationship between job classification of construction workers who got trained on construction safety and health and online self-paced training posttest/pretest ratio.

Years in Industry:

H_0: There is no significant relationship between years spent in the industry by construction workers trained on construction safety and health and online self-paced training posttest/pretest ratio.

H_A: There is a significant relationship between years spent in the industry by construction workers trained on construction safety and health and online self-paced training posttest/pretest ratio.

Union Status:

H_0: There is no significant relationship between union status of construction workers trained on construction safety and health and online self-paced training posttest/pretest ratio.

H_A: There is a significant relationship between union status of construction workers trained on construction safety and health and online self-paced training posttest/pretest ratio.

Education Level:

H_0: There is no significant relationship between education level of construction workers trained on construction safety and health and online self-paced training posttest/pretest ratio.

H_A: There is a significant relationship between education level of construction workers trained on construction safety and health and online self-paced training posttest/pretest ratio.

Past Safety Training:

H_0: There is no significant relationship between past safety training of construction workers trained on construction safety and health and online self-paced training posttest/pretest ratio.

H_A: There is a significant relationship between past safety training of construction workers trained on construction safety and health and online self-paced training posttest/pretest ratio.

Test Duration:

H_0: There is no significant relationship between test duration that construction workers spent in pretest and posttest and online self-paced training posttest/pretest ratio.

H_A: There is a significant relationship between test duration that construction workers spent in pretest and posttest and online self-paced training posttest/pretest ratio.

Hypotheses for Training Success Ratio:

Age:

H_0: There is no significant relationship between age of construction workers trained on construction safety and health and online self-paced training success rate.

H_A: There is a significant relationship between age of construction workers trained on construction safety and health and online self-paced training success rate.

Gender:

H_0: There is no significant relationship between gender of construction workers trained on construction safety and health and online self-paced training success rate.

H_A: There is a significant relationship between gender of construction workers trained on construction safety and health and online self-paced training success rate.

Ethnic Background:

H_0: There is no significant relationship between ethnic background of construction workers trained on construction safety and health and online self-paced training success rate.

H_A: There is a significant relationship between ethnic background of construction workers trained on construction safety and health and online self-paced training success rate.

Number of Employees:

H_0: There is no significant relationship between number of employees in the company of workers trained on construction safety and health and online self-paced training success rate.

H_A: There is a significant relationship between number of employees in the company of construction workers trained on construction safety and health and online self-paced success rate.

Sector:

H_0: There is no significant relationship between working sector of construction workers trained on construction safety and health and online self-paced training success rate.

H_A: There is a significant relationship between working sector of construction workers trained on construction safety and health and online self-paced training success rate.

Experience Level:

H_0: There is no significant relationship between experience level of construction workers trained on construction safety and health and online self-paced training success rate.

H_A: There is a significant relationship between experience level of construction workers trained on construction safety and health and online self-paced training success rate.

Job Classification:

H_0: There is no significant relationship between job classification of construction workers trained on construction safety and health and online self-paced training success rate.

H_A: There is a significant relationship between job classification of construction workers who got trained on construction safety and health and online self-paced training success rate.

Years in Industry:

H_0: There is no significant relationship between years spent in the industry by construction workers trained on construction safety and health and online self-paced training success rate.

H_A: There is a significant relationship between years spent in the industry by construction workers trained on construction safety and health and online self-paced training success rate.

Union Status:

H_0: There is no significant relationship between union status of construction workers trained on construction safety and health and online self-paced training success rate.

H_A: There is a significant relationship between union status of construction workers trained on construction safety and health and online self-paced training success rate.

Education Level:

H_0: There is no significant relationship between education level of construction workers trained on construction safety and health and online self-paced training success rate.

H_A: There is a significant relationship between education level of construction workers trained on construction safety and health and online self-paced training success rate.

Past Safety Training:

H_0: There is no significant relationship between past safety training of construction workers trained on construction safety and health and online self-paced training success rate.

H_A: There is a significant relationship between past safety training of construction workers trained on construction safety and health and online self-paced training success rate.

Test Duration:

H_0: There is no significant relationship between test duration that construction workers spent in pretest and posttest and online self-paced training success rate.

H_A: There is a significant relationship between test duration that construction workers spent in pretest and posttest and online self-paced training success rate.

CHAPTER 4: RESULTS

4.1 Overview

In this section, the findings of the study are presented following the order established in the preceding methodology section. At first, univariate analysis results are presented followed by multivariate analysis with cross tabulation method and ANOVA. At the end of the section, additional analysis results are also shown with figures and tables.

4.2 Univariate Analysis Findings

Results for univariate analysis are given under this chapter. Each variable is organized and represented to give idea about the behavior of the dataset. The aim of the univariate analysis is to have some information about the data for further analysis.

4.2.1 Age

The distribution of age was analyzed among the 96 data. It was found that more trainees were between the ages of 40-49 and 50-59 (See Table 2). The number of trainees whose ages were between the range of 18-29 was 18, which represents the 18.8 % of the overall data. The age group of 30-39 consist of 19.8 % and the group of people who were older than 60 constitutes 5.2 % of the total with the frequency of 5.

Table 2: Frequency of distribution of age

Age Categories	Frequency	Percent	Cumulative Percent
18-29	18	18.8	18.8
30-39	19	19.8	38.5
40-49	32	33.3	71.9
50-59	22	22.9	94.8
60+	5	5.2	100.0
Total	96	100.0	

4.2.2 Gender

It was revealed that 82 of the 96 trainees were male and 14 were female. The female trainees constitutes 14.6 % of the overall data (See Table 3). Since the construction industry is male dominated, this data is close to the occupation of women in U.S. construction industry.

Table 3: Frequency of distribution of gender

	Frequency	Percent	Cumulative Percent
Male	82	85.4	85.4
Female	14	14.6	100.0
Total	96	100.0	

4.2.3 Ethnic Background

Univariate analysis of ethnic background revealed that most of the trainees were White with frequency of 83, which represent 86.46 percent of the overall trainees (See Figure 19). 7 of them were African American and 3 of them were Native American. Only 1 Asian American trainee took part in the study.

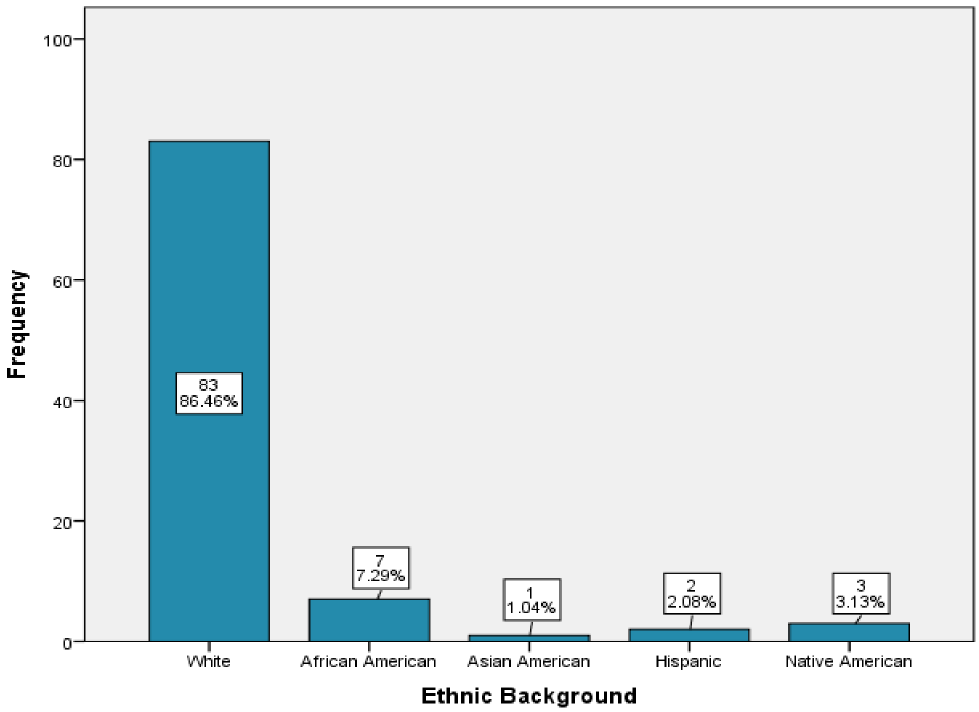


Figure 19: Frequency of distribution of ethnic background

4.2.4 Number of Employees in the Company

Workers are asked to state the number of employees working with them in the company. The aim of this is to show whether the number of employee affects the safety and health concern in the company and make the employer and employee pay more attention to the safety training. As shown in Table 4, Most of the trainees were working in the companies with employee number larger than 200 with the frequency of 60. Only 10 workers, which represents 10.4 % of the overall number of trainees, were working with less than 10 people in the workplace. The group which constitutes the 5.2 % with the frequency of 5, were working with number of people between 101 and 200.

Table 4: Frequency of distribution of number of employee in the company

	Frequency	Percent	Cumulative Percent
1-10	10	10.4	10.4
11-50	10	10.4	20.8
51-100	11	11.5	32.3
101-200	5	5.2	37.5
200+	60	62.5	100.0
Total	96	100.0	

4.2.5 Sector

The sectors of people who attended to the training were also asked prior to the training. According to the results, 53 of the trainees were working in industrial type of projects, and 29 of them were working in commercial project. Only 7 of the attendees were working in institutional projects and six of them were working in Highway and Transportation related projects; see also Figure 20 for percentages.

Table 5: Frequency of distribution of sector

	Frequency	Percent	Cumulative Percent
Highway/Transportation	6	6.3	6.3
Commercial	29	30.2	36.5
Industrial	53	55.2	91.7
Residential	1	1.0	92.7
Institutional	7	7.3	100.0
Total	96	100.0	

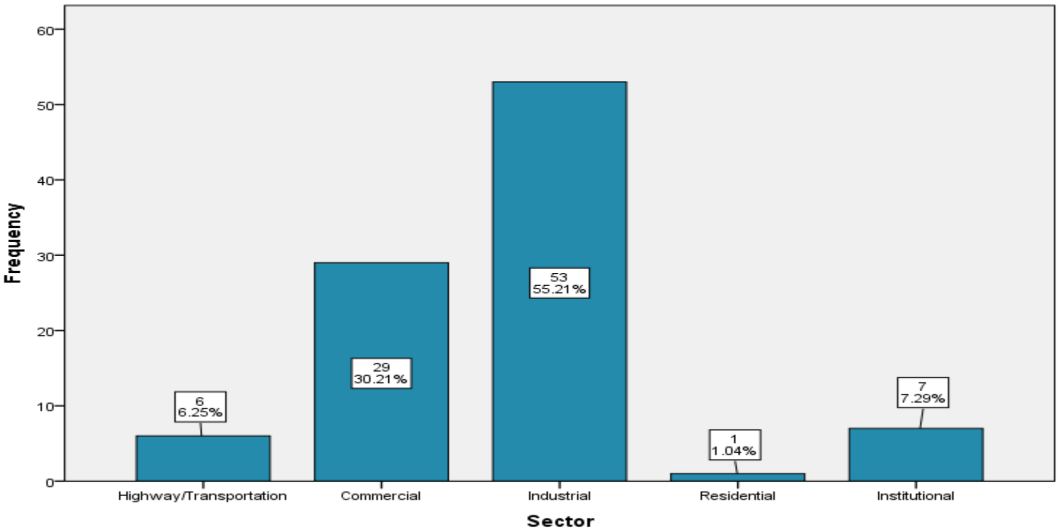


Figure 20: Frequency of distribution of sector

4.2.6 Experience Level

In univariate analysis results of experience level of trainees show that most of the trainees were journeyman with 35.4 %. A total of 14 were apprentice, 11 of them were foreman supervising, 7 of them were foreman working and 30 of the trainees chose option defined as other (See Table 6).

Table 6: Frequency of distribution of sector

	Frequency	Percent	Cumulative Percent
Apprentice	14	14.6	14.6
Foreman (Working)	7	7.3	21.9
Foreman (Supervising)	11	11.5	33.3
Journeyman	34	35.4	68.8
Other	30	31.3	100.0
Total	96	100.0	

4.2.7 Job Classification

The trainees who were trained in this study were mainly comprised of civil/hoisting operators and stationary engineers. Civil / Hoisting operators comprised 51 % and stationary engineers comprised 20.8 % of the total number. The percentage of the trainees who attended to the Hazard Communication Standard training describe their job classification as other is 28%. Figure 21 displays the bar chart of job classification frequency.

Table 7: Frequency of distribution of job classification

	Frequency	Percent	Cumulative Percent
Civil/Hoisting	49	51.0	51.0
Stationary Engineer	20	20.8	71.9
Other	27	28.1	100.0
Total	96	100.0	

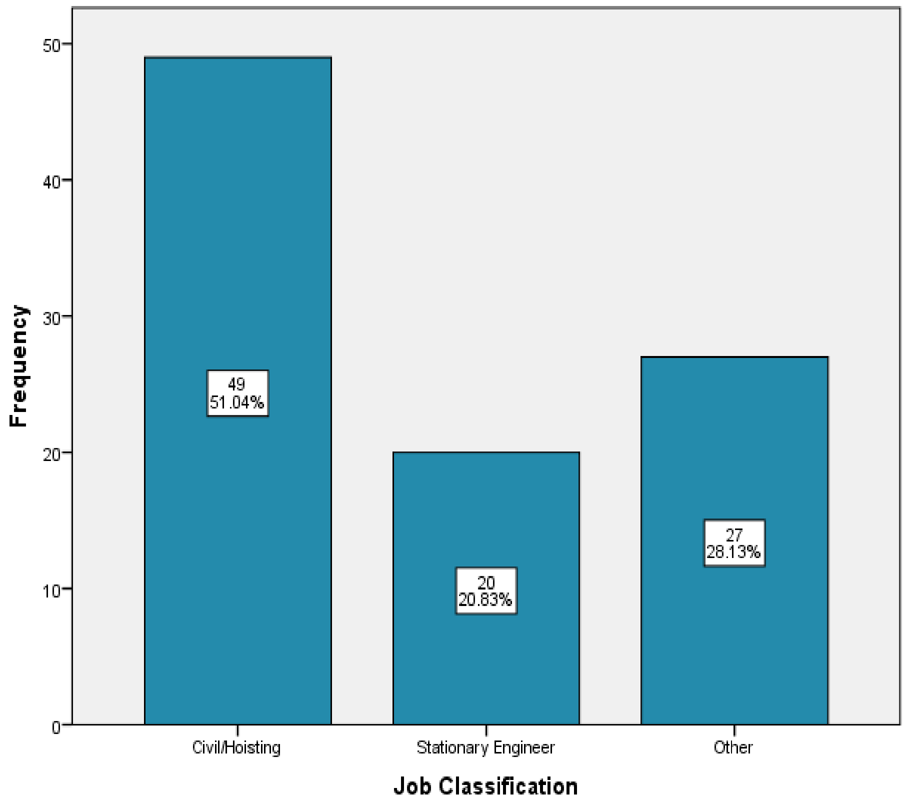


Figure 21: Frequency of distribution of job classification

4.2.8 Years in Industry

In univariate analysis, years that the trainees spent in the construction industry were also analyzed and the results show that the highest percentage of the total were people who have spent more than 20 years in the industry. The number of people with more than 20 years experience is 34 with 35.4 %. Workers who have experience between 1 and 5 years comprised 19.8 % and the number of workers with experience between 6 and 10 years is 9 as shown in Table 8. It can be seen that number of workers who are new in the industry is 8. Bar chart of years in industry is seen in Figure 22.

Table 8: Frequency of distribution of years in industry

	Frequency	Percent	Cumulative Percent
Less Than 1 Year	8	8.3	8.3
1-5	19	19.8	28.1
6-10	9	9.4	37.5
11-15	10	10.4	47.9
16-20	16	16.7	64.6
20+	34	35.4	100.0
Total	96	100.0	

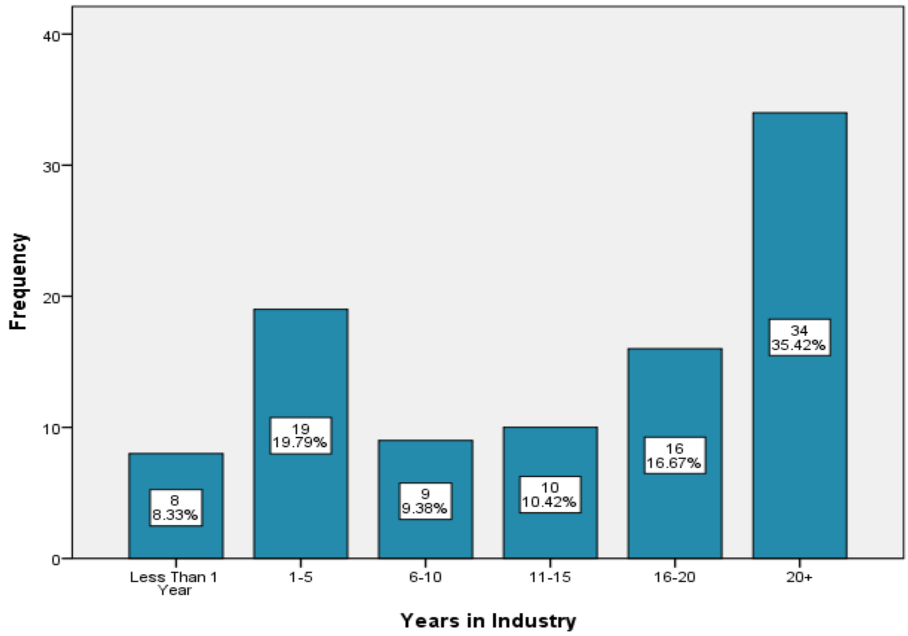


Figure 22: Frequency of distribution of years in industry

4.2.9 Union Status

Union status is another variable used in this study. After frequency analysis of union status, it can be stated that the majority of the trained workers were member of unions. Number of unionized workers is 76 with the percentage of 79.2 % and the number of non union workers is 20 with the percentage of 20.8 %.

Table 9: Frequency of distribution of union status

	Frequency	Percent	Cumulative Percent
Union	76	79.2	79.2
Non-Union	20	20.8	100.0
Total	96	100.0	

4.2.10 Education Level

Table 10 shows that workers with different educational background participated in the training sessions and 37 of the participants took some college courses but they did not have college degrees. 25 of the workers had only high school diploma, 18 of them had bachelors degree , 8 of them had graduate degree and 8 had associates degree (See also Figure 23).

Table 10: Frequency of distribution of education level

	Frequency	Percent	Cumulative Percent
High School	25	26.0	26.0
Some College Courses (No Degree)	37	38.5	64.6
Associates Degree	8	8.3	72.9
Bachelors	18	18.8	91.7
Graduate	8	8.3	100.0
Total	96	100.0	

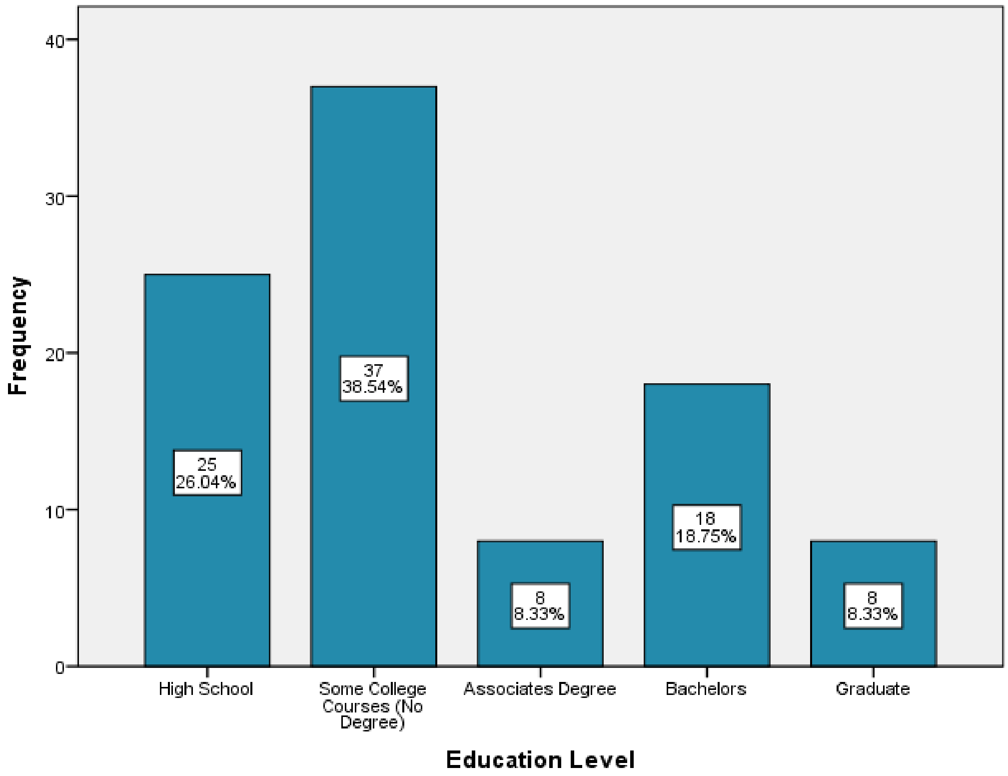


Figure 23: Frequency of distribution of education level

4.2.11 Past Safety Training

According to Table 11, 53 of the trainees were previously trained on construction safety. A total of 7 trainees did not have any training before the training session and with this study they got their first construction safety and health training However, 36 of the trainees did not give information about their past safety training. In the next sections, the effect of having past safety training will be analyzed and the results will be presented.

Table 11: Frequency of distribution of past safety training

		Frequency	Percent	Cumulative Percent
	Previously Trained	53	55.2	88.3
	Previously NOT Trained	7	7.3	100.0
	Total	60	62.5	
Missing	System	36	37.5	
Total		96	100.0	

4.2.12 Test Duration

The duration spent by each trainee was recorded during the pretest and posttest. For this study the difference between the posttest and pretest duration is taken and defined as a variable. This data is used to show whether spending more time in the test affects the training success and test score. As seen from Figure 24, 24 % of the trainees spent more and 76 % of them spent less time in the posttest.

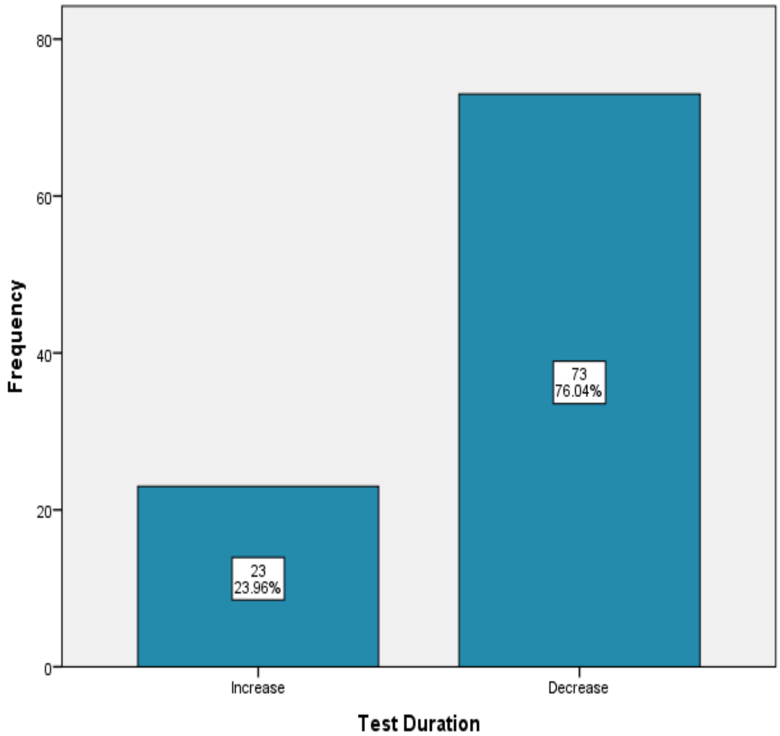


Figure 24: Frequency of distribution of test duration

4.2.13 Posttest/Pretest Ratio

In this study, the knowledge gain of workers is defined as Posttest/Pretest Ratio. This ratio shows whether the posttest score is higher than the pretest score. It was found by dividing the posttest score to pretest score. After that, univariate analysis was conducted and according to the results, 56 of 96 of the posttest scores were equal or less than the pretest scores. Only 41.7 % of the workers increased their posttest scores after the training. Figure 25 displays the bar chart of frequency of distribution of Posttest/Pretest ratio of workers.

Table 12: Frequency of distribution of Posttest/Pretest ratio

	Frequency	Percent	Cumulative Percent
=1	20	20.8	20.8
<1	36	37.5	58.3
>1	40	41.7	100.0
Total	96	100.0	

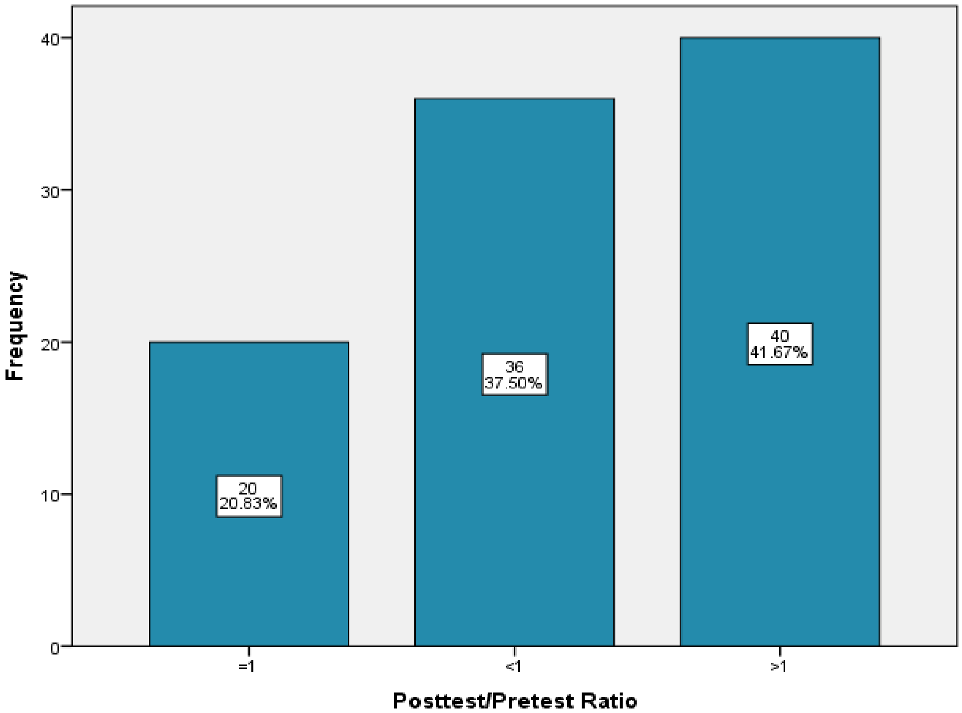


Figure 25: Frequency of distribution of Posttest/Pretest ratio

4.2.14 Training Success

Success rate of this training was decided as 70 % which is commonly used for training certificates by OSHA. In other words, trainees that chose the correct answers for more than 70% of the posttest questions were considered as successful. As seen in Figure 26, 55 % of the trainees answered at least 70 % of the questions correctly. Remaining trainees were considered as unsuccessful after the training.

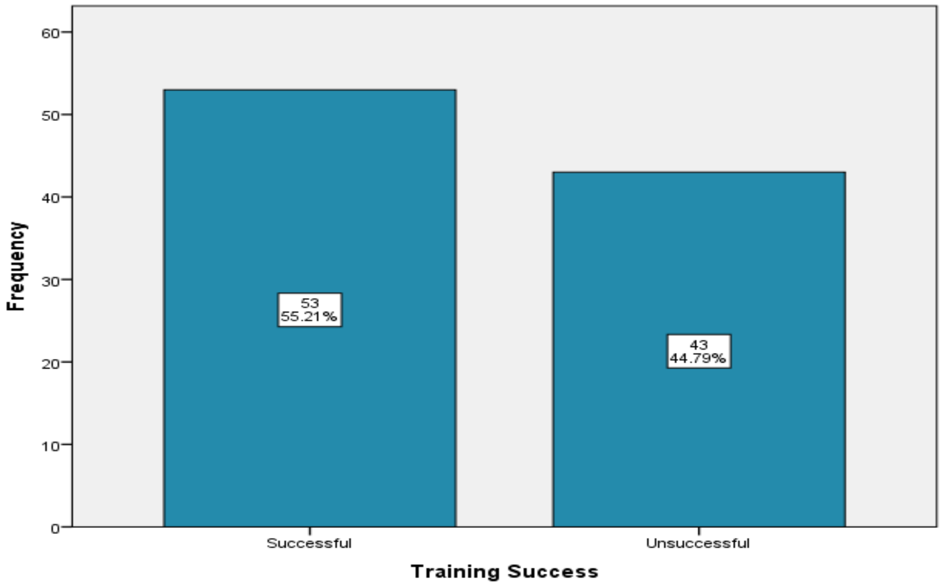


Figure 26: Frequency of distribution of Training Success

4.2.15 Satisfaction Survey (Kirkpatrick Level 1)

At the end of the delivery system, trainees were asked to answer the likert type questions about the training. According to the answers, 13 % of the trainees stated that the training did not improve their knowledge on Hazard Communication Standard. On the contrary, 50 % of the workers answered this question as agree or strongly agree (See Figure 27).

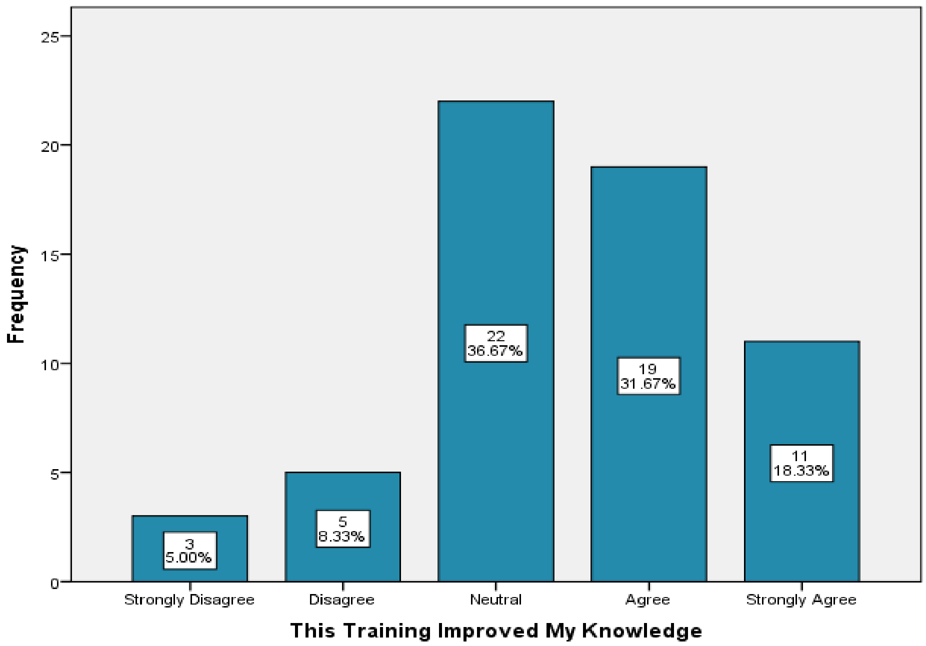


Figure 27: Frequency of distribution of survey (This training improved my knowledge)

Another question was about whether the training would be useful in their works and 55 % of the trainees answered this question as agree or strongly agree. On the contrary, 9 % of the trainees stated that this training will not be useful in their works (See Figure 28).

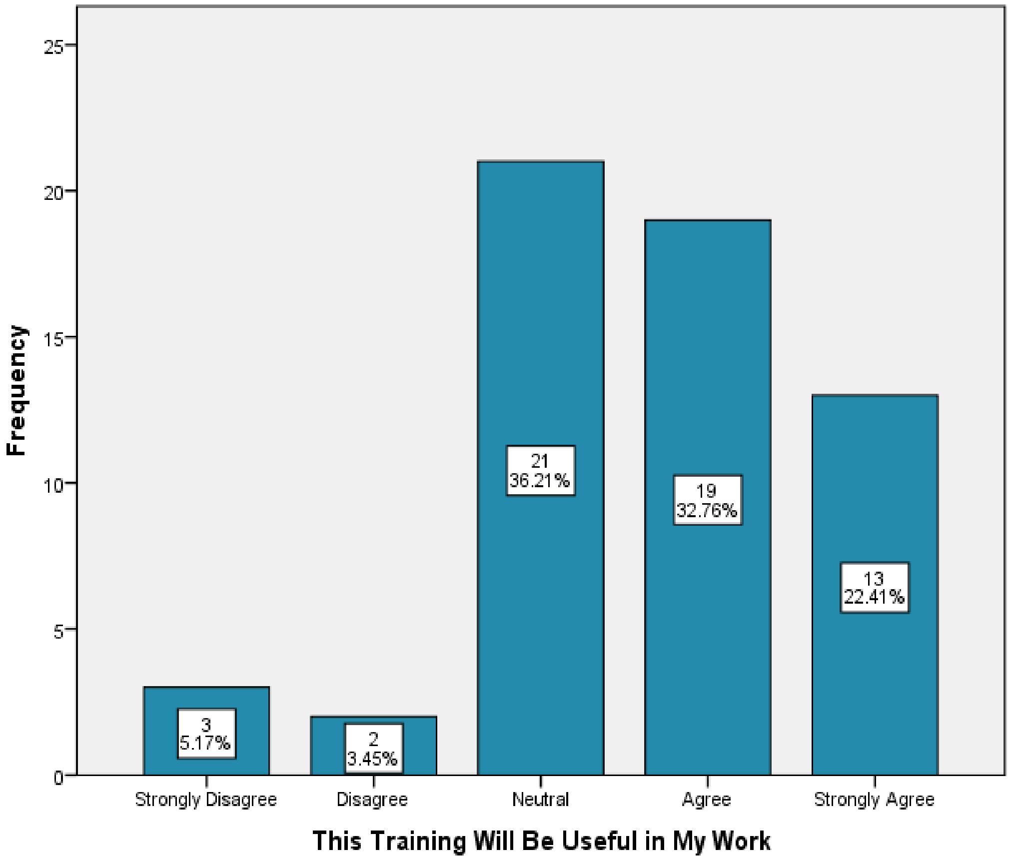


Figure 28: Frequency of distribution of survey (This training will be useful in my work)

4.3 Cross Tabulation Analysis Findings

After having some information and understanding about univariate analysis, cross tabulation method is applied to determine the interaction between dependent variables and independent variables.

In this section, cross tabulation analysis results of the independent variables (age, gender, ethnic background, number of employees, sector, experience level, job specification, years in industry, union status, education level, past safety training, test duration) and dependent variables (posttest/pretest ratio and training success) will be presented.

4.3.1 Cross Tabulation Results for Posttest/Pretest Ratio

Ass seen in Table 13, 50 % of the 18-29 age group increased their knowledge and 4 of them got the same score in both pretest and posttest. A total of 7 workers in 30-39, 13 workers in 40-49, 10 workers in 50-59 and only 1 worker in 60+ age groups increased their knowledge after getting the training. Figure 29 shows the percent distribution of each age group with respect to their posttest/pretest ratio. According to chi square values ($\chi^2(8)=3.772$, p=0,900) the association between age and posttest/pretest ratio is not statistically significant.

Table 13: Age vs. Posttest/Pretest Ratio

		Posttest/Pretest Ratio			
		=1	<1	>1	Total
Age	18-29	4	5	9	18
	30-39	5	7	7	19
	40-49	6	13	13	32
	50-59	3	9	10	22
	60+	2	2	1	5
Total		20	36	40	96

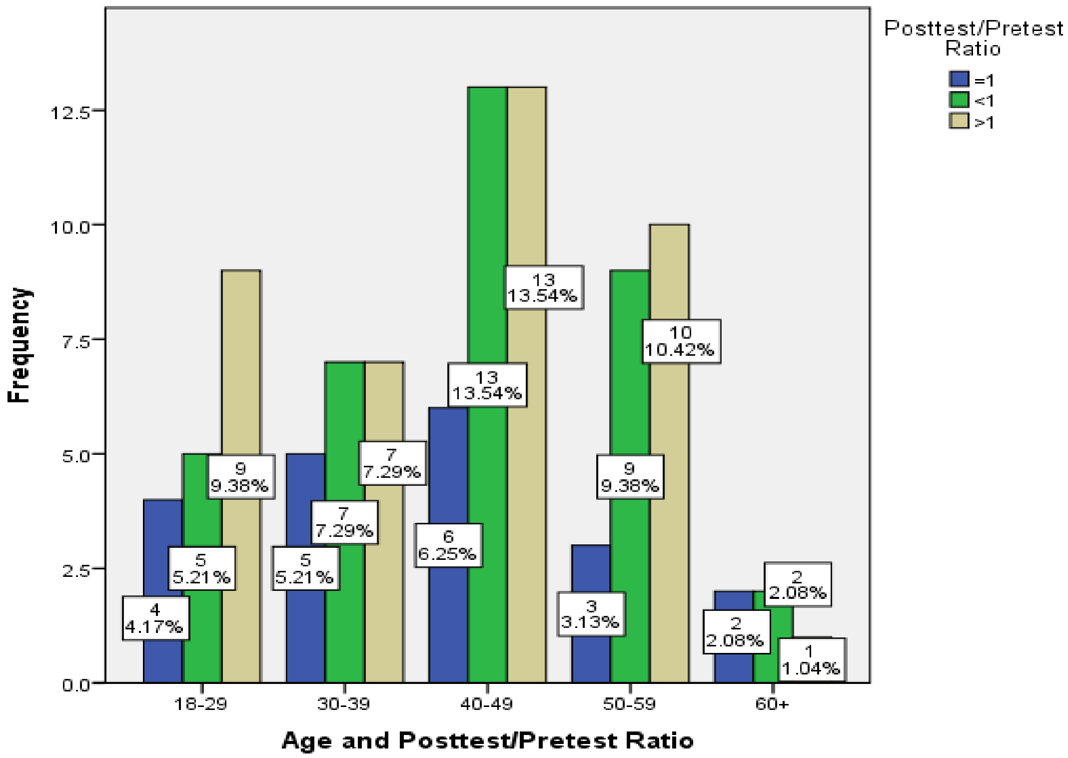


Figure 29: Age vs. Posttest/Pretest Ratio

Gender and posttest/pretest ratio analysis results show that 44 % of the male workers increased their knowledge after the training, and 29 % of the female workers showed better performance in the posttest. Remaining workers did not show any increase in posttest or decreased their scores (See also Figure 30). After multivariate analysis, it can be seen from the chi square values ($\chi^2(2)=2.391$, $p=0.297$) that the relationship between test performance and gender is not statistically significant.

Table 14: Gender vs. Posttest/Pretest Ratio

		Posttest/Pretest Ratio			
		=1	<1	>1	Total
Gender	Male	15	31	36	82
	Female	5	5	4	14
Total		20	36	40	96

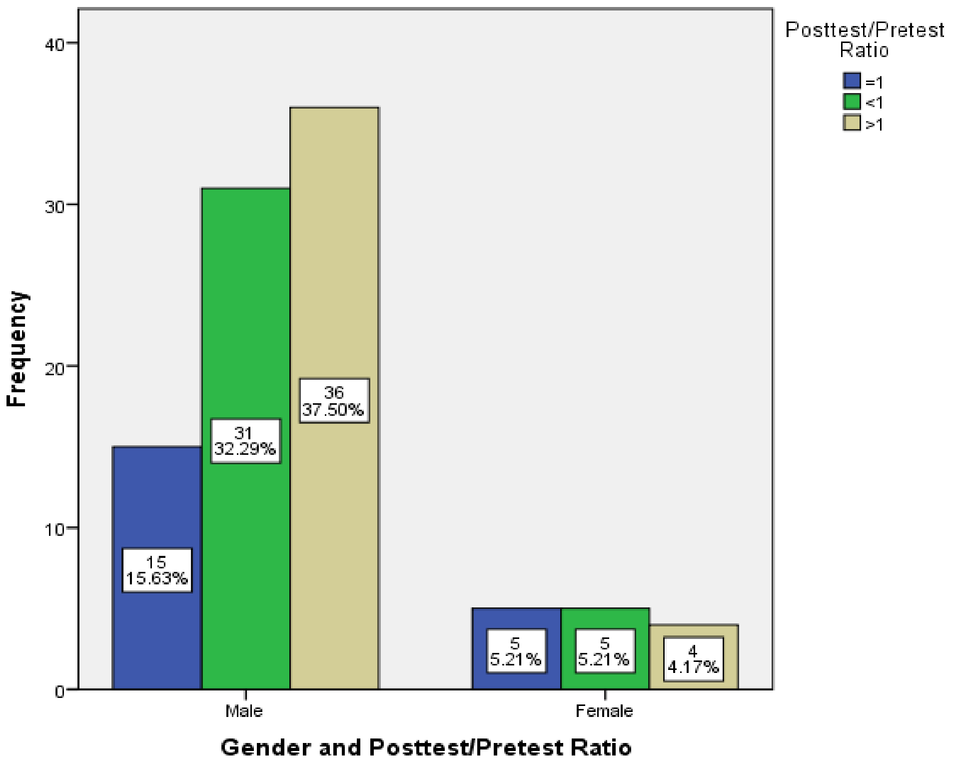


Figure 30: Gender vs. Posttest/Pretest Ratio

After the relationship analysis of ethnic background and posttest/pretest ratio is conducted, results in Table 15 show that 36 of 83 white workers, 4 of 7 African American workers did better in posttest. None of the Hispanic, native American or Asian American workers showed improvement after the training; see Figure 31 for percentages. Chi square analysis results ($\chi^2(8)=9.495$, $p=0.162$) show that the association between ethnic background and knowledge improvement is statistically insignificant.

Table 15: Ethnic Background vs. Posttest/Pretest Ratio

		Posttest/Pretest Ratio			
		=1	<1	>1	Total
Ethnic	White	16	31	36	83
	African American	1	2	4	7
	Asian American	0	1	0	1
	Hispanic	2	0	0	2
	Native American	1	2	0	3
Total		20	36	40	96

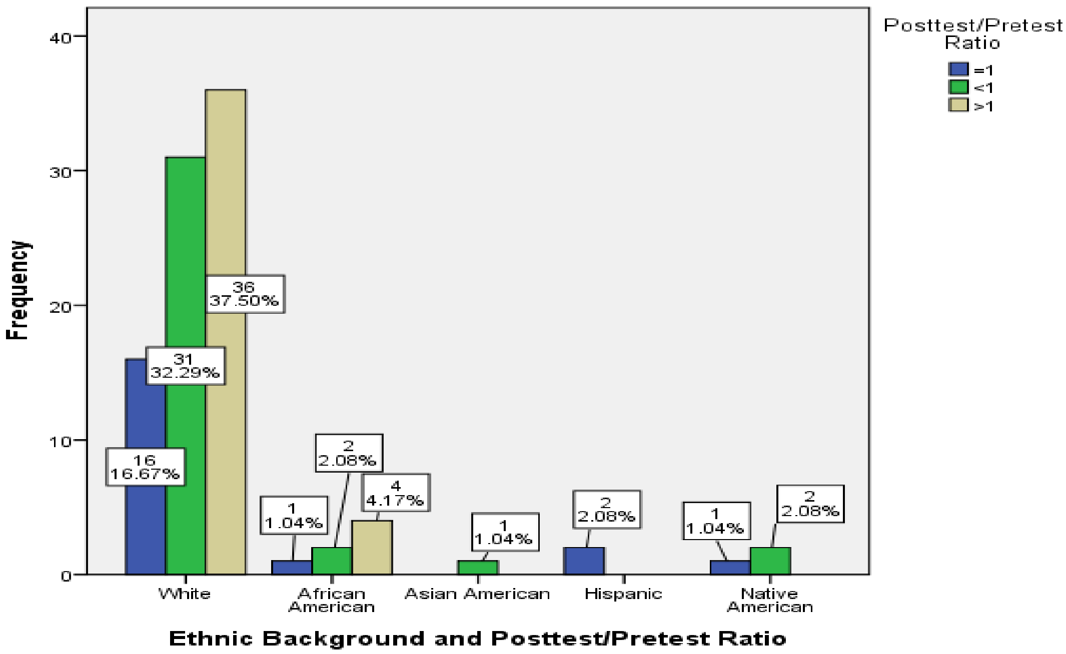


Figure 31: Ethnic Background vs. Posttest/Pretest Ratio

In Table 16, it is seen that 60 % of the people working with less than 10 people in their workplaces increased their knowledge about the Hazard Communication Standard after the training. It was observed that 70 % of the people working for companies that have 11-50 workers did not show any increase, some of them also got lower grades in the posttest. 64 % of workers within number of employees 51-100, 40 % of the workers within 101-200 and 37 % of the workers within 200 + groups increased their scores in the posttest.

Table 16: Number of Employees vs. Posttest/Pretest Ratio

		Posttest/Pretest Ratio			
		=1	<1	>1	Total
Number of Employees	1-10	3	1	6	10
	11-50	1	6	3	10
	51-100	1	3	7	11
	101-200	1	2	2	5
	200+	14	24	22	60
Total		20	36	40	96

Chi square analysis results ($\chi^2(8)=8.250$, $p=0.393$) of number of employees and posttest/pretest ratio showed that there is not a statistically significant association between test scores and number of employees in the company.

Analysis results of working sector and posttest/pretest ratio show that only 1 of the 6 workers in highway/transportation sector, 15 of the 29 workers in commercial sector, 22 of the 53 workers in industrial sector, and 1 of the 7 workers in institutional sector increased their knowledge. There was only one worker working in the residential sector and s/he did better in posttest. After cross tabulation of the variables, the chi square analysis was conducted and the results ($\chi^2(8)=7.387$, $p=0.463$) show that there is no statistically significant association between working sector of the trainee and test score.

Table 17: Sector vs. Posttest/Pretest Ratio

		Posttest/Pretest Ratio			
		=1	<1	>1	Total
Sector	Highway/Transportation	2	3	1	6
	Commercial	6	8	15	29
	Industrial	10	21	22	53
	Residential	0	0	1	1
	Institutional	2	4	1	7
Total		20	36	40	96

Table 18 shows the relationship between experience level and posttest/pretest ratio. A total of 5 of 14 apprentices, 5 of 7 foremen (working), 5 of 11 foremen (supervising) and 15 of 34 journeymen increased their knowledge after the training. 33 % of the workers who classified themselves as "other" also did better in the posttest. In total, 20 trainees got the same scores in both pretest and posttest (See also Table 32). Chi square analysis results ($\chi^2(8)=6.052$, $p=0.656$) show that the relationship between experience level and test scores is insignificant.

Table 18: Experience Level vs. Posttest/Pretest Ratio

		Posttest/Pretest Ratio			
		=1	<1	>1	Total
Experience Level	Apprentice	5	4	5	14
	Foreman (Working)	1	1	5	7
	Foreman (Supervising)	1	5	5	11
	Journeyman	6	13	15	34
	Other	7	13	10	30
Total		20	36	40	96

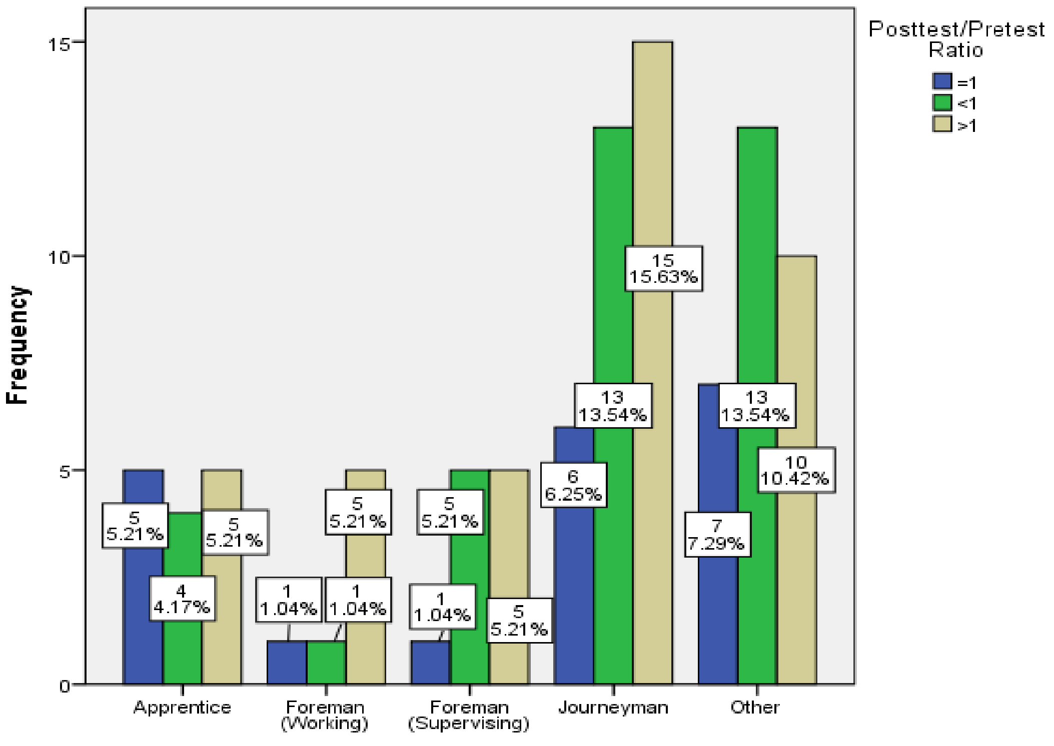


Figure 32: Experience Level vs. Posttest/Pretest Ratio

The relationship between job classification and knowledge improvement was analyzed, and according to Table 19, 29 of 49 civil/hoisting operators and 12 of 20 stationary engineers increased their knowledge after the training. A total of 13 of the civil/hoisting operators, 4 stationary engineers and 3 workers who classified themselves as "other" got the same score in both pretest and posttest; see also Figure 33 for percentage of each category for posttest/pretest scores. According to the chi square analysis results ($\chi^2(4)=2.776$, $p=0.608$), the association between job classification and posttest/pretest ratio is statistically insignificant.

Table 19: Job Classification vs. Posttest/Pretest Ratio

		Posttest/Pretest Ratio			
		=1	<1	>1	Total
Job Classification	Civil/Hoisting	13	16	20	49
	Stationary Engineer	4	8	8	20
	Other	3	12	12	27
Total		20	36	40	96

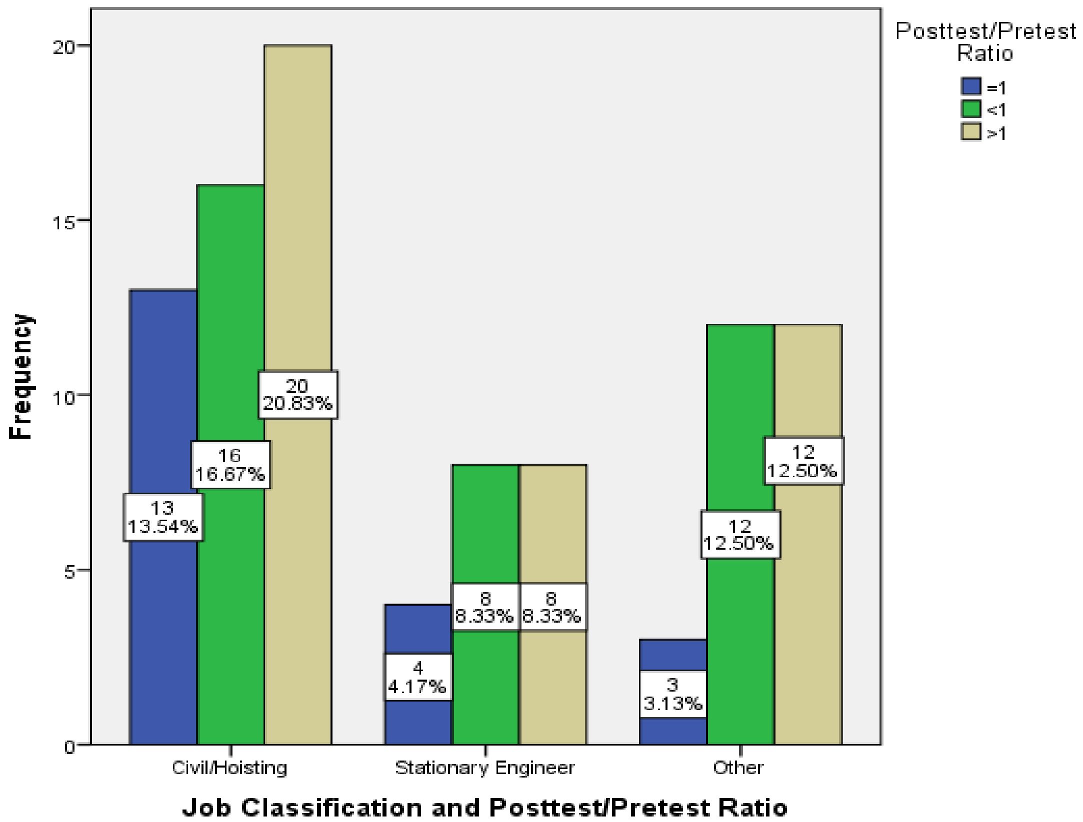


Figure 33: Job Classification vs. Posttest/Pretest Ratio

According to Table 20, 3 of the 8 workers who spent less than 1 year in the industry, 8 of 19 workers who spent 1-5 years, 3 of 9 workers who spent 6-10 years, 3 of 10 workers who spent 11-15 years, 4 of 16 workers who spent 16-20 years and 19 of 34 workers who spent more than 20 years improved their knowledge after the training. Chi square values ($\chi^2(10)=11.848$, $p=0.274$) show that the relationship between the years in industry and posttest/pretest ratio is also insignificant.

Table 20: Years in Industry vs. Posttest/Pretest Ratio

		Posttest/Pretest Ratio			
		=1	<1	>1	Total
Years In Industry	Less Than 1 Year	3	2	3	8
	1-5	3	8	8	19
	6-10	4	2	3	9
	11-15	3	4	3	10
	16-20	2	10	4	16
	20+	5	10	19	34
Total		20	36	40	96

As seen in Table 21, 34 of 76 union member workers and 6 of 20 non union workers increased their knowledge after the training. 16 unionized workers and 4 non-union workers got the same scores from both pretest and posttest. Figure 34 also displays the percentage of posttest/pretest ratio percentages for each category. Results of chi square analysis ($\chi 2(2)=1.871$, $p=0.382$) state that the association between union status and test scores is statistically insignificant.

Table 21: Union Status vs. Posttest/Pretest Ratio

		Posttest/Pretest Ratio			
		=1	<1	>1	Total
Union Status	Union	16	26	34	76
	Non-Union	4	10	6	20
Total		20	36	40	96

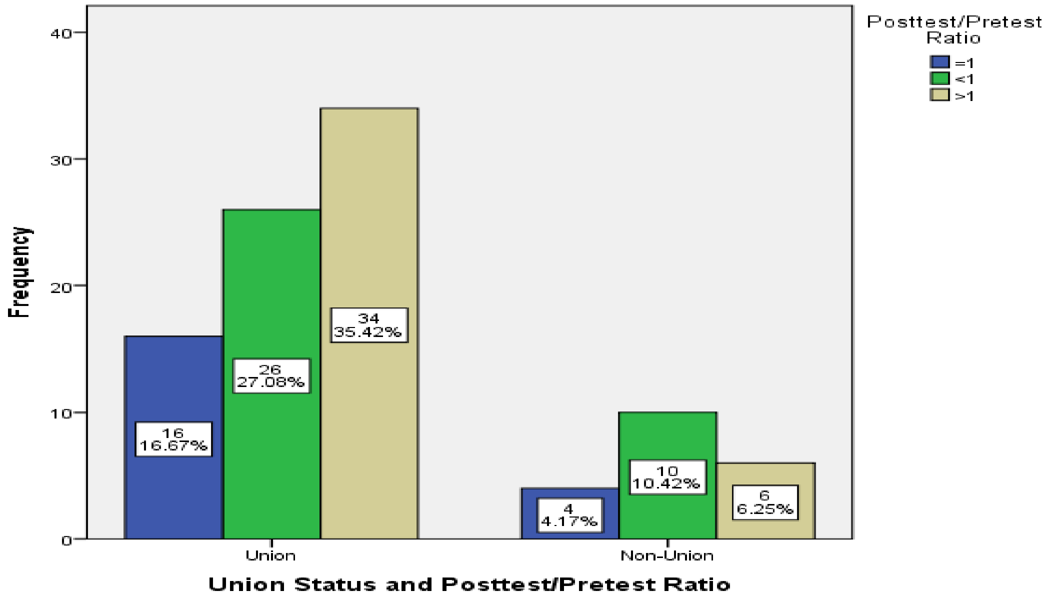


Figure 34: Union Status vs. Posttest/Pretest Ratio

Table 22 shows the relationship between education level and posttest/pretest ratio. 7 high school graduates, 25 workers who took some college courses but not a college degree, 2 workers with associates degree, 5 workers who have bachelor degree and 1 worker with graduate degree showed better performance in the posttest. As seen in Figure 35, 26 % of the workers who increased their test scores in posttest are the workers who took some college courses. Chi square results ($\chi^2(8)=20.441$, $p=0.004$) of the education level and posttest/pretest ratio show that there is a statistically significant relationship between education level and posttest/pretest ratio. Cramer's V value (crv=0.323, p=0.004) defines this significance as moderate association.

Table 22: Education Level vs. Posttest/Pretest Ratio

		Posttest/Pretest Ratio			
		=1	<1	>1	Total
Education Level	High School	8	10	7	25
	Some College Courses (No Degree)	2	10	25	37
	Associates Degree	3	3	2	8
	Bachelors	5	8	5	18
	Graduate	2	5	1	8
Total		20	36	40	96

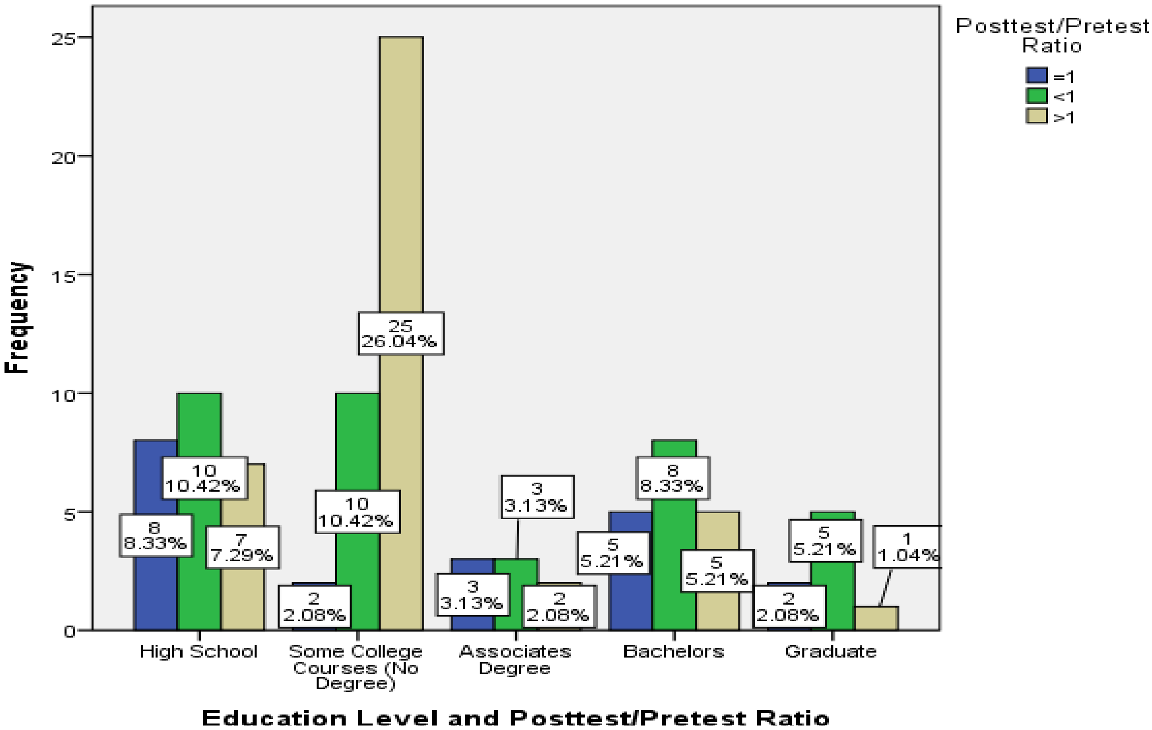


Figure 35: Education Level vs. Posttest/Pretest Ratio

The relationship between past safety training and posttest/pretest ratio was analyzed and the results are presented in Table 23. According to the results, it was found that 38 % of the previously trained workers and 57 % of the previously not trained workers increased their knowledge after the training. However, Chi square analysis results ($\chi^2(2)=1.853$, $p=0.456$) show that the relationship between past safety training and test scores is not statistically significant.

Table 23: Past Safety Training vs. Posttest/Pretest Ratio

		Posttest/Pretest Ratio			
		=1	<1	>1	Total
Past Safety Training	Previously Trained	12	21	20	53
	Previously NOT Trained	2	1	4	7
Total		14	22	24	60

The relationship between the time spent in the tests and posttest/pretest ratio of participants is shown in Table 24. According to the table, 12 of 23 trainees who spent more time in posttest increased their knowledge on the Hazard Communication Standard and remaining trainees did not get better results in the posttest. 62 % of workers who spent less time in posttest did not show any knowledge improvement after the training. Chi square analysis results ($\chi^2(2)=3.336$, $p=0.204$) show that the relationship between test duration and posttest/pretest ratio is not statistically significant.

Table 24: Test Duration vs. Posttest/Pretest Ratio

		Posttest/Pretest Ratio			
		=1	<1	>1	Total
Test Duration	Increase	6	5	12	23
	Decrease	14	31	28	73
Total		20	36	40	96

4.3.2 Cross Tabulation Results for Training Success

In this study, the minimum passing score was 70 % and it was decided with respect to the passing score of OSHA 30 hour test. Trainees that did at least 70 % of the questions in the posttest, were considered as successful and the analysis were conducted accordingly.

Multivariate analysis results of age and training success is shown in Table 25. According to the results, 13 of the workers in 18-29 age group, 13 of the workers in 30-39 age group, 14 of the workers in 40-49 age group, 11 of the workers in 50-59 age group and 2 of the workers in 60+ age group answered at least 70 % of the posttest questions correctly and they were considered as successful after the training. In total, 53 of the 96 workers gave correct answers to at least 70 % of the posttest questions and remaining 43 workers were considered as unsuccessful. According to the group percentages, the highest success percentage is 72 % for 18-29 age group , and the least is 44 % for 50-59 age group. However, chi square analysis results ($\chi^2(4)=5.822$, $p=0.213$) shows that there is not a statistically significant relationship between age and training success rate.

Table 25: Age vs. Training Success

		Training Success		
		Successful	Unsuccessful	Total
Age	18-29	13	5	18
	30-39	13	6	19
	40-49	14	18	32
	50-59	11	11	22
	60+	2	3	5
Total		53	43	96

Another multivariate analysis was conducted to determine the relationship between gender and training success. Table 26 shows that, 47 of 82 male workers and 6 of 14 female workers were considered as successful at the end of the training. As seen in Figure 36, 49 % of the workers who completed the training successfully were men, and 6 % of them were female. Success percentage for male workers is higher than female worker according to the training success percentages. However, chi square analysis results ($\chi^2(1)=1.011$, $p=0.315$) state that there is not a statistically significant relationship between gender and training success.

Table 26: Gender vs. Training Success

		Training Success		
		Successful	Unsuccessful	Total
Gender	Male	47	35	82
	Female	6	8	14
Total		53	43	96

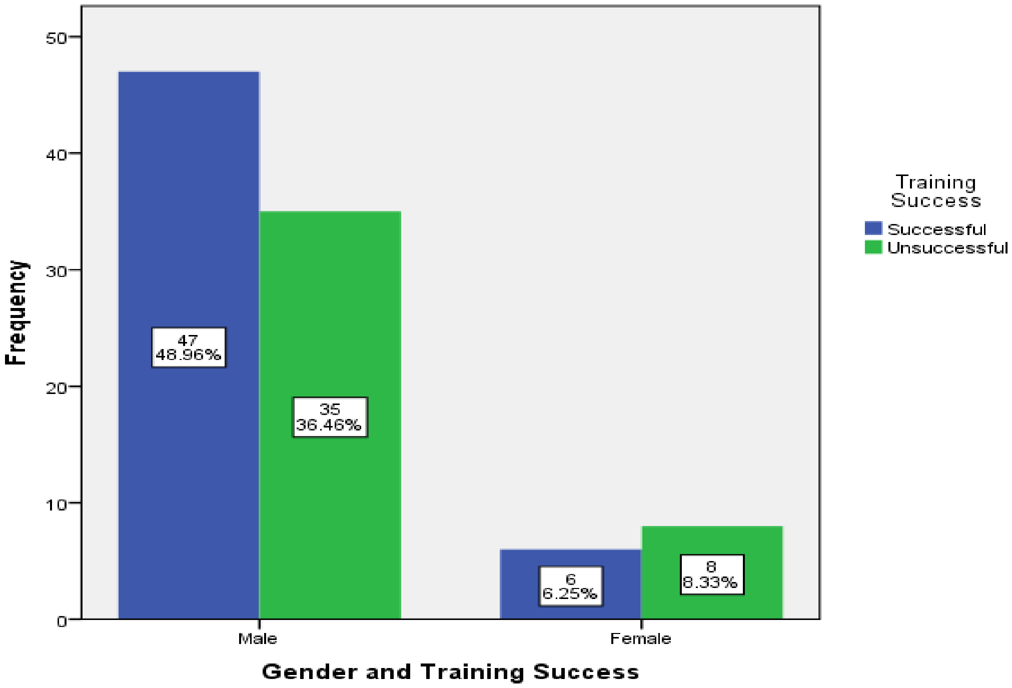


Figure 36: Gender vs. Training Success

Table 27 shows the cross tabulation results of ethnic background and training success. According to the results, 46 of 83 white workers, 3 of 7 African American workers, 2 Hispanic workers and 2 of 3 native American workers were considered as successful after the training. Chi square analysis results ($\chi^2(4)=3.148$, $p=0.638$) shows that there is not a statistically significant relationship between ethnic background and training success.

Table 27: Ethnic Background vs. Training Success

		Training Success		
		Successful	Unsuccessful	Total
Ethnic Background	White	46	37	83
	African American	3	4	7
	Asian American	0	1	1
	Hispanic	2	0	2
	Native American	2	1	3
Total		53	43	96

The relationship between number of employees in the company that the trainee works and training success of the trainee were also analyzed and the results are presented in Table 28. According to the results 30 % of the workers working with less than 50 people, 55 % of

51-100 group, 60 % of 101-200 group and 63 % of 200+ group scored at least 70% in the posttest. According to the percentages, workers working with more than 200 people have the highest percentage. However, the relationship between the number of employees and training success is not statistically significant according to chi square analysis results ($\chi^2(4)=6.721$, $p=0.143$).

Table 28: Number of Employees vs. Training Success

		Training Success		
		Successful	Unsuccessful	Total
Number of Employees	1-10	3	7	10
	11-50	3	7	10
	51-100	6	5	11
	101-200	3	2	5
	200+	38	22	60
Total		53	43	96

When the association between working sector of trainees and their training successes were analyzed, it can be seen that 4 of 6 highway/transportation workers, 17 of 29 commercial workers, 28 of 53 industrial workers and 4 of institutional workers completed the training successfully (See Table 29). To determine the relationship between these two variables, chi square analysis was performed and according to the results ($\chi^2(4)=1.825$, $p=0.852$), there is not a statistically significant relationship between working sector and training success.

Table 29: Sector vs. Training Success

		Training Success		
		Successful	Unsuccessful	Total
Sector	Highway/Transportation	4	2	6
	Commercial	17	12	29
	Industrial	28	25	53
	Residential	0	1	1
	Institutional	4	3	7
Total		53	43	96

Table 30 shows the relationship between experience level of construction workers and their success in the training. According to the analysis results, 71 % of apprentices, 57 % of foremen (working), 45 % of foremen (supervising), 47 % of journeymen and 60 % of workers that classified themselves as "other" were considered as successful after the training. However, once the relationship between experience level and success were analyzed, the chi square values ($\chi^2(4)=3.144$, $p=0.539$) showed that the association between these two variables is statistically insignificant.

Table 30: Experience Level vs. Training Success

		Training Success		
		Successful	Unsuccessful	Total
Experience Level	Apprentice	10	4	14
	Foreman (Working)	4	3	7
	Foreman (Supervising)	5	6	11
	Journeyman	16	18	34
	Other	18	12	30
Total		53	43	96

The frequency distribution of job classification with regard to the training success is shown in Table 31. According to the results, 30 of 49 civil/hoisting operators, 10 of 20 stationary engineers and 13 of 27 workers who classified themselves as "other" successfully completed the training and answered more than 70 % of the posttest questions correctly. However, chi square analysis results ($\chi^2(2)=1.513$, $p=0.488$) show that there is not a statistically significant association between job classification and training success.

Table 31: Job Classification vs. Training Success

		Training Success		
		Successful	Unsuccessful	Total
Classification	Civil/Hoisting	30	19	49
	Stationary Engineer	10	10	20
	Other	13	14	27
Total		53	43	96

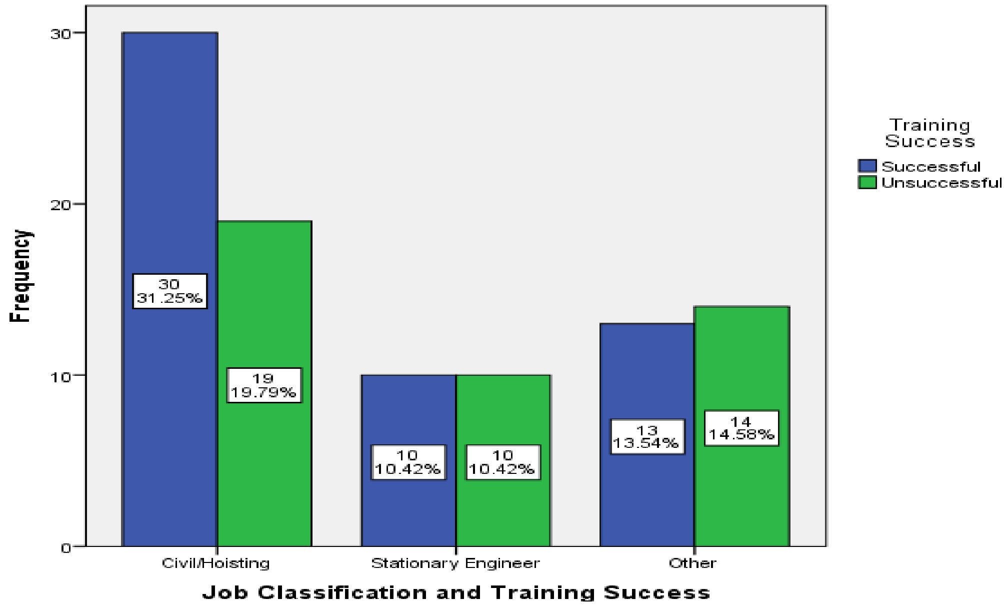


Figure 37: Job Classification vs. Training Success

Association between years spent in construction industry and training successes of workers were also analyzed and the results are presented in Table 32. According to the table, 6 of 8 workers who spent less than 1 year, 11 of 19 workers in group 1-5 years group, 7 of 9 workers in group 6-10 years, 5 of 10 workers in group 11-15 years, 6 of 16 workers in group 16-20 years and 18 of 34 workers in group 20+ years answered at least 70 % of posttest questions correctly. Chi square analysis was conducted to determine significance of relationship between years in industry and training success. Results of chi square analysis ($\chi^2(5)=5.209$, $p=0.394$), show that the relationship between these two variables is statistically insignificant.

Table 32: Years in Industry vs. Training Success

		Training Success		
		Successful	Unsuccessful	Total
Years In Industry	Less Than 1 Year	6	2	8
	1-5	11	8	19
	6-10	7	2	9
	11-15	5	5	10
	16-20	6	10	16
	20+	18	16	34
Total		53	43	96

According to Table 33, 41 of 76 union member workers, and 12 of 20 non union workers successfully completed the training. However, being a union member and training success do not have statistically significant relationship in between according to the chi square analysis results ($\chi^2(1)=0.235$, $p=0.628$).

Table 33: Union Status vs. Training Success

		Training Success		
		Successful	Unsuccessful	Total
Union Status	Union	41	35	76
	Non-Union	12	8	20
Total		53	43	96

Education level and training success were also analyzed and the results are presented in Table 34. Results show that 40 % of high school graduates, 65 % of workers who took some college courses without getting a college degree, 63 % of workers who have associates degree, 55 % of workers who have bachelors degree and 50 % of worker who have graduate degree were considered as successful after the training according to their posttest results. However, when the relationship between these variables were analyzed, according to chi square results ($\chi^2(4)=4.045$, $p=0.411$) it was seen that there is not a statistically significant association between education level of workers and their training successes.

Table 34: Education Level vs. Training Success

		Training Success		
		Successful	Unsuccessful	Total
Education Level	High School	10	15	25
	Some College Courses (No Degree)	24	13	37
	Associates Degree	5	3	8
	Bachelors	10	8	18
	Graduate	4	4	8
Total		53	43	96

Frequency distribution of past safety training with respect to training success can be seen in Table 35. According to the results 20 of 53 workers who were previously trained answered more than 70 % of the posttest questions correctly. On the other hand, 6 of 7 workers who were not previously trained were also completed the training successfully. Only one of the previously not trained workers were considered as unsuccessful after the training. After cross tabulation, chi square analysis were conducted to determine the statistical relationship between these variables. However, according to the results ($\chi^2(1)=2.723$, $p=0.099$), it can be said that there is not a statistically significant relationship between past safety training and training success.

Table 35: Past Safety Training vs. Training Success

		Training Success		
		Successful	Unsuccessful	Total
Past Safety Training	Previously Trained	28	25	53
	Previously NOT Trained	6	1	7
Total		34	26	60

The association between training success and duration that trainees spent in pretest and posttest were also analyzed. From Table 36, it can be seen that 15 of 23 workers who increased the time spent in posttest and 38 of 73 workers who decreased the time spent in posttest were classified as successful after the training. According to chi square analysis ($\chi^2(1)=1.225$, $p=0.268$), statistically significant relationship was not found between test duration and training success.

Table 36: Test Duration vs. Training Success

		Training Success		
		Successful	Unsuccessful	Total
Test Duration	Increase	15	8	23
	Decrease	38	35	73
Total		53	43	96

Cross tabulation analysis results were presented to show whether there is a relationship between the variables. In the next chapter, analysis of variance (ANOVA) and post hoc test will be performed to see which group of variables are better than the others.

4.4 Analysis of Variance (ANOVA) Findings

The association between the groups were analyzed in the previous section and only statistical significant was found between education level and posttest/pretest ratio. In this section, the result of the ANOVA and post hoc test will be shown to determine the relationship between the groups. At first the means scores, standard deviations and standard errors were calculated. For mean calculations, the code values were used for each category. Then, according to the homogeneity of variables, different post hoc tests were utilized. For homogeneous variables (sig. >0.05) Tukey test, for non homogeneous variables Games-Howell test was used. These two tests are most commonly used tests in post hoc analysis.

ANOVA was performed to see the relationship of posttest/pretest ratio between education level groups. Mean values of posttest/pretest ratio for each group of education level is shown in Table 37. Since "posttest/pretest >1" is coded as 2, "posttest/pretest =1" is coded as 1, and " posttest/pretest <1" is coded as 0, higher mean value means higher posttest score. According to the mean values, workers who took some college courses without getting a college degree, have the highest posttest/pretest ratio. On the contrary, workers holding a graduate degree have the lowest posttest/pretest ratio which means their improvement is less than the improvement of other groups. When post hoc results are analyzed, it can be seen that except the mean value of workers who took some college courses, the differences between mean values of groups are not statistically significant. In other words, having a higher degree does not increase the knowledge gain in construction safety training.

Table 37: Education Level and Posttest/Pretest Ratio

	N	Mean	Std. Deviation	Std. Error
High School	25	.88	.833	.167
Some College Courses (No Degree)	37	1.41	.896	.147
Associates Degree	8	.88	.835	.295
Bachelors	18	.83	.857	.202
Graduate	8	.50	.756	.267
Total	96	1.04	.893	.091

4.5 Summary of Findings

4.5.1 Cross Tabulation Results for Posttest/Pretest Ratio

The summary of the cross tabulation results for posttest /pretest ratio is shown in Table 38. According to the results, the relationships between the independent variables and posttest/pretest ratio are statistically insignificant except the relationship between education level and posttest/pretest ratio. This statistically significant relationship between the education level and posttest/pretest ratio is defined as moderate association.

Table 38: Cross Tabulation Results Summary for Posttest/Pretest Ratio

	Pearson's χ2 (df) & p	**Phi & Cramer's V value**
Age vs. Posttest/Pretest Ratio	s (χ^2(8)=3.772, p=0,900)	Statistically Insignificant Relationship
Gender vs. Posttest/Pretest Ratio	(χ^2(2)=2.391, p=0.297)	Statistically Insignificant Relationship
Ethnic Background vs. Posttest/Pretest Ratio	(χ^2(8)=9.495, p=0.162)	Statistically Insignificant Relationship
Number of Employees vs. Posttest/Pretest Ratio	(χ^2(8)=8.250, p=0.393)	Statistically Insignificant Relationship
Sector vs. Posttest/Pretest Ratio	(χ^2(8)=7.387, p=0.463)	Statistically Insignificant Relationship
Experience Level vs. Posttest/Pretest Ratio	(χ^2(8)=6.052, p=0.656)	Statistically Insignificant Relationship
Job Classification vs. Posttest/Pretest Ratio	(χ^2(4)=2.776, p=0.608)	Statistically Insignificant Relationship
Years in Industry vs. Posttest/Pretest Ratio	(χ^2(10)=11.848, p=0.274)	Statistically Insignificant Relationship
Union Status vs. Posttest/Pretest Ratio	(χ^2(2)=1.871, p=0.382)	Statistically Insignificant Relationship
Education Level vs. Posttest/Pretest Ratio	(χ^2(8)=20.441, p=0.004)	(crv=0.323, p=0.004)
Past Safety Training vs. Posttest/Pretest Ratio	(χ^2(2)=1.853, p=0.456)	Statistically Insignificant Relationship
Test Duration vs. Posttest/Pretest Ratio	(χ^2(2)=3.336, p=0.204)	Statistically Insignificant Relationship

4.5.2 Cross Tabulation Results for Training Success

The summary of cross tabulation results for training success is presented in Table 39. According to the results, the relationships between independent variables and training success of workers are not statistically significant. For significant relationship, further analysis cannot be utilized.

Table 39: Cross Tabulation Results Summary for Training Success

	Pearson's χ2 (df) & p	Phi & Cramer's V value
Age vs. Training Success	(χ^2(4)=5.822, p=0.213)	Statistically Insignificant Relationship
Gender vs. Training Success	(χ^2(1)=1.011, p=0.315)	Statistically Insignificant Relationship
Ethnic Background vs. Training Success	(χ^2(4)=3.148, p=0.638)	Statistically Insignificant Relationship
Number of Employees vs. Training Success	(χ^2(4)=6.721, p=0.143)	Statistically Insignificant Relationship
Sector vs. Training Success	(χ^2(4)=1.825, p=0.852)	Statistically Insignificant Relationship
Experience Level vs. Training Success	(χ^2(4)=3.144, p=0.539)	Statistically Insignificant Relationship
Job Classification vs. Training Success	(χ^2(2)=1.513, p=0.488)	Statistically Insignificant Relationship
Years in Industry vs. Training Success	(χ^2(5)=5.209, p=0.394)	Statistically Insignificant Relationship
Union Status vs. Training Success	(χ^2(1)=0.235, p=0.628)	Statistically Insignificant Relationship
Education Level vs. Training Success	(χ^2(4)=4.045, p=0.411)	Statistically Insignificant Relationship
Past Safety Training vs. Training Success	(χ^2(1)=2.723, p=0.099)	Statistically Insignificant Relationship
Test Duration vs. Training Success	(χ^2(1)=1.225, p=0.268)	Statistically Insignificant Relationship

4.5.3 Analysis of Variance (ANOVA)

The only statistically significant relationship is determined between education level and posttest/pretest ratio of workers. To determine the relationship between the education level categories according to the their posttest/pretest ratio mean values, analysis of variance method was utilized. Post hoc analysis results show that the mean value of workers who took some college courses is significantly higher than the mean value of graduate students. However, there is not a statistically significant difference between the mean values of other education level categories. In other words, having a higher degree does not increase the knowledge gain in construction safety training.

4.6 Additional Analysis

4.6.1 Cross Tabulation Analysis Findings

In this part of cross tabulation analysis, the relationship between the demographics of workers were presented. In Table 40, it can be seen that 5 of the workers between age of 18 and 29 were new in the construction industry. 12 of them is in the range of 1-5 years and only one spent more than 5 years in the industry. People between age of 30 and 39, 40-49 and 60+ mostly spent 16-20 years in construction industry. Only 8 of the trainees spent less than 1 year in the construction industry and 34 of 96 trainees spent more than 20 years in the industry.

Table 40: Age vs. Years in Industry

		Years In Industry						
		Less Than 1 Year	1-5	6-10	11-15	16-20	20+	Total
Age	18-29	5	12	1	0	0	0	18
	30-39	1	3	1	4	7	3	19
	40-49	2	2	5	4	6	13	32
	50-59	0	2	2	1	3	14	22
	60+	0	0	0	1	0	4	5
Total		8	19	9	10	16	34	96

According to chi square analysis results ($\chi^2(20)=57.945$, $p=0.000$), the relationship between age and years in industry is statistically significant. Cramer's V values (crv=0.424, p=0.000) define this association as relatively strong association.

Table 41 show the relationship between age and experience level. From the table, it can be observed that workers between age of 18-29 generally classified themselves as "other" and 8 of them stated that they were apprentices. Workers between age of 30-39 generally stated that they were foremen and journeyman. 24 workers between ages of 40 and 49 classified themselves as journeyman and "other". Majority of people in the group 50-59 and 60+ were working as journeymen in their professional life. According to the results, the association between age and experience level ($\chi^2(16)=44.98$, p=0.000) is statistically significant and according to Cramer's V value (crv=0.356, p = 0.000) this association is shown to be moderate association category.

Table 41: Age vs. Experience Level

		Experience Level					
		Apprentice	Foreman (Working)	Foreman (Supervising)	Journeyman	Other	Total
Age	18-29	8	0	0	0	10	18
	30-39	3	3	6	6	1	19
	40-49	3	2	3	12	12	32
	50-59	0	2	2	12	6	22
	60+	0	0	0	4	1	5
Total		14	7	11	34	30	96

The association between age and union status is presented in Table 42, and table shows that majority of each age group was a member of a union. All of the workers older than 60 were unionized and only 1 of the workers between age of 30-39 was not unionized. The percentage of nonunion workers in 18-29 age group was 44 %. 19 of 50-59 age group and 24 of 40-49 age group were members of unions. The statistical association between these two variables is analyzed and it was found that there is a statistically significant association between age and union status according to chi square values ($\chi^2=9.788$, p=0.0032). Cramer's V value (crv = 0.342, p = 0.0032) classifies this association category as moderate association.

Table 42: Age vs. Union status

		Union Status		
		Union	Non-Union	Total
Age	18-29	10	8	18
	30-39	18	1	19
	40-49	24	8	32
	50-59	19	3	22
	60+	5	0	5
Total		76	20	96

Age and past safety training analysis results are based on 60 values since 36 of the participants chose not to provide information about their past safety training. Multivariate analysis results show that 64 % of the workers between ages 18 and 29 were got some trainings on construction safety. 92 % of 30-39 and 50-59 age groups and 94 % of 40-49 age group were previously trained; see Table 43 for frequencies. All trainees above age 60 took construction safety trainings in their professional lives. According to chi square values ($\chi^2(4)$= 5.728, p=0.142) the relationship between age and past safety training is not statistically significant.

Table 43: Age vs. Past Safety Training

		Past Safety Training		
		Previously Trained	Previously NOT Trained	Total
Age	18-29	7	4	11
	30-39	13	1	14
	40-49	17	1	18
	50-59	11	1	12
	60+	5	0	5
Total		53	7	60

After multivariate analysis of gender and union, results show that 66 of 82 (80 %) male workers and 10 (71 %) of the female workers were unionized (See Table 44). Chi square values ($\chi^2(1)$=0.595, p = 0.44) show that the association between gender and union status is not statistically significant.

Table 44: Gender vs. Union Status

		Union Status		
		Union	Non-Union	Total
Gender	Male	66	16	82
	Female	10	4	14
Total		76	20	96

Number of employees in the company and union status cross tabulation analysis results show that nearly all of the workers working companies with less than 200 employees were union members. However 18 of the 60 workers in companies with more than 200 employees were not unionized. The unionized percentage of 200+ company workers was 70 % in this study (See Table 45). Chi square values ($\chi^2(4)$ =7.038, p = 0.096) for this analysis show that there is not a statistically significant relationship between number of employees in the company and the union status.

Table 45: Number of Employee vs. Union Status

		Union Status		
		Union	Non-Union	Total
Employees	1-10	9	1	10
	11-50	10	0	10
	51-100	10	1	11
	101-200	5	0	5
	200+	42	18	60
Total		76	20	96

The association of number of employees and past safety training of workers were also analyzed in this study and Table 46 shows that 5 of 6 workers working with less than 10 employees, 3 of 4 workers in the companies with 11-50 and 51-100 workers were previously trained. This number is 60 % for workers working with 101-200 employees and 95 % for workers who work with more than 200 workers. When chi square values are analyzed ($\chi^2(4)$=8.337, p=0.04), it can be seen that there is a statistically significant association between number of employees and union status. Cramer's V value (crv=0.348, p=0.04) defines this association as moderate association.

Table 46: Number of Employee vs. Past Safety Training

		Past Safety Training		
		Previously Trained	Previously NOT Trained	Total
Employees	1-10	5	1	6
	11-50	3	1	4
	51-100	3	1	4
	101-200	3	2	5
	200+	39	2	41
Total		53	7	60

Table 47 shows the relationship between sector and experience level. According to the table, 2 of the workers were apprentice and 4 of the workers were journeyman in highway/transportation sector. In commercial workers group, there were 9 apprentices, 8 foremen, 10 journeymen. Most of the workers in industrial group were journeymen and the only workers working in residential and institutional sectors were also journeymen. After chi square analysis, the results ($\chi^2(16)=33.765$, $p=0.000$) show that there is a statistically significant relationship between sector and experience level. The category of this association is moderate association according to Cramer's V analysis results (crv=0.037, p=0.000)

Table 47: Sector vs. Experience Level

		Experience Level					
		Apprentice	Foreman (Working)	Foreman (Supervising)	Journeyman	Other	Total
Sector	Highway/Transportation	2	0	0	4	0	6
	Commercial	9	2	6	10	2	29
	Industrial	3	5	5	18	22	53
	Residential	0	0	0	1	0	1
	Institutional	0	0	0	1	6	7
Total		14	7	11	34	30	96

When working sector of the trained construction workers and their union status were analyzed, it can be seen that all of the workers in highway/transportation sector and residential sector, 93 % of workers in commercial sector, 86 % of workers in institutional sector and 68

% of workers working in industrial type of sector were union members. It can be said that the majority of each group are member of unions. Chi square values ($\chi^2(4)=8.875$, $p=0.038$) show that there is a statistically significant association between these two variables and Cramer's V value (crv=0.348, p=0.038) defines this association as moderate association.

Table 48: Sector vs. Union Status

		Union Status		
		Union	Non-Union	Total
Sector	Highway/Transportation	6	0	6
	Commercial	27	2	29
	Industrial	36	17	53
	Residential	1	0	1
	Institutional	6	1	7
Total		76	20	96

Table 49 shows the relationship between sector and past safety training. It shows that 75 % of the workers in highway/transportation sector, 76 % of the workers in commercial sector, 94 % of the workers in industrial sector and all workers in institutional sector were previously trained. Chi square analysis results ($\chi^2(3)=4.563$, $p=0.142$) show that the relationship between working sector and past safety training is not statistically significant.

Table 49: Sector vs. Past Safety Training

		Past Safety Training		
		Previously Trained	Previously NOT Trained	Total
Sector	Highway/Transportation	4	1	5
	Commercial	13	4	17
	Industrial	34	2	36
	Institutional	2	0	2
Total		53	7	60

Experience Level and Years in Industry analysis shows that all the apprentices spent less than 5 years in the industry. 71 % of the foremen (working) and 36 % of the foremen (supervising) were in the construction industry for more than 20+ years. 53 % of the journeyman were working in the industry for more than 20 years (See Table 50). When the association between experience level and years in industry was analyzed, chi square values ($\chi^2(20)=60.414$, p=0.000) show that the association is statistically significant. Cramer's V value (crv=0.462, p=0.000) defines this association as relatively strong association.

Table 50: Experience Level vs. Years in Industry

		Years In Industry						
		Less Than 1 Year	1-5	6-10	11-15	16-20	20+	Total
Experience Level	Apprentice	7	7	0	0	0	0	14
	Foreman (Working)	0	1	0	1	0	5	7
	Foreman (Supervising)	0	0	0	1	6	4	11
	Journeyman	0	2	4	6	4	18	34
	Other	1	9	5	2	6	7	30
Total		8	19	9	10	16	34	96

Table 51 show that all of the apprentices, 86 % of foreman (working), all of the foreman (supervising), and all of the journeymen were member of unions. Only 11 of the 30 workers who classified their experience level as " other" were union members. Chi square analysis ($\chi^2(4)=44.633$, p=0.000) analysis results show that there is a significant relationship between these two variables and Cramer's V values (crv=0.711, p=0.000) defines this relationship as strong association.

Table 51: Experience Level vs. Union Status

		Union Status		
		Union	Non-Union	Total
Experience Level	Apprentice	14	0	14
	Foreman (Working)	6	1	7
	Foreman (Supervising)	11	0	11
	Journeyman	34	0	34
	Other	11	19	30
Total		76	20	96

Table 52 shows the relationship of experience level and past safety training. According to the table, 7 of 11 apprentices, all of the foremen, 96 % of the journeymen were previously trained. In total, 53 of 60 workers who answered the question about their past safety training were trained before this study. According to the chi square values ($\chi^2(4)=7.102$, p=0.066), the relationship between experience level and past safety training is statistically insignificant.

Table 52: Experience Level vs. Past Safety Training

		Past Safety Training		
		Previously Trained	Previously NOT Trained	Total
Experience Level	Apprentice	7	4	11
	Foreman (Working)	4	0	4
	Foreman (Supervising)	8	0	8
	Journeyman	23	1	24
	Other	11	2	13
Total		53	7	60

After analysis of job classification of workers and their union status, it can be seen that 45 of 49 civil/hoisting workers , 17 of 20 stationary engineers, and 14 of 27 workers who classified themselves as "other" were union members (See Table 53). Chi square analysis results ($\chi^2(2)=15.722$, p=0.000) show that there is a statistically significant association between job classification and union status. Cramer's V value (crv=0.426, p=0.000) defines this association as relatively strong association.

Table 53: Job Classification vs. Union Status

		Union Status		
		Union	Non-Union	Total
Job Classification	Civil/Hoisting	45	4	49
	Stationary Engineer	17	3	20
	Other	14	13	27
Total		76	20	96

Table 54 shows the relationship between job classification of workers and their education level. All of the workers were at least high school graduates. 19 civil/hoisting operators, 9 stationary engineers, and 9 worker who classified themselves as " other" took some college courses but they do not have any college degree. 4 civil/hoisting operators, 2 stationary engineers, and 2 workers from "other" have associates degree according to the table. 5 civil/hoisting operators, 1 stationary engineer, and 12 workers from "other" group have bachelors degree. And the 3 civil/hoisting operators and 5 stationary engineers stated that they had graduate degrees. Chi square analysis were performed to find out whether there is a statistically significant relationship between job classification and education level. According to the results ($\chi^2(8)=23.124$, $p=0.002$), the association between the job classification and education level is statistically significant. Cramer's V value (crv=0.379, p=0.002) defines this relationship as moderate association.

Table 54: Job Classification vs. Education Level

		Education Level					
		High School	Some College Courses (No Degree)	Associates Degree	Bachelors	Graduate	Total
Job Classification	Civil/Hoisting	18	19	4	5	3	49
	Stationary Engineer	3	9	2	1	5	20
	Other	4	9	2	12	0	27
Total		25	37	8	18	8	96

Another analysis was performed to determine the statistical significance of relationship between job classification and past safety training. According to Table 55, 94 % of the civil/hoisting operators, and 38 % of the stationary engineers were previously trained. From chi square analysis results ($\chi^2(2)=15.212$, $p=0.001$), it can be stated that there is a statistically significant association between these two variables. Cramer's V value (crv=0.626, p=0.001) defines the category of this relationship as strong association category.

Table 55: Job Classification vs. Past Safety Training

		Past Safety Training		
		Previously Trained	Previously NOT Trained	Total
Job Classification	Civil/Hoisting	33	2	35
	Stationary Engineer	3	5	8
	Other	17	0	17
Total		53	7	60

Table 56 shows the relationship between years that workers spent in construction industry and their union status. 88 % of the workers who spent less than 1 year in the construction industry, 58 % of the of the workers who spent 1-5 years , 78 % of the workers who spent 6-10 years, 90 % of the workers who spent 11-15 years, 75 % of the workers who spent 16-20 years in the construction industry and 88 % of the workers who spent more than 20 years in the construction industry were union members. To determine whether there is a statistical relationship between years in industry and union status chi square analysis were performed and according to the results ($\chi^2(5)=7.309$, $p=0.171$), it was found that there is not a statistically significant relationship between years in industry and union status.

Table 56: Years in Industry vs. Union Status

		Union Status		
		Union	Non-Union	Total
Years In Industry	Less Than 1 Year	7	1	8
	1-5	11	8	19
	6-10	7	2	9
	11-15	9	1	10
	16-20	12	4	16
	20+	30	4	34
Total		76	20	96

When the relationship between years in industry and past safety training was analyzed, it can be seen that 50 % of the workers who spent less than 1 year in the industry, 91 % of the workers who spent 1-5 years , 75 % of the workers who spent 6-10 years, 100 % of the workers who spent 11-15 years, 100 % of the workers who spent 16-20 years in the construction industry and 96 % of the workers who spent more than 20 years in the construction industry were previously trained (See Table 57). Chi square analysis results (χ^2(5)=10.669, p=0.015) show that there is a statistically significant relationship between years in industry and past safety training. Cramer's V values (crv =0.504, p=0.015) defines this relationship as relatively strong association.

Table 57: Years in Industry vs. Past Safety Training

		Past Safety Training		
		Previously Trained	Previously NOT Trained	Total
Years In Industry	Less Than 1 Year	4	4	8
	1-5	10	1	11
	6-10	3	1	4
	11-15	5	0	5
	16-20	9	0	9
	20+	22	1	23
Total		53	7	60

Table 58 shows the relationship between union status and past safety training. 87 % of the union members and 100 % of the non union workers were previously trained. However, chi square analysis results (χ^2(1)=1.219, p=0.27) shows that union membership and past safety training do not have any statistically significant association in between.

Table 58: Union Status vs. Past Safety Training

		Past Safety Training		
		Previously Trained	Previously NOT Trained	Total
Union Status	Union	45	7	52
	Non-Union	8	0	8
Total		53	7	60

Summary of the cross tabulation results for additional analysis can is presented in Table 59. Table only show the statistically significant relationships and their Cramer's V values.

Table 59: Cross Tabulation Results Summary

Analyzed Variables	Pearson's χ^2(df) & p	Phi & Cramer's V Value
Age vs. Years in Industry	(χ^2(20)=57.95, p=0.000)	(crv=0.424, p=0.000)
Age vs. Experience Level	(χ^2(16)=44.98, p=0.000)	(crv=0.356, p=0.000)
Number of Employee vs. Past Safety Training	(χ^2(4)=8.337, p=0.04)	(crv=0.348, p=0.04)
Working Sector vs. Experience Level	(χ^2(16)=33.77, p=0.000	(crv=0.037, p=0.000)
Working Sector vs. Union Status	(χ^2(4)=8.88, p=0.038)	(crv=0.348, p=0.04)
Experience Level vs. Years in Industry	(χ^2(20)=60.41, p=0.000)	(crv=0.462, p=0.000)
Experience Level vs. Union Status	(χ^2(4)=44.63, p=0.000)	(crv=0.711, p=0.000)
Job Classification vs. Union Status	(χ^2(2)=15.722, p=0.000)	(crv=0.426, p=0.000)
Job Classification vs. Education Level	(χ^2(8)=23.12, p=0.002)	(crv=0.379, p=0.002)
Job Classification vs. Past Safety Training	(χ^2(2)=15.212, p=0.001)	(crv=0.626, p=0.001)
Years in Industry vs. Past Safety Training	(χ2(5)=10.67, p=0.015)	(crv =0.504, p=0.015)

4.6.2 Analysis of Variance (ANOVA) Findings

The association between the groups were analyzed and the results were represented in the previous section. In this section, the analysis results of the variables in table 59 are presented. ANOVA post hoc results will show the relationship between each category values in a group.

When the relationship between years in industry and age is analyzed, it can be seen that the mean score for years spent in the industry increases when the mean score of age increases.

Table 60: Age and Years in Industry

	N	Mean	Std. Deviation	Std. Error
18-29	18	1.7778	.54832	.12924
30-39	19	4.1579	1.50049	.34424
40-49	32	4.5313	1.60612	.28393
50-59	22	5.1364	1.39029	.29641
60+	5	5.6000	.89443	.40000
Total	96	4.1354	1.79836	.18354

Since the required homogeneity assumption was not met (sig=0.001) for age and years in industry variables, Games-Howell test was used. Post hoc analysis results show that the mean differences between the age group 18-29 and the other groups are significant. According to post hoc analysis results, the mean differences between the groups except 18-29 are not significant. It can be said that generally older workers spent more time in the industry as expected, but it does not mean all old workers spent more time in the industry than the young workers.

ANOVA results for age and experience level show that mean score increases with age except the group 30-39. Experience level of workers who are older than 60 is the highest; see Table 61. Games-Howell test results state that only mean differences between 30-39 age group and 50-59, 60+ age groups are significant. In other words, there is not a significant difference between 50-59 and 60+ means scores, however mean scores of these groups are significantly higher than the mean score of 30-39 age group.

Table 61: Age and Experience Level

	N	Mean	Std. Deviation	Std. Error
18-29	18	3.2222	2.04524	.48207
30-39	19	2.9474	1.17727	.27008
40-49	32	3.8750	1.26364	.22338
50-59	22	4.0000	.87287	.18610
60+	5	4.2000	.44721	.20000
Total	96	3.6146	1.37932	.14078

Table 62 shows the means scores of past safety training for each group of number of employee. In this analysis, since "1" is used as a code value for previously trained workers, lower mean value mean higher number of previously trained workers. According to the mean scores, it can be said that the percentage of previously trained workers is the highest in 200+ group and lowest in 101-200 group.

Table 62: Number of Employee and Past Safety Training

	N	Mean	Std. Deviation	Std. Error
1-10	6	1.1667	.40825	.16667
11-50	4	1.2500	.50000	.25000
51-100	4	1.2500	.50000	.25000
101-200	5	1.4000	.54772	.24495
200+	41	1.0488	.21808	.03406
Total	60	1.1167	.32373	.04179

According to ANOVA results (F(4)=1.891,p=0.125) there is no significant relationship between number of employee and past safety training.

Working sector and experience level was also analyzed in ANOVA and the results are presented in Table 63. The mean scores show that workers on the institutional sector are working in the higher positions and workers in the commercial sector working in the lowest positions. According to post hoc analysis, the difference between mean score of highway/transportation workers and others is not statistically significant. The differences in mean scores of industrial and commercial, institutional and commercial, industrial and institutional are significant. It can be stated that institutional workers have better experience level than industrial and commercial workers, and industrial workers' experience level is higher than the commercial workers.

Table 63: Working Sector and Experience Level

	N	Mean	Std. Deviation	Std. Error
Highway/Transportation	6	3.0000	1.54919	.63246
Commercial	29	2.7931	1.39845	.25969
Industrial	53	3.9623	1.19232	.16378
Residential	1	4.0000	.	.
Institutional	7	4.8571	.37796	.14286
Total	96	3.6146	1.37932	.14078

Table 64 shows the mean scores of working sector and union status. As the mean value increases, number of union members decreases. It can be seen that the lowest mean is 1 for highway/transportation sector and residential sector which means all of the workers in these groups are union members. Industrial sector has the highest mean and it can be said that the percentage of non union workers in this group is higher than the others. Post hoc analysis is used to see whether these differences is important. According to the results, highway/transportation workers and commercial workers are more prone to be union members when they are compared with industrial workers. The differences between other groups are not statistically significant.

Table 64: Working Sector and Union Status

	N	Mean	Std. Deviation	Std. Error
Highway/Transportation	6	1.00	.000	.000
Commercial	29	1.07	.258	.048
Industrial	53	1.32	.471	.065
Residential	1	1.00	.	.
Institutional	7	1.14	.378	.143
Total	96	1.21	.408	.042

Relationship between experience level and years in industry was also analyzed with ANOVA method and the results are seen in Table 65. According to the results, when mean values increases, years spent in the industry increases because of the code values assigned to the category values. In this study, the results show that for being a foreman (supervising), workers should stay in the industry for a long time. And being an apprentice requires the least time in the industry. According to the post hoc results, the differences between apprentices and the other groups are significant. In other words, apprentices should stay in the industry to have higher positions. Differences between mean values of foreman (supervising), foreman (working) and journeyman are not statistically significant which means some of the foremen spent more time industry than some of the journeymen.

Table 65: Experience Level and Years in Industry

	N	Mean	Std. Deviation	Std. Error
Apprentice	14	1.5000	.51887	.13868
Foreman (Working)	7	5.1429	1.57359	.59476
Foreman (Supervising)	11	5.2727	.64667	.19498
Journeyman	34	4.9412	1.32439	.22713
Other	30	3.8000	1.68973	.30850
Total	96	4.1354	1.79836	.18354

Table 66 shows the mean values of experience level of workers with respect to their union status. According to the mean values, all of the apprentices, foremen (supervising), and journeymen are members of unions. According to the post hoc analysis results, only the mean value of workers classified as "other" is different than the others. There is not a statistically significant difference between the mean values of apprentices, foremen (working), foremen (supervising) and journeymen.

Table 66: Experience Level and Union Status

	N	Mean	Std. Deviation	Std. Error
Apprentice	14	1.00	.000	.000
Foreman (Working)	7	1.14	.378	.143
Foreman (Supervising)	11	1.00	.000	.000
Journeyman	34	1.00	.000	.000
Other	30	1.63	.490	.089
Total	96	1.21	.408	.042

Table 67 represents the mean scores of union status for different job classification groups. It can be seen that the percentage of unionized workers is highest for civil/hoisting operators and lowest for workers classified as "other". According to post hoc analysis results, the difference between mean values of civil/hoisting operators and stationary engineers is not statistically significant. However, the mean values of these two groups are significantly lower than the group called as "other".

Table 67: Job Classification and Union Status

	N	Mean	Std. Deviation	Std. Error
Civil/Hoisting	49	1.08	.277	.040
Stationary Engineer	20	1.15	.366	.082
Other	27	1.48	.509	.098
Total	96	1.21	.408	.042

Relationship between job classification and education level was also analyzed with ANOVA method. Table 68 show that the education level of workers classified as "other" is higher than the others and it is the lowest for civil/hoisting operators. Tukey test results show that the mean score of "other" is significantly higher than the mean score of civil/hoisting operators, but there is not a significant difference between mean values of stationary engineers and civil/hoisting operators.

Table 68: Job Classification and Education Level

	N	Mean	Std. Deviation	Std. Error
Civil/Hoisting	49	2.1020	1.19452	.17065
Stationary Engineer	20	2.8000	1.47256	.32927
Other	27	2.8148	1.17791	.22669
Total	96	2.4479	1.28857	.13151

Table 69 shows the mean scores of past safety training for different job classifications. It can be seen that all of the workers classified as "other" were previously trained. Also, the percentage of previously trained civil/hoisting operators is more than stationary engineers.

Post hoc analysis results state that there is not a statistically significant difference between mean values of workers classified as "other" and civil/hoisting operators. However, mean values of these groups is significantly lower than the mean value of stationary engineer.

Table 69: Job Classification and Past Safety Training

	N	Mean	Std. Deviation	Std. Error
Civil/Hoisting	35	1.0571	.23550	.03981
Stationary Engineer	8	1.6250	.51755	.18298
Other	17	1.0000	.00000	.00000
Total	60	1.1167	.32373	.04179

Table 70 shows the mean scores of past safety training for years spent in the industry. All workers within groups 11-15 and 16-20, were previously trained. The percentage of trained workers is the least for workers who spent less than 1 year in the construction industry. The mean value for group "less than 1 year" is significantly lower than mean values of 1-5, 11-15, 16-20 and 20+ groups. There is not a statistically significant difference between mean values of other groups.

Table 70: Years in Industry and Past Safety Training

	N	Mean	Std. Deviation	Std. Error
Less Than 1 Year	8	1.5000	.53452	.18898
1-5	11	1.0909	.30151	.09091
6-10	4	1.2500	.50000	.25000
11-15	5	1.0000	.00000	.00000
16-20	9	1.0000	.00000	.00000
20+	23	1.0435	.20851	.04348
Total	60	1.1167	.32373	.04179

CHAPTER 5: SUMMARY, CONCLUSIONS, LESSONS LEARNED AND RECOMMENDATIONS

5.1 Summary

This section summarizes the given information and presented analysis results. It covers the summary of the main study and additional analysis.

5.1.1 Summary of Main Study

There are more than 9 million people working in construction industry in the U.S according to the statistics. These workers are facing dangerous works and accidents each day in their workplaces. Therefore, they should be trained about the possible accidents and required OSHA standards. Hazard Communication Standard is one of the standards that employees working with chemicals should be trained on. This standard gives information about the possible hazards of chemical, precautionary statements, pictograms, safety data sheets, etc. For training employees about these standards, employers use different training methods which are traditional, online and blended trainings. However, preparation of the training materials is as important as selection of the training method because each employee has different demographics that may affect the gain of knowledge and success of training such as age, union status, education level, ethnic background, native languages, experience level, working sector, gender, etc.

This study presented the effect of construction worker demographics on e-learning with Hazard Communication Standard training. QR Code based mobile training delivery system was created for the training and demographics of each participant were asked and recorded during the training. The information of trainees and their test results were used as variables in the analysis. Univariate analyses were performed to establish the frequency of distribution of each variable. Multivariate analyses results showed whether there are any relationship between worker demographics and their performance in the training. For variables that have significant relationship, analysis of variance (ANOVA) method was performed to determine the relationship between dependent variable category values.

5.1.2 Summary of Additional Analysis

As an addition to the main analysis, the relationship between the worker demographics were also analyzed. Cross tabulation analysis results showed that some variables have statistically significant association in between. These association can be summarized as follows;

- There is a relatively strong association between age and years that workers spent in the industry.
- The association between age of workers and their experience level can be classified as moderate association.
- It was found that number of employee in the company and past safety training have moderate association in between.
- The association between working sector of the workers and their experience level was classified as moderate association. In addition to that there is also moderate association between working sector and union status.
- Experience Level has relatively strong association with years spent in the industry and it has strong association with union status.
- Job classification of workers has relatively strong association with union status, moderate association with education level and negligible association with past safety training of workers.
- Years spent in the industry also have relatively strong association with past safety training.

After finding statistically significant association between the variables, ANOVA method was used to determine the relationship between the categories of each group. According to the ANOVA results:

- Workers in the range of 18-29 spent significantly less time in the industry than the workers who are older than 30.
- 50+ years old workers have significantly higher experience level than 30-39 years old workers.
- Institutional workers have higher experience level than industrial and commercial workers, and industrial workers' experience level is significantly higher than the commercial workers.
- Apprentices should stay in the industry to have higher positions. In other words, who have higher positions in the industry spent long time in the business.
- Frequency of past safety training for civil/hoisting operators is significantly higher than that of stationary engineers.
- Past safety training of workers who spent less than 1 year in the industry is significantly lower than the others. This shows that workers are not generally trained on construction safety and health in their first year.
- Highway/transportation workers and commercial workers are more prone to be union members when they are compared with industrial workers.

5.2 Conclusions

Companies and institutions started to use online learning to improve quality of the training, decrease the cost of the training and let workers reach the training materials anytime and anywhere. Increase of e-learning usage in industry and educational institutions make researchers to analyze the acceptance and effectiveness of this training method since they change from person to person based on different criteria.

Ho and Dzeng (2010) compared three training methods and concluded that all three methods are effective but e-learning type of training method is more effective when it is compared to others. Ong and Lai (2004) only studied the effect of gender on effectiveness of e-learning and stated that men are more prone to use technology than women. However, they need to be perceived that the training is useful to enhance their job effectiveness. On the other hand, women should be trained on usage of technology to get benefit from online trainings. In addition to that, Wallen and Mulloy (2006) stated that young people are better than old people at learning and supporting text with narration, pictures and animations is the best option for both young and old learners. Islam et al. (2011) also concluded that men and students with higher education level get more benefits from e-learning type of training. Same study also showed that race and marital status do not effect e-learning effectiveness.

According to the findings, this study presented that worker demographics which are age, gender, ethnic background, union status, number of employees in the company, working sector, experience level, job classification, years spent in industry, being previously trained, and the duration spent in the training do not affect the gain of knowledge and training success rate unlike the previous studies. Therefore, the null hypotheses for these dependent variables which states that there is no significant relationship between these dependent variables and independent variables were accepted. On the other hand, it was found that there is a significant association between education level of workers and knowledge improvement. According to the results, workers who took some college courses without getting a college degree have the highest knowledge gain rate. However, this shows that increase in the education level does not increase the knowledge gain.

In addition to the knowledge improvement and training success rate analysis, satisfaction degree of the trainees were also analyzed to measure level 1 effectiveness of the training. According to the results 50 % of the trainees agreed that the training improved their knowledge on hazard communication standard, and 55 % stated that this training will be useful in their works. This results show that, generally the workers liked the mobile training and thought that it would be beneficial in their works.

From the results of the analysis, it can be concluded that there is not a statistically significant association between the demographics of workers and learning with Hazard Communication Standard training. In other words, as long as the training materials and delivery system are prepared properly, each trainee has the same chance to increase his/her knowledge no matter what type of demographics that s/he has.

5.3 Lessons Learned and Recommendations

According to the results, only 42 % of the trainees increased their test scores in posttest and 55 % of them answered 70 % of the posttest questions correctly. These numbers were expected to be higher before the training was delivered to the workers. Therefore, the reasons and problems faced should be addressed to learn from the mistakes and eliminate these problem in future trainings and studies.

The training delivery system was designed as website and trainees were asked to use their mobile phones during the training. To open the website, they are provided a QR Code and they asked to download a QR scanner prior to the training. Workers used different mobile devices and different QR scanners to open the website. Therefore, the system worked differently in each mobile device and it created different problems for each worker. Workers who could not solve the problems that they faced during the training logged out the system without completing all steps. In addition to that, bugs in the system created problems during the training sessions, and it was not possible for workers to use the system for the training.

The system problems were not the only problems that are faced during the study. It was observed that some workers did not know how to use their mobile devices. Therefore, they had difficult time while taking the training. Some of these workers skipped the questions and left the training without completing it. Also, small screen of the smart phones made it hard for older workers to clearly see the screen and click on the choices in tests and survey. Since it was self paced training, some got bored during the training and skipped the presentation and did not answer the posttest questions. Therefore, some of the posttest results were 0 or unexpectedly lower than the pretest results. Also, it was found that the time spent in the pretest and posttest did not have any effect on knowledge improvement. In other words, trainees who increased or decreased their test results in posttest spent approximately the same time in both pretest and posttest. This may be explained by pretest being the first step of the training and people might spend more time to get used to the system. In addition that, Hazard Communication Standard is a long standard and has a lot of technical words. Therefore, it is hard to understand the whole standard for not only workers but also the people in higher positions with higher education and experience levels.

To eliminate this type of problems some changes can be made for further studies. Instead of using QR codes and website, an application can be created to eliminate the effect of QR scanner and mobile device. Also for people who do not know how to use their mobile devices, short course can be given about the usage of the system or mobile device prior to the training to improve their self-efficacy. For people who lost their motivation during the training, voice or video about the standard or possible accidents related to the violation of the standard can be added to the system to make them understand the importance of the standard. Pretest and posttest results can also be added to the system and presented to workers once they submit their tests. This may also increase their motivation and make them pay attention to the training material and improve their test results in posttest. The problem caused by the technical language in the standard cannot be eliminated. However, the language used in this training may be simplified.

In future studies, other standards or training presentation should also be used to evaluate the effectiveness of the construction safety and health training. Another delivery system can be created or current system can be improved to help workers to use the system smoothly. Also, the number of workers should be increased and workers from different demographics should be found to have homogeneous distribution between the category values and have more reliable results.

APPENDIX A: Training Success and Posttest/Pretest Ratio

In this study, not only the posttest/pretest ratio but also training success of the workers were analyzed as a dependent variable. However, improving the posttest result does not mean also being successful. According to Figure 38, 30 % of the trainees were successful and they increased their knowledge after the training which is desired outcome of the training. On the other hand, 29 % of the trainees were both unsuccessful and decreased their posttest score.

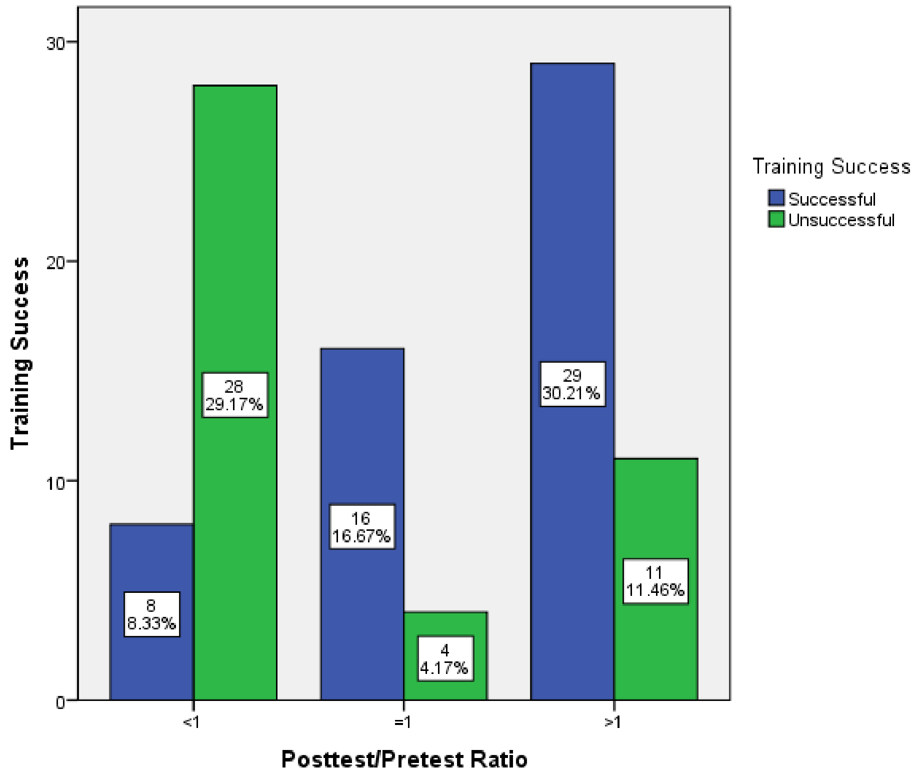


Figure 38: Homepage, registration page and training delivery system sections

APPENDIX B: Training Delivery System Screenshots

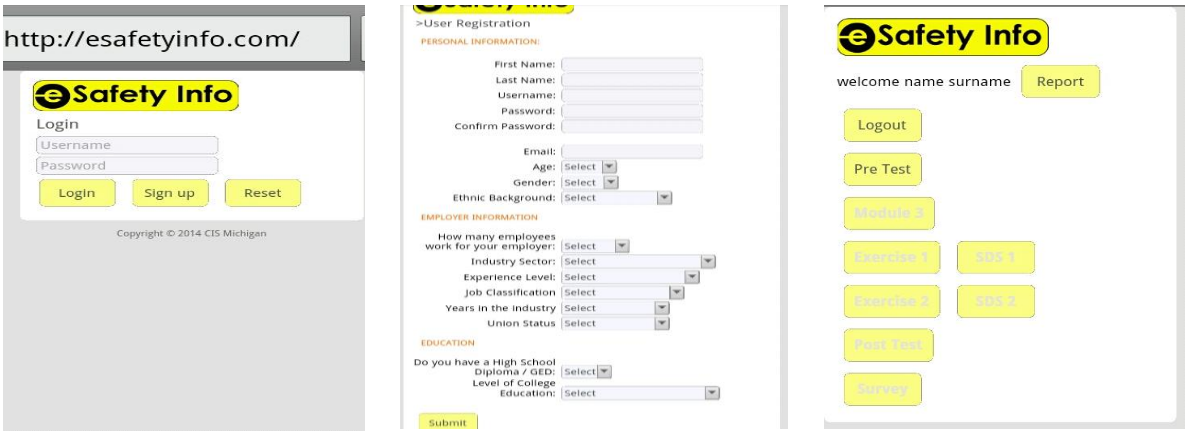


Figure 39: Homepage, registration page and training delivery system sections

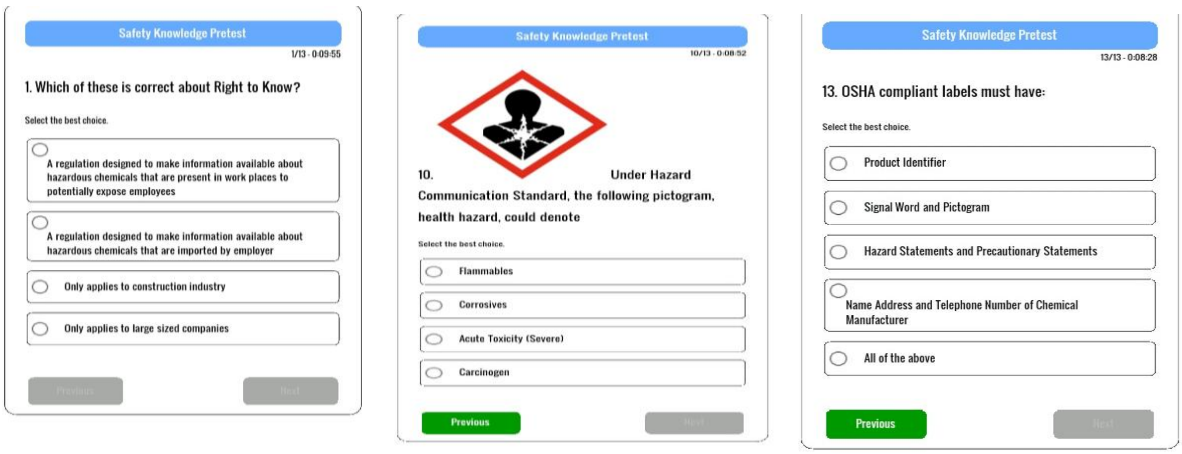


Figure 40: Pretest questions

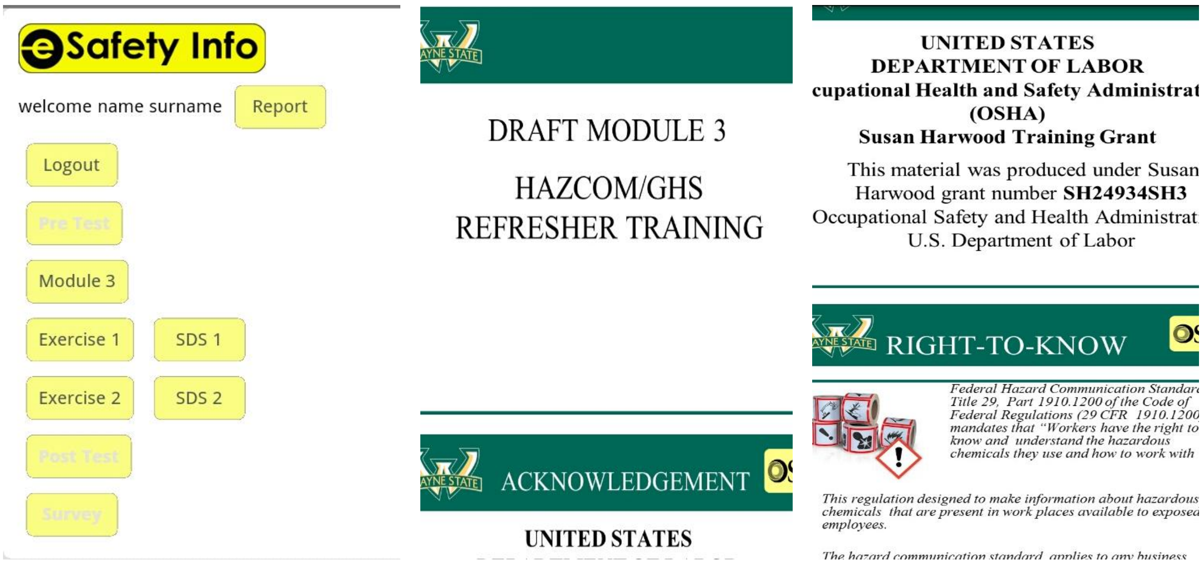
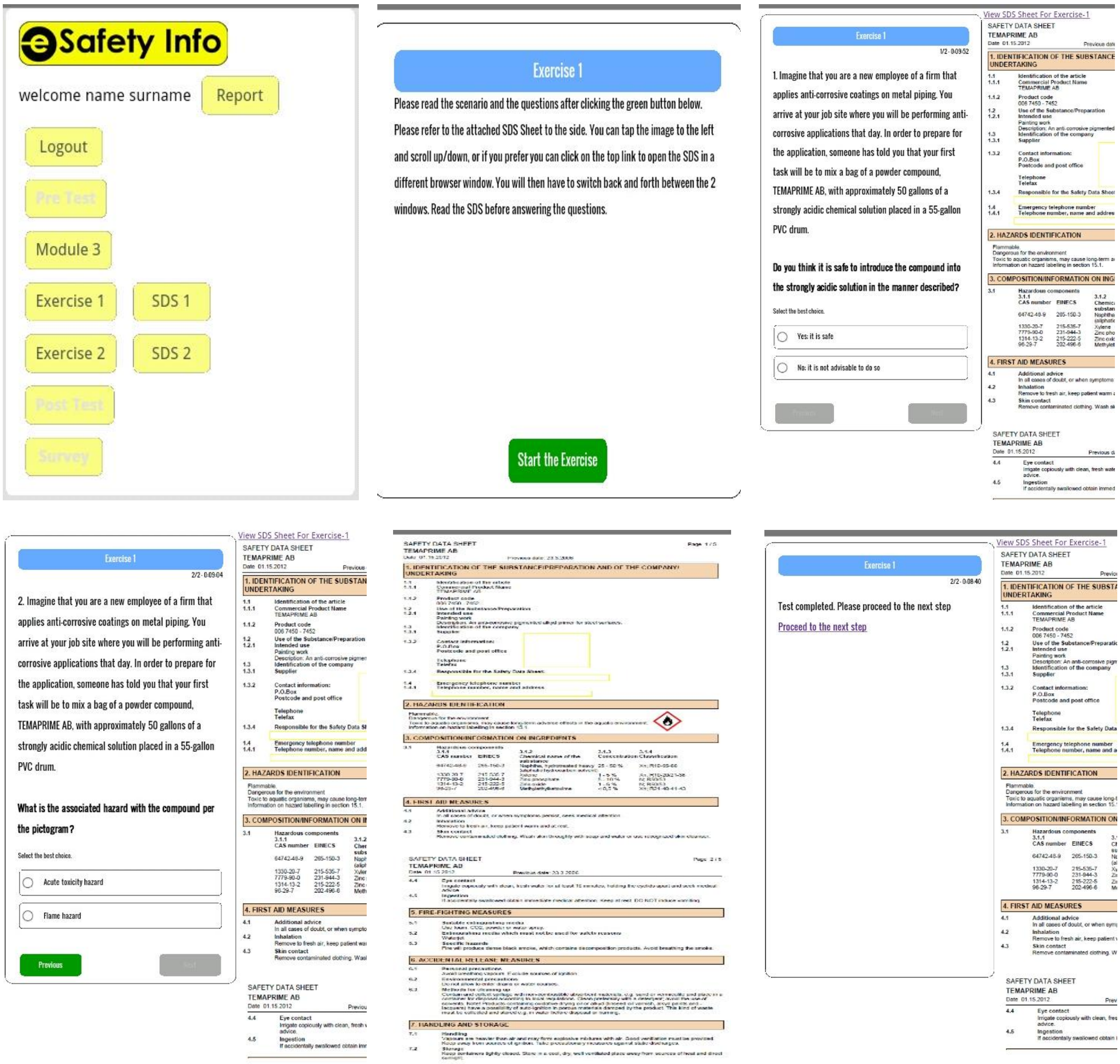


Figure 41: Training module



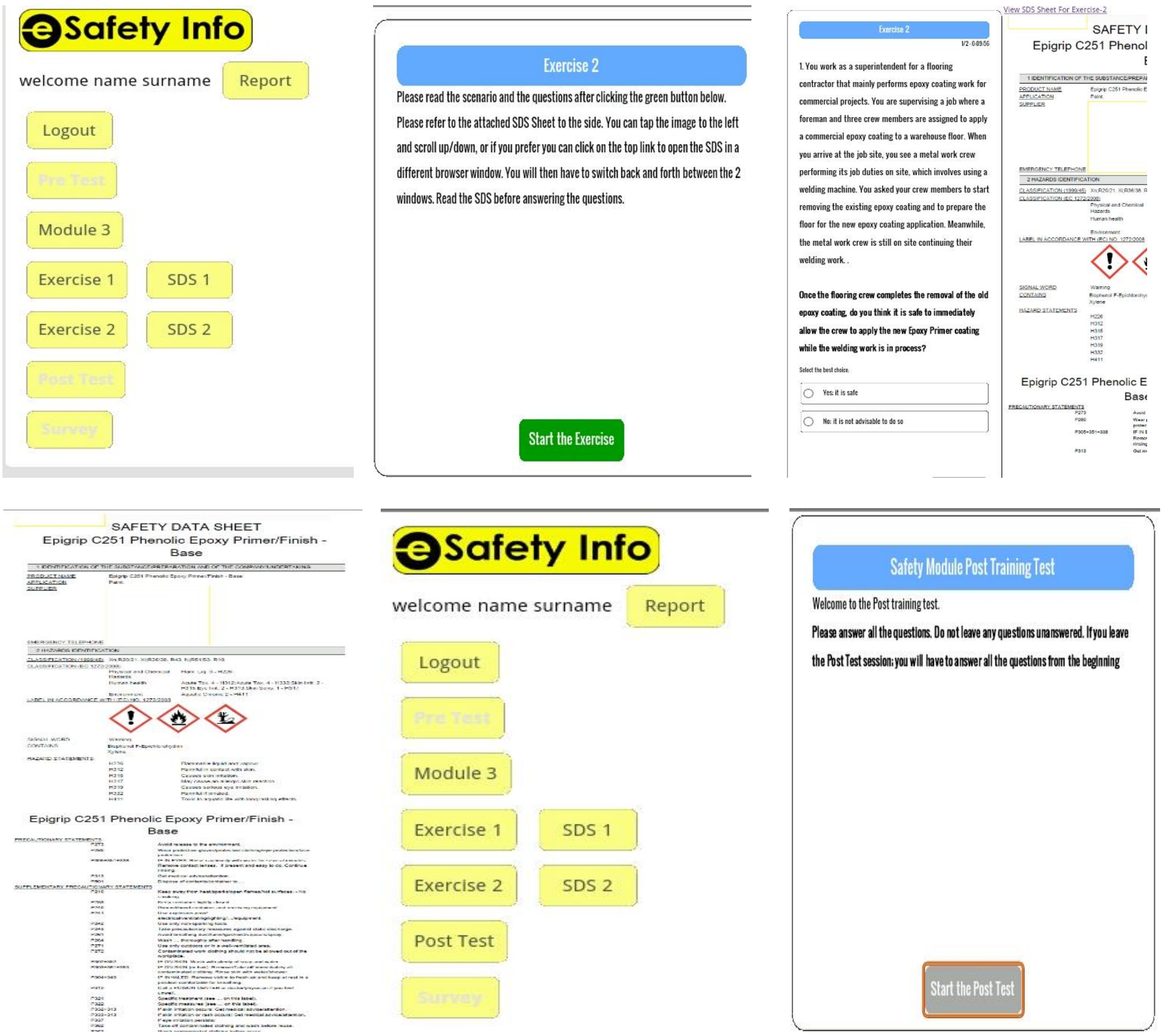


Figure 42: Exercises and Posttest

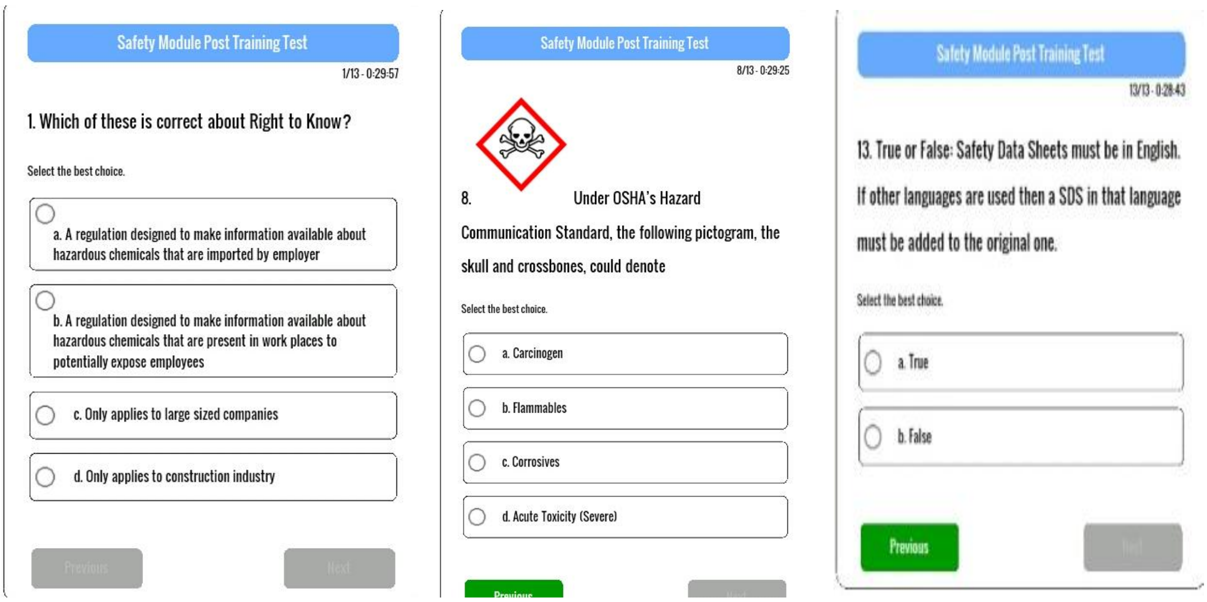


Figure 43: Posttest questions

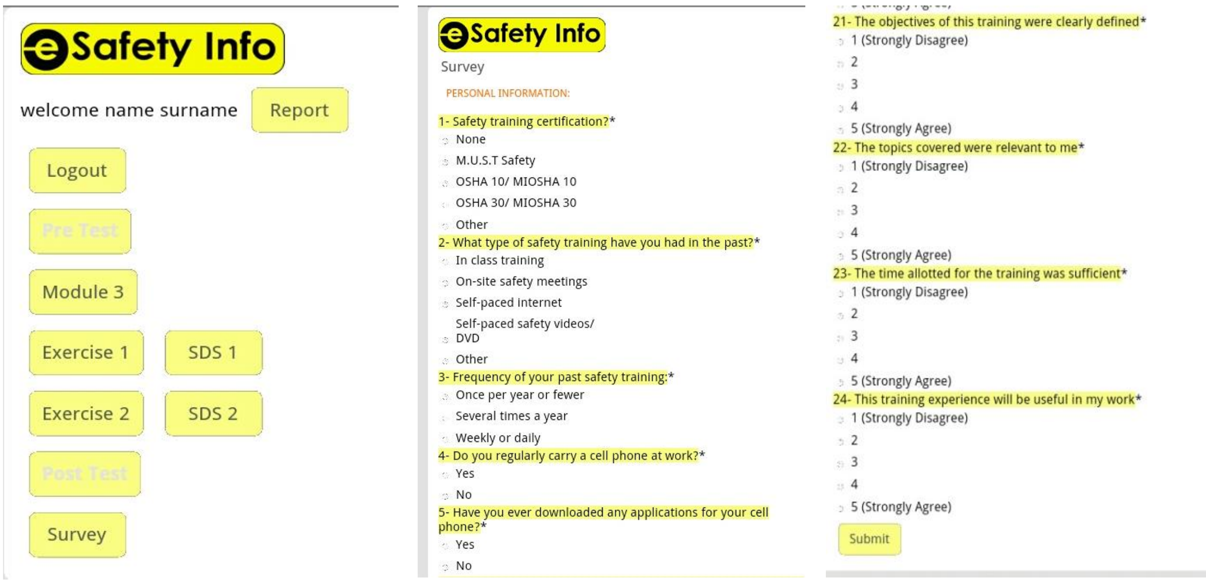


Figure 44: Survey

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ABSTRACT

EFFECT OF CONSTRUCTION WORKER DEMOGRAPHICS ON E-LEARNING WITH HAZARD COMMUNICATION STANDARD TRAINING

by

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Advisor: Mumtaz Usmen, PhD, PE

Major: Civil Engineering

Degree: Master of Science

Construction safety and health training can be delivered by different training methods, such as traditional, online and blended learning. E-learning is a newly introduced method whose effectiveness is still being investigated. This study focuses on the effect of construction worker demographics on the effectiveness of e-learning. The univariate analysis technique was used to find out the distribution and frequency of data collected by an internet based system. Further, multivariate analysis (cross tabulation) and analysis of variance (ANOVA) were performed to determine the association between the independent variables which are age, gender, ethnic background, union status, number of employees in the company, working sector, experience level, job classification, years spent in industry, being previously trained, and the duration spent in the training and the dependent variables of posttest/pretest ratio and training success. It was concluded that cross tabulation analysis and analysis of variance (ANOVA) can be used to evaluate the training effectiveness, and e-training can be effective for all workers of varying demographics if properly applied. Workers' literacy level and motivation were found to be important factors in the successful implementation of e-learning.

AUTOBIOGRAPHICAL STATEMENT

Serhan Kaya graduated from Middle East Technical University, Turkey in 2013 with a Bachelor of Science degree in civil engineering. Same year, he came to the U.S. and attended Wayne State University to pursue his graduate education. He is currently a masters student at Wayne State University Civil Engineering Department. He has been serving as a Graduate Teaching Assistant in the same department since August, 2013.