CONSTRUCTION INDUSTRY INSTITUTE®

Construction Industry Craft Training in the United States and Canada

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Research Report 231-11

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by

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A Report to
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The University of Texas at Austin

Under the Guidance of
CII Research Team 231
Construction Industry Craft Training

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EXECUTIVE SUMMARY

Enhanced craft training is where safety training was 15 years ago. There was great scope for safety improvements then, and there is great scope for improving the skills of our work force now. Improving safety resulted in large payoffs, and it continues to be the right thing to do. Evidence exists that craft training pays off just as well. In fact, RT 231 examined many aspects of construction craft training using various methodologies, and has concluded that on a single capital construction project, each dollar invested in craft training can yield $1.30 to $3.00 in benefits. The benefits accrue to the project in the form of increased productivity and reductions in turnover, absenteeism and rework, as well as in other areas. When groups of owners and employers cooperate, the benefit/cost ratios are even greater.

Our industry has predicted craft shortages since the early 1980s. Since then, the average age of craftworkers has continued to climb. And now, in 2007, real wages are rising rapidly. These higher wages will attract new entrants, but new entrants may stay only briefly. Craft training will be one major way to retain these new entrants in the construction profession and make them fully productive.

To substantiate these conclusions, this document first summarizes current efforts in the construction industry in craft training. There is increased emphasis on the merit shop side of training mainly due to this sector's growing share of craftwork. The union sector has supported craft training through mandatory dollar contributions to union training, while the funding in the merit shop sector has fallen short in many geographic regions. One area thus requiring focus is funding for craft training. Our research team found a strong argument for funding based on a positive benefit/cost ratio.

Our research also revealed that most owners and/or constructors often lack the means to measure the effectiveness of craft training. Yet we identified some metrics that are appropriate. We have also examined various types of training, how they can best be applied, what training programs are available, and what makes these programs most effective.

So, when is training a good deal? A large body of evidence shows that construction craft training can be effective in a broad range of circumstances. It is good for single capital projects, and the business case for craft training improves the longer craftworkers are engaged in training. The team has examined the business case for craft training from the perspective of the owner, the constructor, and the craftworker. Those business cases are summarized later in this document.

Some owners have begun requiring craft training and certification (passing both written and proficiency tests) for all craftworkers. Current shortages of certified workers are driving up wages, which will attract new craftworkers to enter the profession. These new workers are largely helpers and need training in construction basics (safety, hand & power tools, blueprint reading, etc.). They also will benefit greatly from mentoring and formal on-the-job (OJT) training programs. When new craftworkers recognize that efforts on their part to obtain training pays off in higher wages, they will make the sacrifices necessary to move ahead.

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CHAPTER 1: INTRODUCTION

1.1 Background and Motivation

The construction industry is built on a foundation of skilled craft workers. These skilled workers, primarily supplied through various training programs, are essential to the safety of construction sites and the reliability of bridges and roads, factories and power plants, and offices and homes. However, over the years, the North American construction industry has not invested enough to nurture and develop an adequate construction craft work force required to sustain economic growth.

The issue of craft shortages is not new to the North American construction industry. In the early 1980's, the Business Roundtable predicted that unless training was improved, a shortage of skilled craft workers would occur and hamper the growth of both open shop and union construction sectors by the late 1980s (BRT 1983). The prediction was confirmed by a study in 1996 by the Business Roundtable that found that 60% of its surveyed members were experiencing a shortage of skilled craft workers, and 75% of the respondents indicated the shortage had worsened in the five years prior to the study (BRT 1997). The shortage of craft workers unfortunately worsened in recent years. The Construction Users Roundtable (CURT) conducted a survey in 2001, and among the survey respondents, 82% reported shortages on their projects and 78% indicated that the shortage had worsened in the 3 years prior to the study (CURT 2001). In addition, the labor demands of the US construction industry are strong. The Construction Labor Research Council predicts that 185,000 new workers need to be attracted, trained, and retained each year up to 2016 in order for the industry to replace expected turnover and sustain industry growth expectations (CLRC 2005). Similar research has estimated the rate to be closer to 200,000 to 250,000 new craft workers need to be added per year (CURT 2004).

Many research efforts have attempted to identify the root causes and to develop strategies to overcome these shortages. The reasons behind the shortage are numerous, ranging from a poor image of the industry, declining real wages, and a lack of adequate training opportunities, to poor work environments and the lack of stable worker career paths, which contribute to the failure of attracting and retaining qualified workers in the construction industry (Haas 2003). Therefore, providing effective training for construction workers can relieve the pressure from shortages of skilled workers in the construction industry.

As a typical career path in construction, workers can enter the construction industry through a variety of educational and training backgrounds. Starting positions in construction, such as laborers, helpers or apprentices, are suitable for those who have just graduated high school. Some laborers and helpers can acquire the skills needed in their job quickly, however it takes craft workers years to learn the required skills in many trades. Construction workers usually learn the skills through a combination of formal classroom instruction and on-the-job training. Skilled workers, such as electricians, welders, plumbers, and other construction trade specialists, most often obtain their formal instruction by attending a local technical or trade school, or through an apprenticeship or other employer-provided training programs. As they increase their skills, they are allowed to work more independently, and responsibilities and earnings increase. Many persons enter the construction trades through apprenticeship programs. Apprenticeships administered by local employers, trade associations, and trade unions provide the most thorough training (US Department of Labor 2006). Apprenticeships usually last between three and five years and consist of on-the-job training and 144 hours or more of related classroom instruction each year (US Department of Labor 2006). However, the U.S. Bureau of Apprenticeship and Training (BAT) is working with State Apprenticeship Councils (SAC), joint employer and labor groups, individual employers, and employer associations to develop competency standards in place of time requirements, making it possible to complete a program in a shorter time. Workers enter construction from technical or vocational schools many go through apprenticeship training at a faster pace because they already have learned mathematics, mechanical drawing, and woodworking.

Based on an examination of a typical career path of a construction worker, it is clear that training plays a major role in the development of craft skills. Providing effective training for construction workers is a promising solution to solve the shortage of skilled workers in the construction industry, but for construction industry stakeholders to make an informed decision whether to invest in craft training, much information has been missing.

1.2 Research Objectives

The purpose of this research was to identify and quantify the business case for construction craft training. Significant debate exists in the industry regarding the value of craft training. Providing quantifiable data regarding the benefits and costs of training will help stakeholders to identify which concerns are legitimate and also serve as a first step toward their resolution. The potential benefits of training include improved productivity, improved safety, improved quality, decreased absenteeism, and decreased turnover. The research team was composed of individuals who together had over 375 years of experience in the construction industry and was supported by not only CII but NCCER and CURT as well. The analyses examined existing data sources as well as data collected by the team's own efforts. The research was coordinated and complimentary to other ongoing research and craft training initiatives in the industry, including previous CII research, CURT, NCCER, ABC, and The Center for Construction Industry Studies (CCIS).

The primary objective of this study was to qualify the outcomes and effectiveness of strategies for construction craft training. Four secondary objectives were established in order to achieve the primary goal.

(1) Analyze the current state of construction training

- Identify the characteristics of construction training among different demographic groups, and
- Investigate the major factors affecting craft training.

(2) Quantify the outcomes of construction training on the individual craft level and the project/company level

- Identify the impact of craft training on worker's wages, career satisfaction and attitude toward construction job, and
- Quantitatively measure the impact of training on productivity, turnover, absenteeism, safety and rework on a construction project.

(3) Develop comprehensive models to determine the benefit/cost ratio of construction craft training

- Benefit/cost ratio models were developed for a typical industrial project, which was partly based on the Construction Industry Institute (CII) Model Plant and on the survey administrated by the study team as well as on existing industry data from participating companies.
- Examine the benefits of craft training to the individual craft worker by examining the net present value of construction craft training to a young individual.

(4) Develop training implementation tools to help implement and improve a craft training program.

1.3 Research Scope

The impact of construction craft training can be evaluated on the level of individual workers engaged in a training program, the level of projects/companies employing trained workers, or the level of society. On each of level, different metrics can be applied to measure the impact of training. On an individual craft worker level, the metrics include self performance ratings, self assessment ratings, job satisfaction, qualifications and earnings. On a project / company level, the metrics include absenteeism, unexpected turnover, accident frequency, rework/off-quality products, labor productivity, material/resource utilization, cost and time savings, and the number of workers hired on a project. On a society level, the metrics include the level of structural unemployment, international competitiveness, inflation, economic growth, and work force availability. The data used by the study is mainly from the individual worker level and project/company level, so the proposed study focused on the individual worker and project/company level.

Finally, the proposed study focused on projects in the heavy industrial, light industrial, building, and infrastructure construction sectors since all projects included in the existing data sets and current survey primarily come from construction projects of industrial characteristics.

1.4 Report Organization

This report consists of eight chapters. Chapter 1 describes the research background and motivation, objectives, and scope. Previous research projcets are reviewed in Chapter 2, which covers the current state of craft training, the evaluation of training effectiveness, the shortage of skilled workers in the construction industry and known training strategies. Chapter 3 discusses the research methodology. After that, two case study findings from the union and open shop construction sectors are presented in Chapter 4. Chapter 5 shows the findings from existing data sets. The findings from analyzing the National Craft Assessment and Certification Program (NCACP) data are presented in Chapter 6. Chapter 7 analyzes the data collected from the RT 231 craft training survey. Based on craft training survey data, Chapter 8 develops the business case for craft training and investigates the economic justification of craft training programs. Chapter 9 introduces the craft training toolkits, which include the Training Investment Analysis Tool (TIA) and checklists of best training practices. Chapter 10 summarizes the research as a whole and gives recommendations for construction craft training.

CHAPTER 2: PREVIOUS STUDIES

Construction craft training has received much attention and discussion in the past years. The following chapter reviews the current state of craft training in North American, the research on evaluations of training effectiveness, the shortage of skilled workers and training strategies.

2.1 The Current State of Training in North America (U.S. and Canada)

Craft training currently exists both informally (on-the-job training) and formally (classroom) in North America. Not all on-the-job training is informal. Training on the job can be formalized through mentoring and by providing performance feedback to the trainee. RT-231 examined data from the *Survey of Employer Provided Training* (SEPT), which was conducted by the U.S. Bureau of Labor Statistics in 1995. The SEPT survey involved approximately 1,000 private nonagricultural business establishments and examined different aspects of training, including the type of training (formal or informal) provided to employees. The SEPT survey found that 76% of the training provided in the construction industry was informal. Only the retail sales industry reported a higher percentage of informal training.

Both union and open-shop construction arenas have formal training programs. In the union sector, formal apprenticeships and other training programs are established jointly by unions and employers. The national unions strive to make the content of the training programs consistent through standards adopted by national Joint Apprenticeship and Training Committees (JATCs). Union-sector training is funded through contributions to training funds based on each hour of work, as mandated through collective bargaining agreements.

One of the greatest obstacles to implementing a quality training program for any organization is lack of funding (BRT, Report D-4, 1982). Contractors fear they will lose jobs if they include the cost of training in their bid packages. Trade associations cannot establish or implement training until they have a commitment from contractors to support and pay for training. Schools fear that enrollments will not meet expectations, which directly impacts funding. Traditional funding methods include employer-paid training allocated from their general overhead accounts, tuition-based funding, cents-per-worker hour assessments, work force investment act funds, and local, state, and federal grants.

Most training programs are funded either by charging students tuition or by collecting contributions from employers on the basis of hours worked. A few programs may be funded by a combination of both. Most training programs in the unionized section of the industry are funded through cents-per-hour contributions established in a collective bargaining agreement (BRT, Report D-4, 1982).

Vendors and suppliers are often overlooked resources in developing and running a training program. Vendors and suppliers frequently have personnel who can offer specific training, and they often can provide needed tools, equipment, materials and other resources at a reduced price or even as a contribution to the training program.

In some areas, open shop formal training programs are funded through cents-per-hour voluntary contributions from owners and contractors into a local training fund, although this rarely happens as frequently as it does in the union sector. In most cases, open-shop apprentices often pay for all or a portion of their training (BRT, Report D-4, 1982).

Currently, craft training is insufficient to keep pace with the demand for qualified craft workers. This situation is aggravated by an aging work force and the high retirement rates of experienced craft workers (CII, 2003). Shortages of craft workers and the barriers to formal training are intertwined. Indeed, geographic regions in North America that are experiencing the most significant craft shortages are also experiencing significant increases in craft real wages (CII 2007). In time, higher real wages will attract more craft workers to construction, but it is uncertain whether this will balance out. It is not economically efficient for wages and training capacity to swing wildly. Spikes in wage levels due to temporary shortages distort the expectations of new craft entrants and result in excessive turnover.

Training can also be categorized as either short or long term. Short-term training is typically task oriented and only requires a very limited number of hours to complete. Short-term training is generally referred to as task specific or journeymen upgrade training. Examples of short-term training are a 30-hour blueprint class or a 24-hour motor controls class. Long-term training focuses on the comprehensive skills necessary for a trade and generally takes several years to complete. One example of long-term training is apprenticeships, which are registered with the government through the U.S. Bureau of Apprenticeship and Training (BAT). Apprenticeships cover a wide range of skills over a specified number of years and produce a full craft professional. Task training can be included as a part of a long-term training program. Apprentices and other craft trainees can take training simultaneously in the same classroom, which represents a recent development in craft training practice.

New instructional methodologies emerge as needs and demands change in the industry. Notable new training methodologies include technology-based instruction and accelerated craft training models. Technology-based instruction includes computer-based, web-based, and simulation methods. Due to the pressing needs for skilled craft workers in the construction industry, accelerated craft training models are being increasingly examined and implemented by many construction organizations.

Accelerated models are based on compressing long-term craft training instruction into dramatically shorter periods of classroom instruction. Three- and four-year training programs have been compressed into blocks of 6 to 24 months (CII, 2007). There are significant benefits to technology-based and accelerated models, as well as notable challenges. The primary benefit is faster preparation of craft workers to meet the pressing work force demands of our growing industry. The primary challenge for both technology-based and accelerated models is in meeting the hands-on skills development requirements of craft training under these models.

While technology-based and accelerated models do an excellent job of enhancing or facilitating classroom delivery, hands-on skills development is still essential to the overall training needs of a craft worker. Hands-on skills development takes time; it is difficult to simulate or accelerate, and it must not be overlooked in developing a craft professional. Historically, government regulators have been slow to adapt to changing conditions in the industry and emerging methodologies (BRT, Report D-2 1982). The following sections provide an overview of the various types of training that are in use in the industry today.

(1) Apprenticeship training

Apprenticeship training is a combination of school and work under a formal contract between the apprentice and the sponsor, often referred to as an "indenture." Some states have changed the name of the indenture to the "apprentice contract." Formal apprenticeship programs are recognized and governed by either the state apprenticeship agency or the Bureau of Apprenticeship and Training (BAT) in the U.S. Department of Labor. Apprenticeship training is long-term training, lasting three to five years depending on the craft.

One advantage of operating a formal apprenticeship program from a company perspective is that state and federal governments recognize it for purposes of the Davis-Bacon Act and other "prevailing wage" legislation. Prevailing wage and Davis-Bacon laws require that a specific skilled worker wage rate and benefits package be paid to anyone working on a project where state or federal money is involved. Only registered apprentices can be paid less than the full skilled worker rate, in accordance with the percentages outlined in apprentice wage schedule. This can offer the contractor who trains registered apprentices a significant advantage in bidding work.

Non-apprentice trainees or helpers must be paid the full skilled craft rate determined by the state or federal agency. In addition to defining the wage rates, the apprenticeship contract defines the term of the apprenticeship program, including required hours of related instruction and specific work processes to be learned in the OJT portion.

Since apprenticeship is a formal training program, recognized by either a state or federal apprenticeship agency, there are several requirements imposed, such as stringent record keeping, maintaining a specified ratio of apprentices to skilled workers and compliance with equal opportunity selection procedures specified in state and federal regulations, which some employers consider to be a disadvantage of maintaining an apprentice program. Apprenticeship training combines classroom instruction and work experiences to produce a skilled craft with broad-based knowledge. The school or classroom portion of the training is often called "related instruction." Typically, related instruction is approximately 10% of an apprenticeship program, at a minimum (CII, 2007), while on-the-job-training (OJT), or work experience, accounts for the remaining 90%.

(2) Craft Training

Many organizations operate long-term craft training programs in addition to formal apprenticeship training. Depending on the craft, training programs can run from one to five years in length, which is equivalent to an approved apprenticeship. In some states and programs, registered apprentices and craft trainees can be in the same class at the same time, although there are some state laws that prohibit mixing types of students (CII, 2007). Many organizations operate craft training programs instead of formal apprenticeship training, because they perform little or no public work affected by Davis-Bacon or other prevailing wage requirements.

Until the creation of the National Center for Construction Education and Research (NCCER), the construction industry as a whole did not recognize craft training outside of apprenticeships as being of the same quality as apprenticeship training. NCCER has developed standardized curricula, instructional materials, assessments and certifications that have become a standard in the open-shop sector. In 2004, the State of Texas Skill Standards Board and owner firms (e.g. Exxon-Mobil) formally recognized NCCER Accredited Training Programs as equivalent to approved apprenticeship programs.

(3) Task Training

Task training is typically classified as short-term training taking less than a year to complete. Short-term training, by definition, is not apprenticeship training. These programs are often known as task specific, skill upgrade training or continuing education. Many contractors use task training to prepare craft workers for specific tasks that they need performed on a job. Skill upgrade training is typically used to upgrade the skills of an experienced craft or to help them prepare for licensing or certification exams.

Many contractors will also use task training to help give experienced crafts new skills in other craft disciplines, which creates a multiskilled worker who is more productive throughout all or many phases of a project. Vendor-based and specialized technical training are typically offered as task training

With the introduction of NCCER's National Craft Assessment and Certification Program, many contractors and organizations use the assessments to help them determine "targeted" task specific training needs for their workers. Contractors and organizations then offer specific module-based task training in response to assessment results.

2.2 Research on Evaluation of Training Effectiveness

Kirkpatrick (1994) developed a four-level model to assess the effectiveness of a training program (Figure 2.1). At level-1, participants' satisfaction with the training program is measured, and a list of their plans for implementing the training is included. At level-2, measurements focus on what participants learned during training. At level-3, the measures assess how participants applied learning on the job. At level-4, the measures focus on the business results achieved by participants when the training objectives are met. The American Society for Training and Development (ASTD) found that 93% of training courses are evaluated at Level One, 52% of the courses are evaluated at Level Two, 31% of the courses are evaluated at Level Three and 28% of the courses are evaluated at Level Four (Eseryel 2002).

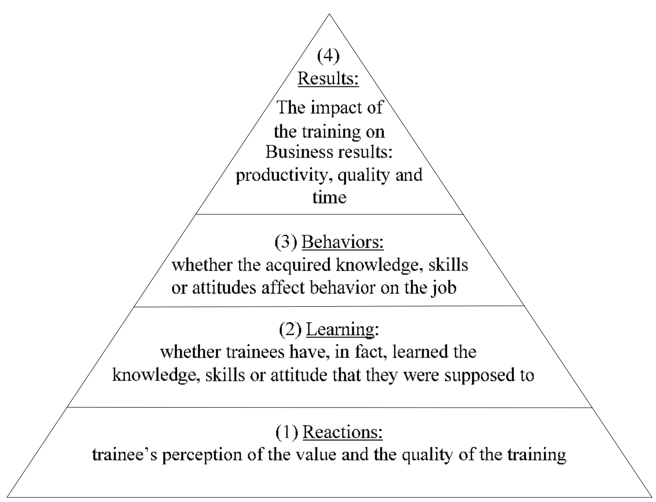


Figure 2. 1: Kirkpatrick's Four-Level Model

Philips (1996) further developed Kirkpatrick's model by building the fifth level, which is to identify the return on investment (ROI). It compares the training's monetary benefits with the cost. When using ROI to evaluate training, the analysis can be defined as:

$$\text{ROI\%} = \frac{\text{Net Training Benefits}}{\text{Total Incurred Costs}} \times 100$$

ROI is a very popular tool in the analysis of purchase decisions for investment in capital equipment or technologies, although ROI does not consider the time value of investment, unlike a rate of return economic analysis.

Based on the assumption that training costs will be compared with monetary benefits and that all training programs will also have intangible but reportable benefits, Philips (1996) proposed a framework for developing ROI when evaluating training effectiveness (Figure 2.2). It is believed that deployment of ROI analysis to investment in training can give a better understanding of human capital and cause productivity growth and technological change. Meanwhile ROI analysis requires a company to emphasize the management of documentation and measurement and feedback, which is consistent with Total Quality Management practices. The company can also monitor the process of transferring knowledge and skills from the classroom to the work place and obtaining critical information for addressing the serious problem of poor transfer of knowledge while conducting a ROI analysis.

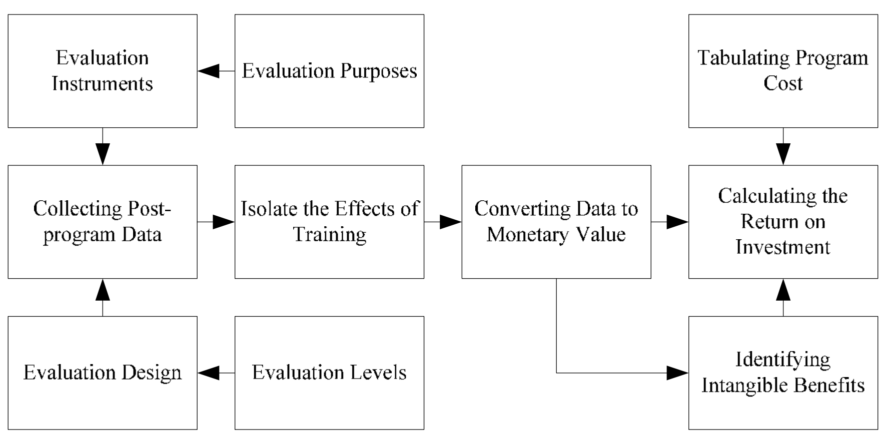


Figure 2. 2: Philips' ROI Model (Philips, 1996)

Four steps involved in calculating ROI were developed by Lilly (2001):

(1) Isolate the effects of training by using two sample groups of employees to compare the

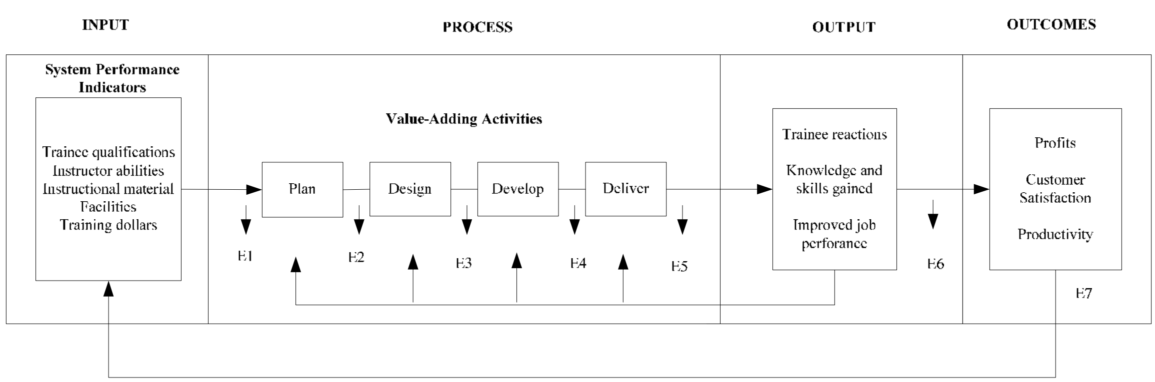
pre-training and post-training data in order to solve the problem that many companies do not maintain pre-training data.

(2) Convert training effects (benefits) into monetary values. Examples of "hard" data for determining the effects of training are productivity, quality, unexpected turnover, and absenteeism measures. Examples of "soft data" effects are improved job satisfaction, organizational commitment, and teamwork.

(3) Calculate the costs of training. The most common training costs include course development, wages of human resource staff, instructors and trainees, and cost of instructional materials.

(4) Compare the value of the effects to the incurred costs.

Other evaluation models include Bushnell's input-process-output (IPO) approach (1990), which determines whether training programs are achieving the right purpose and can detect the types of changes regarding the training content and delivery. For the IPO approach (Figure 2.3), Input Stage includes an evaluation of system performance indicators such as trainee qualification, availability of materials, and appropriateness of training. The Process Stage includes planning, design, development and delivery of a training program. At this stage, the training actually takes place and adds value to the human resources. Output elements include gathering information regarding the results from training interventions, and it examines the short-term benefits or effects of training. At the Outcomes Stage, the long term results associated with training, such as profitability and competitiveness, are collected.



E_i: the evaluation results from each stage

Figure 2. 3: Input-Process-Output Approach to Training Evaluation (Bushnell 1990)

Fitz-Enz (1994) developed a Training Validation System (TVS) which was used to evaluate training programs. The implementation of a TVS approach includes four stages. First at the *Situation Stage*, pre-training data are collected to ascertain current levels of performance within the organization and defining a desirable level of future performance. Second, the *Intervention Stage* identifies the reason for the existence of the gap between the present and desirable performance to find out if training is the solution to the problem. Next, the *Impact Stage* evaluates the difference between the pre- and post-training data. Finally, the *Value Stage* measures differences in quality, productivity, service, or sales, all of which can be expressed in terms of dollars.

Based on the literature review, the research found that while ROI analysis is a well established decision tool in the acquisition of physical capital and equipment purchase, its application remains in a relative developmental stage in the arena of human capital (Glover 1999). Only a small percentage of U.S. firms currently measure the return to their investments in training. From an academic perspective, three central problems facing current training evaluation models are obtaining accurate measures of the full costs, measuring benefits without relying on subjective estimates, and perhaps the most difficult, isolating the impact of training on changes in performance.

2.3 Research on Shortage of Skilled Workers in the Construction Industry

The construction industry has suffered a shortage of skilled labor over the last two decades as documented by a series of previous research efforts. A survey of owners in the construction industry found that 43% of respondents indicated “overcoming labor shortages” as the most difficult of the top challenges facing owners (Brandenburg 2006). Based on survey data, Brandenburg (2006) developed an average weighting to indicate the relative difficulty among a number of challenges faced by construction owners in successfully executing their projects. ”Overcoming labor shortages” was ranked as the third most difficult challenges (Table 2.1).

Table 2. 1: Top Challenges for Construction Owners (Brandenburg 2006)

	Least Difficult	Moderately Difficult	Difficult	Most Difficult	Weighted Average
	1	2	3	4	
Meeting budgets	0	14	14	71	3.58
Meeting schedules	0	35	21	43	3.08
Overcoming labor shortages*	7	21	36	43	3.07*
Finding the right construction manager/general contractors	7	21	36	36	3.01
Finding the right architects/engineers	7	64	14	14	2.35
Achieving a quality end product	7	57	21	14	2.42
Satisfying end users	7	43	43	7	2.50

The Construction Industry Institute (CII) implemented a survey among 1,200 construction workers during the research project "The Shortage of Skilled Craft Workers in the U.S." (Haas 2003). The research found that the median age of the construction work force was increasing. In 2000, the median age was 37 years. In 2002, it had increased to almost 39 years, and the data collected in the research (Haas, 2003) suggests that the average age of construction journeyman level workers is almost 41 years. This means that as these workers retire in the next 10 to 12 years, the skilled labor shortage could become an even greater problem in the North American construction industry.

It is commonly believed that the main reasons craft workers leave the industry include undesirable, relatively low pay and benefits, the generally poor image of the construction industry and its workers, unclear paths in construction, and the transient nature of construction work (Construction Users Roundtable, 2001). These reasons were confirmed by the findings of the survey launched by the CII research project RT135 "Attracting and maintaining a skilled construction work force" (CII, 2000). The research listed poor pay and benefits, the need for a permanent job, poor safety, and poor treatment and poor working conditions as top five reasons causing workers to leave the construction industry.

Besides the shortage of labor, construction companies are also facing the problem of bimodal age and the experience of employees; the employees in the construction industry are constituted primarily of highly experienced professionals and a few new recruits, with very few employees in the middle range of age and experience (Black et. al 2001). To resolve the problems of loss of expertise and the lack of sources for new hires, companies are addressing possible new sources for hiring, developing closer interaction with schools in recruiting, beginning formal mentoring programs, and conducting knowledge-transfer seminars where senior employees share their knowledge and experience with younger, less-experienced employees. When compared with the owner, the contractor firms faced a more difficult situation as a result of work force shortages, since owner firms tend to have higher rates of retention (Black et. al 2001). It is suggested that construction firms make more effort to transfer knowledge from experienced workers to younger workers, to use nonstandard workers (e.g., contract employees, temporary employees, leased workers), and to seek employees from additional or new hiring sources (e.g. minorities and women) in attempt to short-term challenges imposed by the work fore shortage. .

As a solution to the labor shortage, more and more craft worker recruitment efforts are targeting Hispanic and female workers. The Construction Industry Institute (CII) research project RT182 "the Shortage of Skilled Craft Workers in the U.S." (Haas 2003) found that workers with Hispanic origins make up 17 percent of the construction work force; 12 percent of Hispanic workers in the construction industry were born in Mexico, and 17 percent of them use Spanish as their primary language. As a result, greater effort is needed to train and retain Hispanic workers in the industry. CII RT182 (Haas 2003) also found that women comprised approximately 47 percent of employees in all industries in the U.S, however they only accounted for 9 percent of construction occupations, and 47 percent of women in construction held clerical or support positions. In the CII RT182 survey, only 2 percent of journey-level workers were women.

Previous research found that the pressure of skill workers shortage can be relieved by developing an understanding of the specific manpower supply information, identifying sources of desired information, and analyzing the gaps between information that users and contractors need and what is available. It is believed that the Labor Department's Construction Labor Demand System (CLDS), a management information system designed to provide forecasts of the volume, type and regional location of construction activity as well as the associated on-site labor requirements by crafts, had the potential to be useful to the construction industry (the Business Roundtable Report D-5 1982), but the system never transpired. On the other hand, the Canadian Construction Sector Council (CSC) has developed the labor market information (LMI) program, which provides annual demand and labor forecasts by trade for each Canadian Province. The CSC is a Canadian national organization that is primarily funded by the Canadian federal government with additional funding from industry. CSC collects both new and existing information from a combination of different industry stakeholders including: industry and government representatives, governmental statistical sources, labor/management/owner associations from different provinces, national owners committees, and large project partnerships between construction firms and different organizations in each Canadian province and territory. The Construction Labor Research Council (CLRC) in the US, with the support and cooperation the Construction Users Roundtable, has created similar labor market forecasts with the overall focus primarily on the demand side and labor availability information pertaining to the union sector. Most recently, the CLRC developed an industry construction demand forecast for the Southeastern US, but it is not clear whether future forecasts will be developed for the region or expanded to other industry and geographic regions of the US.

Other possible solutions to the craft worker shortage identified by previous research (CII RT135 2000; Pappas 2004) include:

- Conduct a needs assessment to train workers on continuous basis;
- Conduct supervisory human relations training;
- Tie documented wage progress to skill;
- Provide training incentives;
- Give long-term preferential treatment to tenured employee;
- Improve the image of the construction industry;
- Increase pay; and
- Reduce demand for labor through the use of automation and technology.

Among all possible solutions, appropriate craft training is quite a promising solution to solving the labor shortage in the construction industry.

2.4 Research on Training and Management Strategies for Construction Workers

Several studies have been performed to exam current craft training approaches and to improve their effectiveness. It is believed that training construction laborers through traditional vocational education systems is ineffective in providing both enough workers to the construction industry and the requisite skills needed by an individual worker (the Business Roundtable Report D-3 1982). The major problems that impede increasing the use of construction training via vocational education include lack of continuing communication between the construction industry and the vocational education program, building trades unions and some large trade associations preference for the traditional craft apprentice programs, and a dwindling attitude towards vocational training throughout North America. In construction, the open shop sector now represents a majority of the craft labor market. However, previous research believed that training in the open shop sector is less sufficient than the union sector (the Business Roundtable Report D-

4 1982). The open shop sector does not have a funding method for training, unlike the union sector, which typically funds training through negotiated cents-per-hour charges paid by all contractors, which serve to finance joint labor-management administered union apprenticeship programs. The cost of training is finally charged to the ultimate owner as part of the cost of the facility being built.

Traditionally most construction workers only needed initial proficiency in a few skills in one trade, which is not sufficiently flexible and economical to accommodate the highly volatile manpower demands and training needs of today's local construction markets. Previous studies developed multiskilling strategies, which aim to train workers to possess a range of skills appropriate for more than one work process which can be used flexibly on a project or within an organization. Multiskilling has the potential to improve project performance, to better utilize the current pool of skilled workers, and to provide a solution of the problems with poor labor productivity, craft training, and the declining number of trade entrants into construction (Haas et. al. 1999). Four alternative multiskilling strategies were developed by CII research RT137 (Table 2.2).

Table 2. 2: Multiskilling Strategies

Dual-skills:	Crafts are combined with complementary work loads so that workers arrive on the project and remain longer by working on multiple tasks before demobilizing.
Four multiskilled craft strategy:	Crafts are grouped into civil/structural workers, general support workers, mechanical workers, and electrical workers.
"Four Crafts-A" strategy:	All three skill levels (helper, craftsman, and foreman) of each craft are included in the new multiskilled grouping.
"Four Crafts-B" strategy:	The helper-level workers are removed from the originating craft group and are added to the "general support" multiskilled craft grouping.
Theoretical Maximum:	This strategy assumes that there is only one craft classification for the construction industry, "construction worker."

(Source: CII RT137)

Based on project cost and labor usage analysis, the research identified that the "Four Crafts-B" strategy was the most effective approach among the four alternative multiskilling strategies, which was estimated to save approximately 5% of a project's total labor cost and reduce the required project work force by 35%, when assuming no productivity variation (CII RT137 1998).

Since this study, Haas found that five multi-skilling models exist in practice, including:

1. Crew composed of multiple craft workers – usually used in maintenance and small capital projects

2. Work force composed of 10%-30% of dual-craft workers and a higher percent of workers with one craft journeyman level certification and lower level skills in other crafts – usually used in small to medium capital projects

3. Work force incidentally composed of ambient percent of workers with one craft journeyman level certification and lower level skills in other crafts – used on large capital projects with ready labor markets and/or where constructor is not deliberately implementing multi-skilling

4. Work force composed of meta-crafts (e.g. NCF)

5. Work force composed of single-craft workers – usually where labor unions predominate; however many union workers are multi-skilled within their craft

Previous research found that currently the construction industry is not utilizing any formal, structured work force management strategies, nor does it have a way to measure the success of its current management practices (CII RT182 2003). In order to establish better management strategies for the current work force in the construction industry and relieve the demand of recruiting more workers, Tier I and Tier II strategies were developed by the Center for Construction Industry Studies (CCIS). Tier I strategy seeks to develop a strong field supervision team to effectively manage the existing field work force. The Tier II strategy seeks to improve workers' skills and productivity within the journey-level work force. The implementation of these strategies is intended to reduce the demand for skilled labor by improving overall on-site productivity and help retain the current work force.

In order to successfully implement the Tier I strategy, the front-line supervisors (foremen, general foremen, and superintendents) must be willing to participate. One primary element of the strategy is training, especially training in the use of technology, administrative skills, planning skills, and management skills. The research found that the field supervisors have a strong desire to receive training (see Table 2.3).

Table 2. 3: Field Supervisors' Receptiveness to Training

	Percent of field supervisors responding positively
Will to adapt to new technology	79.7
Willing to training in administration skills	81.6
Willing to train in computer skills	81.1
Willing to train in planning skills	86.8
Willing to train in management skills	84.9

(Source: CII RT182)

A successful implementation of the Tier II strategy requires a high percentage of journeyman level craft workers and high percentage of multiskilled workers. To satisfy this requirement, effective craft training has to be implemented to ensure that there are enough journeyman level craft workers and multiskilled workers.

CHAPTER 3: RESEARCH METHODOLOGY

RT-231 research examined the hypothesis that construction craft training programs can bring benefits to individual workers and construction projects/companies, that the benefits of construction craft training can be quantitatively measured, and that the expected benefits are higher than the expected implementation cost. The research examined this hypothesis by using quantitative methods to measure the benefits of craft training programs on the individual craft worker level and the project/company level.

The research began by analyzing the characteristics of construction craft training and the major issues affecting training and by evaluating the current construction training program and skill assessment programs throughout North America. Next, the research used quantitative methods to measure the construction training benefits on the individual and the project/company level. Comprehensive evaluation models were developed to measure the benefit/cost ratio of construction craft training using the Construction Industry Institute (CII) Model Plant Project.

3.1 Case Studies

The first phase of the research project involved a series of expert interviews associated with the training of construction craft workers, which were conducted with individuals throughout the North American construction industry. This targeted population of experts included training directors, in both the union and open shop sectors, involved in training programs within a particular company, association, or building trade union. The research also sought interviews with human resource managers, estimators, or other individuals who identified the need and amount of training for a given project through either a labor analyses or a similar process. The intent of the interviews was to identify:

1. Existing training efforts;
2. The cost of training based on a given unit of desired outcome (e.g. a single task or a full craft);
3. Insights into the underlying causes for the success and failures of craft training;
4. Existing metrics regarding how organizations measure the effectiveness of their training efforts;
5. The criteria that organizations use to determine how much they invest in training and the expected outcomes as a result; and
6. Innovations and best practices in the training of craft workers.

With this information, the research team authored a survey questionnaire that was administered on a national population. The purpose of the questionnaire was to validate the findings of the interviews and help develop industry and corporate strategies necessary for the North American construction industry to train construction craft workers to meet future work force demands.

3.2 Analysis of Existing Data

The research also analyzed data from the following existing data sources:

- The National Longitudinal Survey of Youth (NLSY79)
- The Shortage of Skilled Craft Workers in the U.S. (Haas 2003, CII),
- Work Force View of Construction Productivity (Goodrum 2004, CII),
- Craft worker's Experiences with and Attitudes towards multiskilling (Haas 1999, The Center for Construction Industry Studies (CCIS) research), and
- The National Craft Assessment and Certification Program (NCACP) Data.

Several data sets were used by the research to complete the analysis. They were either obtained through previous research projects or were administrated during this research. A brief introduction of each of these data sets is given as follows.

3.2.1 National Longitudinal Survey of Youth (NLSY79)

National Longitudinal Survey of Youth (NLSY79) is a dataset of 12,686 young men and women who were between the ages of 14 and 22 in 1979 and who have been interviewed annually since that year, and the response rate has been 90 percent or greater in each year. "Training" is one of the sections in the survey questionnaire, which collects the information about formal and informal training received by individuals. In general, the "Training" section of each NLSY79 questionnaire:

- Collects information on each respondent's participation since the date of the last interview in a training program; and
- Confirms and updates information on training programs in which he/she was enrolled on the date of last interview.

A key feature of the NLSY is that it collected information in an event history format, in which dates were collected for the beginning and ending of important life events. In particular, the start and end date of all jobs were recorded, as well as the timing of the training program. Based on the timing of these events, it was possible to create measures of training received on a current job along with measures of training received prior to the current job. Meanwhile, the NLSY collected the information regarding individual demographic characteristics, employment history and income, which allowed the research to compare the training characteristics between groups having different demographic backgrounds and to evaluate the returns of training.

The research used the NLSY datasets collected after the 1988 survey, because before 1988 survey, the training recorded in the NLSY had to be longer than one month. This training duration restriction may eliminate short time training received by individuals and may exclude a large portion of training events. However, from 1988, the training questions in the survey were changed so that respondents were asked about all types of training since the last interview, regardless of duration.

3.2.2 CII Research Project RT182 – Addressing the Shortage of Skilled Craft Workers

The data was gathered from CII member projects and included 19 projects in 9 states. The data includes projects from most of the major industry sectors within industrial construction, such as chemical processes, food processing, manufacturing, petrochemical, pharmaceutical, and power generation and transmission. The database is considered to be representative of the projects in the industrial sector of the construction industry. Over 900 journeyman level craft workers were interviewed and surveyed. Researchers collected the total hours of training during the past three years prior to the survey and information such as the hourly wages and career satisfaction, all of which can be used to measure the benefits of training. The demographic information of each respondent, such as gender, age and race, was used to identify the training experience among different demographic groups. Furthermore, RT182 data identified the journeyman level craft skills each responding individual possessed at the time of the survey, which was used in a skill affinity analysis.

3.2.3 CII Research Project RT215 – The Work Force View of Construction Productivity

The research aimed to identify the factors affecting construction productivity from the craft worker's perspective. As part of the research, a survey was administrated to collect data measuring the perception of craft workers and their immediate supervisors on the frequency of occurrence of several productivity factors and the severity of their impact on productivity. The data were gathered from CII member projects and included 28 projects, and over 1900 craft workers participated. The survey asked the training history of each individual and worker's perspective of the training availability, project productivity and project management, which was used by RT-231 to measure the effect of training from the perspective of workers. Meanwhile the demographic information of each respondent, such as gender, age and race, was collected, which was used by RT-231 to compare the characteristics of construction training between groups having different demographic backgrounds.

3.2.4 Craft Workers' Experiences with and Attitudes towards Multiskilling (CCIS)

The research was sponsored by the Alfred P. Sloan Foundation's Center for Construction Industry Studies (CCIS) at the University of Texas at Austin. The research aimed to determine construction craft worker's attitudes towards and experiences with the labor utilization strategy known as multiskilling. Over 1,100 craft workers across the United States were surveyed as part of the research effort. The workers were asked about their current attitudes on job satisfaction, work hours, relationship with supervisors and co-workers, and wages. Next, the workers were asked what their attitudes would be if they received training and obtained additional skills. Finally, the data set also included the construction skills each worker possessed. The information was used by RT-231 in the skill affinity analysis.

3.2.5 The National Craft Assessment and Certification Program (NCACP) Data

The National Craft Assessment and Certification Program (NCACP) was developed by the National Center for Construction Education and Research (NCCER) to assess the competence levels of experienced workers who have no formal documentation of their training. NCACP evaluates journey-level knowledge and skills of experienced craftsmen. The core competencies for all assessments are NCCER's Contren® Learning Series standardized curricula. The assessments may be used for both pre- and post-employment testing. The worker who achieves a score above a cut-off point is classified as passing their respective written certification, otherwise training is recommended.

NCCER collected information on approximately 130,000 workers who took the NCACP Assessment between 2000and 2006. Besides the worker's test results (score, pass/training needed) and the assessment location, the NCCER also recorded information regarding the craft workers' gender, race, training curriculum, training provider (contractor, local union, association, and school), and years of experience

RT-231 used the data set to identify the geographic distribution of the workers taking the NCACP assessment, and to compare the NCACP performance of workers gender, race, and training background (curriculum and training provider used). Meanwhile, the study identified the effect of different training curriculums and training providers on the workers' passing rate of the NCACP.

3.3 Survey Effort

The study designed and administrated a nationwide craft training survey, which was aimed at obtaining information regarding the major issues of construction craft training, such as the effectiveness of the existing construction craft training programs, the core training subjects, the percentage of formal classroom training and on-the-job training in difference trades, the major barriers to advancing formal training in construction, and the training completion rates in different trades. The survey targeted the training directors and construction. The survey was sent to 150 members of Associated Builders and Contractors (ABC) and Construction Industry Institute (CII) member companies, and 93 completed surveys were returned.

3.4 Statistical Analysis

Descriptive analysis was used to recognize the major issues of construction craft training. Chi-Square analysis distinguished the potential difference of the major training characteristics among different demographic groups. Multiple regression models identified the impact of construction training on the worker's wage and career satisfaction. Based on the quantitative impact of craft training on project productivity, turnover, absenteeism, rework and safety, the study developed a benefit cost model to estimate the benefit/cost ratio of construction craft training.

3.4.1 Analysis of Variance (ANOVA)

The Analysis of Variance (ANOVA) was chosen to test the difference between the means of the two or more groups of respondents. Usually an independent sample *t*-test[1] can also be used to

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[1] Independent sample t test examines the mean of a single variable for subjects in one group differs from that in another. It is calculated by the formula:

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

Where:

$\bar{x}_i$ =mean of group i;

n_i =number of observations in group i;

examine whether the variation between two groups is "significant". However, when the number of groups grows, the number of needed pair comparisons grows quickly. Therefore, the *t*-test is not the efficient answer when the groups are large. In contrast, ANOVA puts all the data into one analysis and provides one number (*F*[2]) and one *p value* for the null hypothesis.

For both *t*-test and ANOVA, one assumption is the data following normal distribution. However, when the sample size is large, this assumption is not too strict (Rosner, 2005).

3.4.2 Pearson Correlation

Pearson correlation coefficient (r) is a measure of the correlation of the two variables, X and Y, measured on the same object, that is, a measure of the tendency of the variables to increase or decrease together. It is defined as the sum of the products of the standard scores of the two measures divided by the degrees of freedom:

$$r = \frac{\sum z_x z_y}{n-1} \qquad (3.1)$$

Note that this formula assumes the Z scores are calculated using standard deviations which are calculated using n-1 in the denominator.

The result obtained is equivalent to dividing the covariance between the two variables by the product of their standard deviations.

The coefficient ranges from −1 to 1. A value of 1 shows that a linear equation describes the relationship perfectly and positively, with all data points lying on the same line and with Y increasing with X. A score of −1 shows that all data points lie on a single line but that Y increases

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$\bar{s}_i$ =sample variance in group *i*;

2 The F statistic is constructed for testing the hypothesis, $H_0: \mu_1 = \mu_2 = \cdots = \mu_k$

where μ_j is the mean of group *j*.

the F statistic is computed by the formula:

$$F = \frac{variantion\ among\ the\ sample\ means}{variation\ within\ the\ samples} = \frac{MS_B}{MS_W}$$

where $MS_B = \frac{SS_B}{df_B} = \frac{\sum_j n_j \left(\bar{y}_j - \bar{y}_{..}\right)^2}{(k-1)}$ and $MS_W = \frac{SS_W}{df_W} = \frac{\sum_{ij}\left(y_{ij} - \bar{y}_j\right)^2}{\sum_j \left(n_j - 1\right)}$

as X decreases. A value of 0 shows that a linear model is inappropriate – that there is no linear relationship between the variables.

The Pearson coefficient is a statistic which estimates the correlation of the two given random variables. Pearson correlation assumes that the data in the pairs are sampled from normal distribution populations

3.4.3 Multivariate Regression Analysis

The regression model example is given by:

$$Y = b_0 + b_1 \times x_1 + b_2 \times x_2 + \cdots + b_n \times x_n \qquad (3.2)$$

Where b_i, the regression coefficient for the corresponding independent variable x_i, may be conceived as the "potential influence" of x_i on dependent variable, Y. However, it is difficult to rank the independent variables directly based on the magnitude of the regression coefficients (b_i), since the independent variables (x_i) have different standard deviation, and are often in different units (Rosner 2000).

The standardized regression coefficient represents the average increase in dependent variables (expressed in standard deviation units of dependent variable) per standard deviation increase in the independent variable while controlling all other variables in the model. Therefore, the independent variable with a greater standardized regression coefficient is considered to have a stronger influence on the dependent variable. The standardized regression coefficient can be computed as the following formula:

$$b_i^s = \frac{b_i \times s_{x_i}}{s_y} \qquad (3.3)$$

where b_i^s is the standardized regression coefficient for the i^{th} variable. s_x is the corresponding standard deviation of the independent variable, and s_y is the standard deviation of the dependent variable.

R^2, the coefficient of determination, measure how much variation of the dependent variable is explained by the independent variables. Usually R^2 is considered as an indicator of how well a statistical model fits a set of observations. However, it should be noted that R^2 always increases when a new independent variable is added to the model. As a complement, the adjusted R^2 takes into account the number of independent variables and the number of observation included in a regression as formula 3.10.

$$\text{adjusted R}^2 = R^2 - \frac{k-1}{n \times k} \times (1 - R^2) \qquad (3.4)$$

where n=number of observations, and k=number of independent variables.

The adjusted R^2 is a good benchmark for comparison when adding variables into the model in an attempt to improve the current model (Lattin et al 2003).

3.4.4 Logistic Regression

Logistic regression is a regression model for binomially distributed dependent variables. It is a generalized linear model that uses the logit as its link function. Logistic regression analyzes binomially distributes data of the form $Y_i \sim B(p_i, n_i)$, for i = 1, ... , m, where the numbers of Bernoulli trials n_i are known and the probabilities of success p_i are unknown. The logits of the unknown binomial probabilities (i.e., the logarithms of the odds) are modeled as a linear function of the Xi.

$$\log it(p_i) = \log(\frac{p_i}{1-p_i}) = \beta_1 x_{1,i} + ... + \beta_k x_{k,i} \qquad (3.5)$$

Note that a particular element of X_i can be set to 1 for all i to yield an intercept in the model. The unknown parameters β_j are usually estimated by maximum likelihood.

The interpretation of the β_j parameter estimates the additive effect on the log odds ratio for a unit change in the j^{th} explanatory variable. In the case of a dichotomous explanatory variable, for instance gender, e^{β} is the estimate of the odds ratio of having the outcome for, say, males compared with females.

The model has an equivalent formulation as

$$p_i = \frac{1}{1 + e^{-(\beta_1 x_{1,i} + ... + \beta_k x_{k,i})}} \qquad (3.6)$$

Extensions of the model exist to cope with multi-category dependent variables and ordinal dependent variables, such as polytomous regression.

CHAPTER 4: CASE STUDIES

The following thirteen case studies were carried out in both the union and open shop construction sector:

- **Non-Union Sector**
  - BE&K - Birmingham, AL
  - TIC - Steamboat Springs, CO
  - Fluor Constructors - Sugarland, TX
  - Houston Business Roundtable - Houston, TX
  - Lee College - Baytown, TX
- **Union Sector**
  - Carpenters Training Center (Las Vegas) - Las Vegas, NV
  - Pipefitters Free Port Local - Free Port, TX
  - Sheetmetal International Training Institute - Alexandria, VA
  - Hapring Contractors - Louisville, KY
  - Sheetmetal Louisville Local, - Louisville, KY
  - Carpenters 27 Toronto Local - Toronto, Ontario, Canada
  - Boilermakers 128 Toronto Local - Toronto, Ontario, Canada
  - IBEW 353 Toronto Local, - Toronto, Ontario, Canada

As representative examples of the above case studies, the following section provides details of the case studies relating to the Carpenters Training Center and the Sheetmetal International Training Institute in the Union Sector and the Houston Business Roundtable efforts in the open shop sector.

4.1 Craft Training in the Union Sector

The union sector of the construction industry traditionally has conducted the bulk of training of skilled craft workers through apprenticeships registered with the U.S. Department of Labor or state apprenticeship agencies. All building trades programs in the union sector are sponsored jointly by unions and employers. In 1982, the Business Roundtable Construction Industry Cost Effectiveness Project reported that the union sector provided 90 percent and the open-shop sector provided 10 percent of the expenditures on formal training, even though an estimated 60 percent of the construction market was open shop and 40 percent union (BRT, 1982). More recent research covering the period 1996 through 2003 found that jointly sponsored programs contained nearly three-quarters of all registered apprenticeships in the building trades despite the fact that the union sector represented no more than an estimated 20 percent of the construction market (Glover and Bilginsoy, 2005).

The union sector has developed training institutions to cope with the problems raised by construction labor markets where attachment between workers and individual employers is casual, jobs and job sites are ever changing, and employment is subject to cyclical and seasonal fluctuations. In this environment, individual employers tend to under-invest in training because they fear losing their investment as workers who move to other employers. Multi-employer sponsorship and training trust funds negotiated through collective bargaining help alleviate this problem by offering a means to share the benefits and costs of training among all stakeholders in the industry—workers, contractors, and unions. Whether or not contractors train apprentices themselves, all firms pay the same negotiated rate per hour worked into a dedicated training fund. The rate varies widely by trade and area. Collective bargaining contracts provide the union sector a means to mandate funding for training, which offers advantages over open shop employers who must rely on voluntary contributions.

Overall, jointly sponsored programs have higher enrollments, greater participation by minorities and women, and enjoy significantly higher rates of apprenticeship completion than registered apprenticeships sponsored by employers alone (Glover and Bilginsoy, 2005). Yet even among jointly sponsored programs, more than half of apprenticeships are cancelled and a large portion of these were cancelled early in the apprenticeship before significant skill acquisition could occur. Participation of women remains low, which effectively limits the available pool of applicants to the industry. Overall, the average age of a starting apprentice is 27 years, which raises the question “How might the industry reach young adults earlier to bring them to full levels of productivity?”

Apprenticeships in the union sector face significant special challenges as well. For example, it is often difficult for local union officials–who must stand for elections regularly– to agree to start sufficient numbers of apprentices in a declining market with journeymen union members unemployed. Also, many union members reach journeymen status without completing an apprenticeship. Some unionized employers question whether the apprenticeship system is efficient and what return they are getting for their mandated investment. Yet we found no examples of benefit-cost studies of training conducted in the union sector. Also lacking was quantitative studies of the impact of apprenticeships on safety and on productivity.

There is certainly much to be learned from the union sector’s experience with training. For example, one important innovation has been the development of national training funds. In some trades, a portion of the rate per hour paid for training goes into a national training fund, administered by a national joint apprenticeship and training committee. The general mission of these national training funds is to improve the quality and uniformity of training. The national funds commission studies of future technology and upcoming tends and developments affecting the craft, develop curriculum materials and conduct instructor training, make arrangements for college credit, monitor the quality of local programs, and provide special training assistance or equipment where it is needed. Several specific examples of national activities are described below, drawing especially from experience in carpentry and sheet metal work; these profiles illustrate how national organizations promote and improve training in the union sector.

4.1.1 Carpenters

(a) The Historical Evolution of National Activities in Carpentry Training

Traditionally, carpenter training was left to the best that the local programs could accomplish; national activities were quite limited.

In the late 1960s, the United Brotherhood of Carpenters (UBC) began participating in the Job Corps, a federally funded residential training program for disadvantaged youth, funded by the federal government and administered by the U.S. Department of Labor. The Job Corps contract helped to provide a locus for national training endeavors. In the 1970s, Carpenters began producing national training materials, using grants from the United Brotherhood of Carpenters and Joiners and proceeds from sales of materials. They produced an innovative curriculum entitled Performance Evaluated Training Systems (PETS). The carpenters' PETS program was among the first to be overtly organized on a modular basis. Altogether more than 70 modules were produced. Several other unionized trades had resisted adoption of a modular curriculum because they viewed it as an encouragement to task training and a threat to full craft training. The PETS curriculum was structured so that all apprentices began their training studying the same core group of basic modules, such as safety. Once apprentices successfully completed the core materials, they could undertake training on the remaining modules in any order. PETS emphasized a learning-by-doing approach. Instructional materials consisted largely of carousels featuring a series of photo slides illustrating how various carpentry tasks and projects were accomplished. After watching the slides, the apprentice undertook to build a project, using what they learned. PETS largely changed the role of the instructor from the "sage on the stage" to "guide at the side." Instead of lecturing all the time, the teacher became a resource, offering advice and tutoring to individual apprentices and evaluating the final products of apprentice work.

PETS helped to resolve some persistent challenges in apprenticeship. One common problem is coordinating what is learned in apprentice classes with the activities on the job. Achieving such coordination for each apprentice in a group instructional format is difficult or impossible because the apprentices in a class are employed doing different types of work. PETS individualized instruction so that apprentices could choose modules that related to their job at the time. Thus, an apprentice working on column building could simultaneously study the module on column building. PETS offered flexibility to enable local programs to tailor their training to the type of work being conducted in their jurisdictions. The carpentry craft includes a wide array of skills and tasks, ranging from framing and form building through interior systems, cabinet making and other finished carpentry work. In addition, the carpenters represent workers involved in specialty areas such as millwright work and pile driving. With PETS, packages of learning modules could be developed in all of these skill areas across the full spectrum of the craft. Local programs could then designate which modules were required for work in their area and which modules were elective. Journeyman status was defined as successfully mastering a specific number of modules. The modular organization of PETS also facilitated upgrade training for journeymen; journeymen carpenters could access learning modules to update their knowledge or broaden their skills.

Not all local carpentry programs adopted the PETS program. The Carpenters did not mandate standardization of training and instructional materials, allowing their local programs flexibility. Rather, they attempted to encourage high quality training by producing an excellent curriculum and instructor development and allowing the market to drive the training. This remains their policy today. The PETS curriculum was based on some good concepts; but PETS materials did not go far enough. PETS lacked depth and the curriculum was short on audio and written materials. Further, PETS materials were not updated and became stagnant.

In the late 1980s, the Carpenters began to see a need for a nationally funded mechanism to improve carpenter training through continuous curriculum development and better training of instructors. Thus they established the Carpenters International Training Fund (CITF) in 1989. The CITF is administered by a national joint labor/management Board of Trustees. By 2006, 98 percent of the locals (comprising about 99 percent of the membership) had agreed to contribute to the Carpenters International Training Fund. CITF is financed through a 4-cents-per-hour contribution to the Carpenters International Training Fund. The total contribution levels to local training funds ranged from 15 cents to 60 cents per hour or more.

(b) The Carpenters International Training Center in Las Vegas

In summer 1991, the first international carpenters instructor training session was conducted in St. Louis, Missouri, using the training facilities of the carpenters' local apprenticeship program. The size of the national instructor training grew fast, so that a decade later, it had outgrowth the capacity of any local program and needed its own dedicated facility.

The Carpenters International Training Center (CITC) opened in Las Vegas, Nevada on January 1, 2001 as an international residential training center for Brotherhood instructors from the United States and Canada. The facility accommodated 127 trainees in single rooms with a cafeteria, a gym and a swimming pool, along with classrooms, shop and computer facilities. All rooms are wired for computers. By 2006, construction was already underway to increase the capacity of the facility, enlarging the cafeteria, building a divisible room capable of seating 650 for a sit-down dinner (or be divided into 10 breakout rooms), and a residential building with an additional 100 dorm rooms. The $30 million facility is owned by the United Brotherhood of Carpenters and Joiners of America and leased to the Carpenters International Training Fund.

The CITC facility was designed and equipped with input of the best practice ideas from carpenters training programs all across North America. For example, shop spaces were built adjoining classroom space. Chairs in classrooms were placed off of center with space for a table running the full length of the sidewall used for handouts, demonstration materials, etc.

The Carpenters International Training Fund finances training activities in several ways. It pays for the round-trip transportation (airfare) costs for instructors to attend training at the Center, for lodging and meals, for any training materials, and for tuition for all classes. Local carpentry programs pay the wages of their instructors in training; but the CITF pays the wages of subject matter experts and consultant facilitators engaged in developing curriculum for the CITF. "Master instructors" are brought in from the field to teach one or two courses in their area of specialization. CITF has a vast array of talent to draw upon in the field.

The Center is used for "train the trainer" instructor training activities, for curriculum development, and for advanced millwright training (which involves very expensive equipment). In addition, Center staff provide assistance to local programs. The staff of the Carpenters International Training Fund includes five Technical Coordinators along with related support staff. The technical coordinators have extensive experience in administering local carpentry training programs. Their responsibilities include: monitoring local program quality; identifying promising new technologies affecting the trade; designing courses and instructional aides, collaborating with venders of construction materials to improve training; and assembling, preparing, and lending to local programs gang boxes full of equipment and consumable supplies needed by local programs for various specialty training courses that are taught irregularly.

By 2006, the Center offered about 300 training sessions per year in 102 course offerings. Thus, as a general average, each course is offered about three times per year. Courses ranged in length from 1 to 10 days. The course listing and schedule and reservations are available on the web at www.reservation.carpenters.org. About 20 of the 102 courses offered either certifications or qualifications. Four types of courses were offered to carpentry instructors: technical skills, pedagogical skills, safety training, and computer skills.

For each apprenticeship course that carpentry instructors teach, CITC instructors receive a CD with instructional aides arranged in a standardized format with the following components:

- Administrative Package
- Sequence of Instruction
- Equipment Lists
- Related Training Exercises
- Forms
- PowerPoint Slides (annotated with note pages)
- Resource Materials
- Tests

CITC staff prepares PowerPoint presentations for instructors to use in training because (1) they put ideas in appropriate and consistent order and (2) they help assure that instructors do not miss covering anything important

The CITC course list also includes a series of work force education courses provided by Pennsylvania State University. Since 1992, the Carpenters have collaborated with the Pennsylvania State College of Education Continuing Education program to offer a series of customized work force training courses. Each course involves three full days of instruction in Las Vegas, followed by computer-based exercises taken at home in the following weeks. Upon successful completion, each course confers three units of college credit.

The Carpenters have approximately 1,600 full-time instructors and 3,500 part-time instructors teaching approximately 50,000 apprentices and more than 200,000 journeymen in 250 local training programs across the U.S. and Canada. The majority of instructors attend one or more classes per year at the International Training Center.

In addition to instructor training and curriculum development, the Carpenters International Training Center provides advanced training to millwrights. Advanced millwright training is centralized at Las Vegas due to the large investment in equipment involved in this training (including two full scale gas turbines and one full scale steam turbine.) Prior to coming to Las Vegas for advanced training, each millwright must complete nine (9) days of perquisite instruction in his/her local area. About 5,000 individuals had completed millwright training at the International Training Center from 2003 to 2006.

The International Training Center operates year-round. The only season in which it is difficult to fill courses is during the Christmas holidays. Millwrights tend to come during the winter rather than during spring or fall, when the outages occur. Instructors are generally available for "train the trainer" sessions during the summer, because they are teaching apprentices throughout the school year. However, instructors often have regular construction jobs and often cannot get away for more than a week or so.

4.1.2 Sheet Metal Industry

The International Training Institute for the Sheet Metal and Air Conditioning Industry (ITI) is a national training trust fund established jointly by the Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) and the Sheet Metal Workers International Association (SMWIA). ITI is directed by a national joint apprenticeship and training committee (JATC) of six trustees—three from management and three representing labor. At the local level, SMACNA and the Sheet Metal Workers sponsored 159 local apprenticeship programs across the United States in 2006. The Sheet Metal Worker apprenticeship is a 5-year, 10,000-hour program, with 1,000 hours of related training.

The ITI serves the following functions (http://www.sheetmetal-iti.org/):

- Developing a comprehensive curriculum and instructional materials for local apprentice and journeymen training programs;
- Offering comprehensive Instructor Training Programs;
- Certifying of JATC training and testing programs (Certification programs include

welding, Testing and Air Balancing (TAB) and HVAC Service);

- Anticipating the implementation of changing technology;
- Providing assistance and enhancement to local training programs. For example, ITI offers local programs 5-year, zero interest loans to pay for equipment, but not for facilities.

The rate paid by local programs to participate in the International Training Institute (ITI) is 12 cents per hour worked in the jurisdiction. In addition, 3 cents per hour is charged to fund the National Energy Management Institute (NEMI), and 2 cents for the Sheet Metal Occupational Health Institute Trust (SMOHIT). Thus, a total of 17 cents per hour is charged for these national trust funds.

The local charge for training differs significantly by collective bargaining agreement. There is considerable variation among local programs in the levels of funding for training. Local contributions for sheet metal training range from 3 cents to 56 cents per hour.

The International Training Institute conducts training for instructors in Las Vegas. Instructor training was formerly organized by the Center on Education and Training for Employment at Ohio State University in Columbus, Ohio and in Albuquerque, New Mexico. However, the International Training Institute dropped its contract with Ohio State University for instructor training in part because the University had rejected offering regular college credit for the training. Currently, ITI offers instructor training in the local apprenticeship facilities in Las Vegas, Nevada. Instructor training is provided during the day while the facility is used for apprentice and journeymen related training in the evenings. Ideally, the facility accommodates 80 instructors at a time. Types of training provided to instructors include technical updating, pedagogy, and leadership training.

Several building trades have negotiated with the National Labor College in Washington, D.C. to develop a bachelor's degree program in construction management. Reportedly, there is significant interest in college credit and college degrees among the apprentice instructors.

Recently, there has been a notable switch to offering related training for apprentices during the day rather than in the evenings. There were many problems associated with providing related training in the evening, including fatigue and difficulties for apprentices to travel to the programs. More programs are making use of blocked training.

In 1995, a SMACNA/SMWIA Joint Training Task Force was appointed to look at current and future markets and to analyze the skills sheet metal workers will need to be successful in these markets. In 1996, the Task Force made its recommendations, which included creation of a new curriculum organized into core and specialties. The rationale behind this recommendation was recognition of the need to adapt to changing markets while maintaining the essential skills of the trade, and that skill diversification will improve employment opportunities for sheet metal workers, while providing specialty contractors with the skilled work force they need to compete in niche markets.

The 1996 Training Task Force reviewed current training programs and recommended additional training curricula and training delivery systems. The group also identified the following niche markets requiring special consideration in planning for future training: siding and decking, architectural, industrial, service, commissioning and TAB (Testing, Adjusting, and Balancing), kitchen equipment, controls, and residential.

The resulting sheet metal apprenticeship curriculum is now divided into a core and various specialty modules. The core curriculum is standard for all apprentices, and is a two-year module. The core is a comprehensive 400-hour instructor-led sheet metal apprentice training program that delivers materials on all the basic sheet metal skills along with an introduction to personal skills. The training delivery system is based on the traditional textbook, with modules easily reordered from the ITI to suit a JATC's immediate needs. Training content remains skill-based and features DVD technology in the instructor resource package that will introduce rich graphics, 3-D animations, and detailed videos to illustrate complex concepts. Additionally, the videos provide demonstrations, show the use of dangerous equipment, expose apprentices to personal skill issues, and provide broad exposure for all students.

After completing the core, apprentices must choose a specialization and take the training module in that specialty. Available specialization modules include training in architectural sheet metal work, industrial sheet metal work, and heating, venting and air conditioning (HVAC). The HVAC curriculum is the specialization field most commonly chosen. Journeymen also have access to specialty modules to keep up with new technology and to broaden their skills.

The current sheet metal curriculum also features additional modules that can stand-alone or be used to support the apprentice curriculum. These include Mathematics. Welding, Soldering, Servicing Environmental Systems, Reading Plans and Specifications, Testing, Adjusting and Balancing (TAB), Residential Sheet Metal, Roofing, Detailing, Sign Industry Sheet Metal work, and Foreman Training.

Thanks to arrangements nationally negotiated by ITI, sheet metal apprentices can receive college credit toward an associate's degree through Ivy Tech in Indiana. By taking five additional general education courses at about $200 per course, a completing apprentice can obtain an associate degree. Individual apprentices pay the tuition for these added courses to attain the degree. The sheet metal industry does not mandate that apprentices obtain an associate degree. However, some local programs with the United Association of Plumbers and Pipefitters (UA) do mandate attainment of an associate's degree; an example can be found in Ann Arbor, Michigan. The Ann Arbor UA program keeps completing apprentices at 80 percent of full journeyman pay scale until they complete classes for the associates' degree at Washtenaw Community College, where they get a substantial break on tuition. The educational courses are nearly free to apprentices due to an arrangement the UA negotiated with the college. Washtenaw Community College is a primary site for apprentice instructor training in the plumbing and pipefitting trades.

The sheet metal industry has developed innovative instructional materials using CDs and DVDs. Perhaps the most significant change is self-paced learning programs. Self-paced learning materials allow apprentices who miss a class to catch up through self-study. However, the executive director of ITI cautioned the need in self-paced programs to gauge not only the individual's technical intellectual development gained through the program, but also assessing if their social development is ready before they move into journeyman status. Some sheet metal industry programs are also teaching life skills in apprenticeship programs, such personal finance topics as balancing a checkbook.

To help socialize apprentices to the workplace, some locals have formed a volunteer network of mentors. The mentor acts as the big brother/big sister to the apprentice. This gives the apprentice the chance to seek a reality check from a trusted source.

Sheet metal programs are involved in testing and skill certification. Both written and performance tests are conducted. Indeed, the Testing, Adjusting, and Balancing (TAB) examination takes a full day of testing. Equipment vendors, such as Trane Air Conditioning, are promoting certification to help assure that the firm's product is installed correctly. When a product fails, regardless if is has been installed correctly or not, the vendor looks bad.

As a national policy, the sheet metal industry JATC has established broad standards for apprenticeship program. It also requires all its trainees (including instructors) to sign "scholarship-loan agreements." If individuals trained leave to work outside of the signatory contractors within 10 years, they owe a pro-rata share of the training expenses spent on them.

Most decisions on sheet metal apprenticeship and training are left to the local level. For example, whether to offer related training at night, during the day one day per week, in one-week blocks per month, whether to pay apprentices for related training, and where related and supplemental training is conducted.

Considerable variation exists among local programs and their circumstances. In some states, apprentices can collect unemployment insurance while they participate in blocks of related training; employers simply lay them off during training periods. In Wisconsin, sheet metal apprenticeship related training is conducted in state vocational schools. The training is open to all indentured apprentices, whether they are in the union program or not. If not in the union program, however, the books and other curricular materials produced by the union sector cannot be taken away from the school. Also at the local level, decisions are made on whether life skills are taught, whether a mentoring system is implemented, and policies are made regarding rotation. The Milwaukee sheet metal program has a practice of mandatory rotation of its apprentices each year. Employers and apprentices often don't like rotating; but the practice gives the apprentice a good overview of various employers and types of work and puts the completing apprentice in a better position to choose the employer and work he or she wants to do. In some areas, apprentices must find their own jobs. In other localities, apprentices are kept employed in order to maintain them in training through downturns. Most locals do not have exclusive hiring hall arrangements; but sponsoring apprenticeship committees may take special responsibility for maintaining employment of apprentices.

4.2 Craft Training in the Open Shop Sector

For craft training in the open shop sector, the RT-231 research had a case study about construction work force development in Houston

4.2.1 Why Study Houston?

Houston is a key labor market for employment in industrial construction and maintenance. Indeed Houston has the world's largest concentration of petrochemical industry and chemical processing plants, along with several of the world's largest construction and engineering firms. Many of these firms are members of the Construction Industry Institute.

Houston also has a concentration of skilled craft workers. It is the home sending area or source of traveling craft workers, especially for turnarounds and outages across the country.

By any measure or anecdote, demand for skilled industrial construction and maintenance workers along the Gulf Coast is increasing and shortages are getting worse. Several factors are involved. Houston industrial construction has an aging work force with few new recruits in the pipeline. Construction is no longer perceived to be an attractive career choice. Youth commonly see construction jobs as involving heavy physical labor, unpleasant and unsafe working conditions, and unstable employment. Another important factor in Houston is that wages and benefits had not kept pace with cost-of-living increases; but due to the labor shortage situation, wages have been rising dramatically lately, (about 25 to 30 percent). At the same time, site security and safety requirements, including increased drug and alcohol testing, criminal background screening, and English-only requirements have reduced the pool of available workers.

Yet demand for skilled craft workers within Greater Houston is increasing and is expected to continue to do so into the foreseeable future. Houston's skilled construction craft workers have increasing opportunities to work elsewhere. Cleanup and rebuilding following the hurricanes, Katrina and Rita, which struck Texas and Louisiana in fall 2005, has drawn significant numbers of workers away from Houston. Construction of eleven additional coal-fired electric utility plants is planned across East Texas. The Beaumont-Golden Triangle area of Southeast Texas, adjacent to Houston to the east, has projected a need as many as 20,000 additional industrial construction craft workers for construction of a new refinery, expansion of an existing refinery, and upcoming offshore work, and other projects.

In an effort to control costs, major industrial construction owners in the Houston area largely abandoned the use of unionized contractors several years ago. Along with the decline of Houston-area unions came reductions in funding for the training trust funds and joint apprenticeship and training programs, which were financed under mandatory arrangements through collective bargaining agreements. Training now largely relies on voluntary funding.

Shortages of skilled craft workers provide motivation for work force development. The current shortage situation is challenging and the outlook for the future is worse. The situation in Houston demonstrates what is possible to accomplish through a voluntary approach under motivating circumstances.

4.2.2 Key Features of the Houston Open Shop Approach to Work force Development

Houston has a reputation for having one of the strongest approaches to open-shop work force development among major urban labor markets in the U.S. Houston-area firms provided key support for the establishment and support of the NCCER. Several NCCER founding firms are located in the Greater Houston Area. Houston firms have contributed funding, shared curriculum materials and assessments, provided subject matter experts for the development of curriculum and assessments, and offered a significant source of members for the NCCER Board of Directors.

Houston offers a good example of an industry-wide community approach that has the advantage of large owners and major contractors who serve as anchors for work force development activities. Houston has well-established organizations, including the Houston Business Roundtable (HBR), the Houston Area Associated Builders and Contractors (ABC) Houston Area Safety Council, Construction Maintenance Foundation (CMEF).

Although both owners and contractors both actively participate in construction work force development, an important feature of Houston's approach is that it tends to be owner-driven (especially by several large owner firms). A key motivating factor is that owners have begun to require contractors to have a certified work force.

Houston Business Roundtable (HBR)

The Houston Business Roundtable was established in 1973 as a non-profit association of construction users, primarily in the petroleum refining, chemical and energy industries. HBR was initially an affiliate of the National Business Roundtable; but it not currently formally affiliated with either the National Business Roundtable or the Construction Users Roundtable (CURT). The initial focus of HBR was on containing costs, but the organization has also played a major role in promoting safety and work force development.

HBR aims to be the owners' voice for industrial construction in Greater Houston. Contractors, service companies and suppliers are invited to become "subscribers" of the Houston Business Roundtable. In spring 2006, dues-paying affiliates of the Houston Business Roundtable included 27 members and more than 100 subscribers. HBR serves as means of developing consensus among major owners as well as a platform for communication and action among owners and contractors as a community on issues that affect the industry, such as promoting safety and work force development.

HBR conducts its work through committees. The "operating committee" is composed exclusively of owners and makes decisions for the organization. In addition to the operating committee, HBR committees included the safety committee, the health and environmental resources committee, and the crane and rigging committee, and the contractor work force development committee.

4.2.3 Efforts to Improve the Quantity and Quality of Craft Training

The HBR Work force Development committee describes its mission as follows: "to assure that there is an adequate supply of highly skilled craft workers with verifiable skills to construct and maintain its member companies' plants and facilities." Toward this end, the HBR promotes training through a voluntary "Key points of Agreement" signed by both owners and contractors. HBR conducts semiannual Work force Projection Surveys, supports the Construction and Maintenance Education Foundation (CMEF), and administers an annual Work force Excellence Award program, designed to recognize and share best practices. In addition, HBR sponsors a variety of forums and events in which owners and subscribers share knowledge and experience and promote best practices.

Key Points of Agreement

The "Key Points of Agreement" is a voluntary signed written agreement in which owners agree to use contractors who are committed to Work force Development. Owners use such commitment as part of the criteria for pre-qualifying contractors and verify the commitment through audits. In addition, firms that sign the "Key Points of Agreement" agree to the following:

- To endorse the NCCER/NCCCO skills programs
- To require craft workers to become qualified through formal or upgrade training, certifying their skills through written testing, and practical performance verifications.
- To maintain at least 10% of the site craft positions for helper-trainees, in order to keep open entry paths into the industry for new workers.
- To include 6¢ per hour for all site hours to support CMEF education and credentialing programs. Owners can pay the charge to CMEF directly or pay through their contractors.
- To apply the Key Points of Agreement to all maintenance, construction and turnaround work.

Surveys to Develop Work force Projections

One issue that clouds the situation is the general lack of information about industrial construction labor markets. Statistics available from government sources are commonly not sufficiently detailed to be useful.

Realizing this gap in information, HBR began surveying its owner membership on a semi-annual basis, requesting a month-by-month forecast of anticipated demand for workers in industrial construction, maintenance, and turnaround work over the subsequent 18-month period. Since members provide the information, it has greater credibility than data from other sources. The results, which are regularly posted regularly on the HBR website, serve as a vehicle to help develop consensus around the facts and to motivate owners and contractors to give greater attention to work force development issues—especially in periods when upcoming shortages can be foreseen.

Construction & Maintenance Education Foundation (CMEF)

The Construction & Maintenance Education Foundation (CMEF) was jointly established by ABC and by HBR in 1988 as a vehicle to sponsor and promote training and certification. Although CMEF also serves commercial contractors, most of the interest in training has come from industrial employers, who sponsor ninety percent of the trainees.

CMEF organizes initial training courses in a variety of crafts with industrial and commercial contractors. In addition, CMEF administers records for the NCCER written and performance craft certification processes in the Houston area. CMEF offers other craft training as needed. It provides training for electricians to meet the continuing education requirements under Texas state licensing authorities. CMEF also provides upgrade training—which offers remedial or tutorial assistance for workers who score within 20 points of the cutoff for passing the written craft tests.

Training for electricians and upgrade training are offered at the Houston Area Safety Council (HASC) facility in Deer Park or, if demand is sufficient, at individual work sites.

Initial craft training is offered through community colleges. Five college campuses across the Houston area participate with CMEF. Some campuses have been more responsive to the industry's training needs than others. Generally, community college campuses located near plant sites seem to be most cooperative (e.g., Lee College in Deer Park).

Community college courses organized by CMEF are not open to the public. All students must be sponsored by a firm or through a scholarship from CMEF or HBR scholarship to be eligible to participate in the classes. Thus, firms control the access to this training.

There are considerable advantages for companies to approach community colleges as an organized industry rather than as individual firms. They have greater leverage to influence courses offered, curriculum, teacher, and quality of facility issues. In short, industry collaboration can improve community college training programs. In turn, community college assistance with training can also save on expenses paid by firms

On the other hand, community college participation does present challenges. Classes and facilities may not be available when needed. Locations of the training may not be convenient.

Facilities and equipment may not be up to date. Teachers may refuse to use instructional materials and curricula developed by industry.

Community colleges are driven by student enrollments. Without enrollments, classes simply are not offered. Why is this important? As long as working in the construction remains unattractive to youths and the public, few enrollees will apply to any construction courses open to the public and thus sufficient training may not be unavailable. The result is a “chicken and egg situation.”

Records of CMEF training by firm are available from 2003 through 2006. Over the four years, workers from a total of thirty-five construction firms participated in CMEF training at some time during the four years. However, a core group of sixteen contractors consistently sent workers to CMEF college classes over the period. These contractors included the largest firms and their workers accounted for 89 percent of all courses taken.

HBR Work force Development Excellence Award

Begun in 2002, the HBR Work force Development Excellence award process was modeled on the successful HBR Safety Award program begun in 1987. The overall aims of the Award process are to recognize high performing firms, to share best practices in work force development, and to encourage participating contractors and owners to improve their performance each year.

The selection process includes three steps: nomination, self-study, and audit. First, owners nominate outstanding contractors who work for them, using an initial checklist. Likewise, contractors nominate outstanding sub-contractors who work for them and exemplary client owners. Awards are made in four categories (owner, general contractor, specialty contractor—“hard” (electrical, mechanical, and metal) trades, specialty contractor—“soft” (civil) trades). In the second step, each nominated firm completes a self-study checklist, providing supporting evidence. Finally, an audit team led by an owner representative and composed of representatives of owners and contractors, spends a morning verifying the application submitted by the nominated firms, including interviews with a selection of workers to compare their knowledge and perspectives against the company’s work force development policy and programs. More detailed information, along with the award criteria are available on the website of the Houston Business Roundtable (http://www.houbrt.com/2005/programs.htm)

The HBR award selection process has several attractive features, including its <u>promotion of best practices</u> and <u>continuous improvement</u>. The competition promotes good human resource practices in several ways. The award criteria become standards against which firms can judge their own practices. Members of the audit teams have the opportunity to view and learn from practices of the best firms. In early November each year, the awards are announced at an evening banquet. Later that month, the winners present a workshop on their work force development practices.

As an example of continuous improvement, the criteria used in the ratings are revised and the scoring rubrics have become more demanding each year—all of which is aimed at encouraging firms to stretch and constantly improve. Also, pressing issues of current concern are addressed. For example, in 2005, HBR initially requested documentation of the benefits of training. The following year, this item became a part of regular scoring sheet.

Among the items that were examined in the 2006 Award competition were the following:

- Availability and comprehensiveness of company's written work force development policy and procedures
- Rates of participation in formal craft training (CMEF college construction training, NCCER upgrade training, etc.)
- Skills assessment and certification—percent of journeymen who have written craft certification in one craft, in two or more crafts, performance verification (Certified Plus),
- Openings are available for apprentices or sub-journeymen-level workers ($\geq$ 10%) to encourage recruiting of new craft workers into the industry
- Industry and community involvement of the firm—participation in communitywide training and work force development efforts (CMEF, HBR, NCCER, working with area schools, recruiting efforts, etc.
- Tracking the benefits and improvements resulting from work force development efforts (i.e., training, written certification and performance certification)

4.2.4 Efforts to Recruit New Workers into Industrial Construction Work

Making training opportunities available is not sufficient; good applicants are needed to fill them. Thus a second major work force thrust of HBR is to recruit new workers into the skilled crafts. An impediment to new workers entering craftwork has been that owner facilities, such as petrochemical or chemical plants, have traditionally restricted their hiring to experienced workers only. This is the reason why the criteria for the Work force Development Excellence Award include reserving at least 10 percent of job openings for apprentices or sub-journeyman-level workers.

Outreach to Area High School Students

Outreach and recruiting at area high schools has been a long-standing interest of the construction industry in Houston. Numerous initiatives have been undertaken independently by the Associated Builders and Contractors (ABC), by the Construction & Maintenance Education Foundation (CMEF), or by the Houston Business Roundtable (HBR) over several years. In 2006, these three organizations agreed to join in a promising new collaborative joint effort, entitled the Construction Careers Initiative. The initiative is led by a Construction Careers Executive Leadership Team. A subcommittee, the Construction Careers Industry Marketing Team, focuses on reaching the general public. A second subcommittee, the Construction Careers for Youth Committee, specifically focuses on reaching high school youth. To date, various activities have been sponsored, including an annual high school exposition offering "hands-on" activities for youths from several high schools and an annual craft skill competition.

Outreach to high schools is especially difficult in Houston because there are so many school districts in the Houston area. Focused efforts have been the most effective. Receptiveness of individual high school depends on the attitudes of principals and other administrators. Successful relationships have often begun as a result of the personal initiative of a company employee who has taken a special and sustained interest in the endeavor.

Pilot Program: Basic Training for Future Craft Professionals

One of the newest and most promising work force development initiatives in Houston is a pilot program entitled "Basic Training for Future Craft Professionals." This program aims to bring new recruits (helper-trainees) into the industry on a fast track. It provides a two-week course of study, meeting eight hours per day, using the NCCER Core curriculum, employability skills modules and safety orientation. The course is conducted at the Lee College campus. The program is designed to address the shortage of new entrants into industrial construction and the reluctance of employers to hire inexperienced workers, especially in the face of tightening jobsite restrictions.

Contracting firms hire workers and refer them to the training program prior to reporting for work at the job site. Trainees are paid a stipend of $ 200 per week while attending the classes. Both owner and contractor commit to keeping the new recruit on the same job site for 12 months if s/he performs satisfactorily and stays enrolled in classroom training in a craft. Each participant agrees to remain enrolled in CMEF-sponsored college construction courses for at least one year.

For their part, contractors agree to conduct performance reviews at the end of each semester, which may result in a wage increase.

Mentoring is a key feature of the program. Each recruit is assigned an established employee of the firm as a mentor at his/her worksite for one year. Training is provided to mentors and mentees near the end of the two weeks of offsite training. Mentors help the new trainees acclimate to life on a construction site, thereby reducing turnover. They also pass down their knowledge to new trainees.

The pilot program was inaugurated in May 2006. Of the original 28 trainees who entered the program, 24 stayed through to completion. A second round of the program was begun in August 2006. The third class began on November 27, 2006. In this third cycle, 22 individuals were invited, but only 14 showed up. As originally envisioned, the program will cycle three times per year. In August 2006, CMEF in collaboration with Lee College received a grant, which provides funding for additional cycles of the program and for laboratory facilities verify performance of electricians to qualify for certification as “certified plus” craft workers.

Working Effectively with Non-English-Speaking Workers

In spring 2006, HBR sponsored a survey of owners to examine company policies regarding hiring non-English speaking workers. With many firms, having non-English speaking workers on the worksite raises safety concerns; but at least two Houston-area owners employ non-English speaking workers on their worksites. The survey identified barriers and facilitators to using non-English speaking workers. In addition, Houston has begun to translate craft training materials into Spanish. For example, in fall 2006, a contractor member of HBR developed a Spanish translation of instructional materials and conducted pilot training sessions for scaffolding.

4.2.5 Concluding Observations and Recommendations

Progress in safety was achieved earlier than in work force development. The HBR Safety Award program was started 14 years prior to the HBR Work force Development Excellence award. The Houston Area Safely Council (HASC) was established in 1990 to provide safety training and screening services. Over the years, HASC have expanded to include organizing a system of drug testing, criminal background checks, and verification of social security cards and legal work status. HASC also has become more active in work force development activities; the Council houses a major facility for computerized craft certification and serves as a site for upgrade training.

Advantages of the Houston Approach

The organized community-wide approach offers several advantages. It gives the industry greater influence in working with community colleges. Also, firms can devise and pay for the development of training materials and curricula as a group—rather than duplicating one another's efforts as individual firms. The result of these arrangements is a common curriculum and portable credentials, which clearly benefit workers as well.

Contributions to CMEF provide a core level of funding for training and certification on a communitywide basis. Most firms supplement this community-wide training with additional investments in training their work force. The core private funding raised also gives the industry credibility to pursue government grants for work force development.

Remaining Challenges

Although much has been accomplished in Houston, much remains to be done—given current and prospective skill shortages that construction faces on the Gulf Coast. Contractors have begun to respond to owner requirements to have certified workers. The scale of training and certification activities needs to be raised further. Performance certification is especially needed. Expanding the number of firms participating and contributing to the community training efforts is critical.

Owner requirements for certified craft workers has expanded the numbers of craft workers who have written certification; but it has not always resulted in expanded training. Employers care more about skill certification than completion of training. Some workers have been able to pass the written tests after only one or two courses. Performance certification may help remedy this problem; but to date, performance certification has not been widely implemented because it is expensive and has been conducted on the job on busy worksites.

The construction industry needs to identify and implement effective strategies to reach and recruit young workers. A positive development in Houston is that ABC, HBR, and CMEF have recently joined forces to accomplish this through the Construction Careers Initiative.

When turnarounds coincide or overlap, the result is greater peaks in employment. Staffing turnarounds, especially when they are scheduled all at once, is a major challenge. However, owners in other cities, such as Baton Rouge, apparently have found ways to coordinate turnaround schedules; but owners in the Houston area have been reluctant to do this for fear of violating anti-trust laws and regulations.

CHAPTER 5: ANALYSES OF EXISTING DATA

5.1 Analyses of Work force Perspective of Construction Productivity (RT-215) Data

The CII Research project Work force Perspective of Construction Productivity aimed to identify the factors affecting construction productivity from the craft worker's perspective. As part of the research, a survey was administrated to collect data measuring the perception that craft workers and their immediate supervisors have on the frequency and severity of several factors that impact their daily productivity. The data was gathered from CII member projects and included 28 projects; over 1900 craft workers participated. The survey asked the training history of each individual and the worker's perspective on training availability, project productivity and project management, which were used to measure the effect of training from the perspective of workers. Researchers also collected demographic information such as gender, age and race on each respondent, which was used to compare the characteristics of construction training between groups having different demographic backgrounds (CII RT-215 2006).

Among the respondents, 49.5% were union members, which is significantly higher than industry percentages. BLS (2006) reported that union workers accounted for 13.1% of the wage and salary workers in the construction industry in 2005. The reason for the even distribution is the fact that some 46% of the investigated projects were union projects.

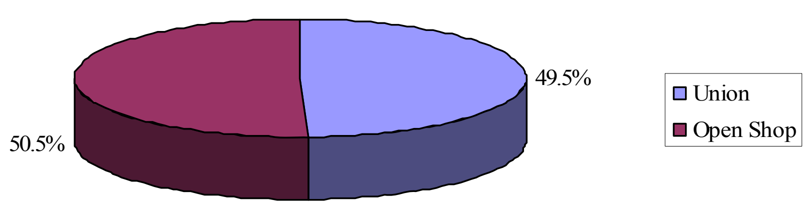


Figure 5. 1: Respondent Union Status

As shown in Figure 5.2, the top four responding trades were pipefitting, electrical work, carpentry, and ironworking. Others refer to the trades which account for less than 1% of the respondents, including Roofing and Waterproofing, Plastering, Drywall, Lathering, and Acoustical Tile, Glazing, Painting, Masonry, Instrumentation, Scaffolding, warehouse attendants, clerk, supervisors, engineers, and managers.

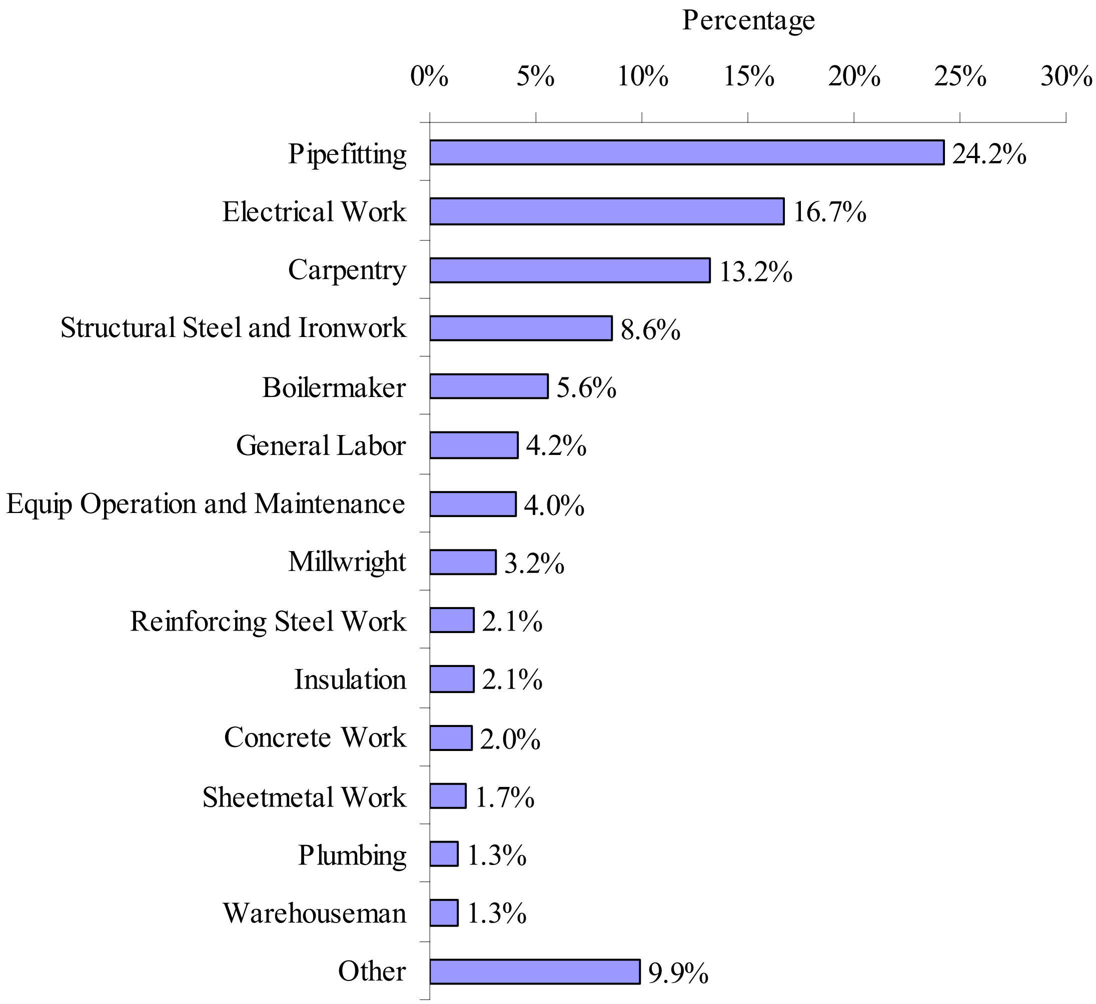


Figure 5. 2: Distribution of Surveyed Trades

In order to help future discussions and analysis, this research organized the crafts into four trade groups: civil, piping, other mechanical, and electrical. Civil trade includes carpentry, masonry, painting, insulation, roofing, waterproofing, plastering, drywall, lathering, concrete work, acoustical tile and glazing, structural steel, iron work and reinforcing, equipment operation and maintenance, general labor and warehouseman. Piping trade includes pipefitting and pipe welding. Other mechanical covers plumbing, boilermaker, millwright, and sheet metal work. Electrical trade refers to electrical work and instrumentation. As shown in Figure 5.3, civil, piping, electrical and other mechanical trade accounted for 49.4%, 23.6%, 16.3% and 10.8% respectively.

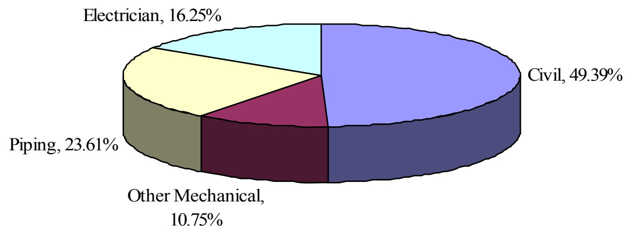


Figure 5. 3: Distribution of Surveyed Trade Groups

Of all the participants, 56.1% were journeymen, 9.6% percent were apprentices, and 7.2% were helpers. Foremen and general foremen accounted for a total of 26.0% of the respondents. Around 1.1% of respondents identified themselves as others, including clerk, supervisors, engineers, and managers.

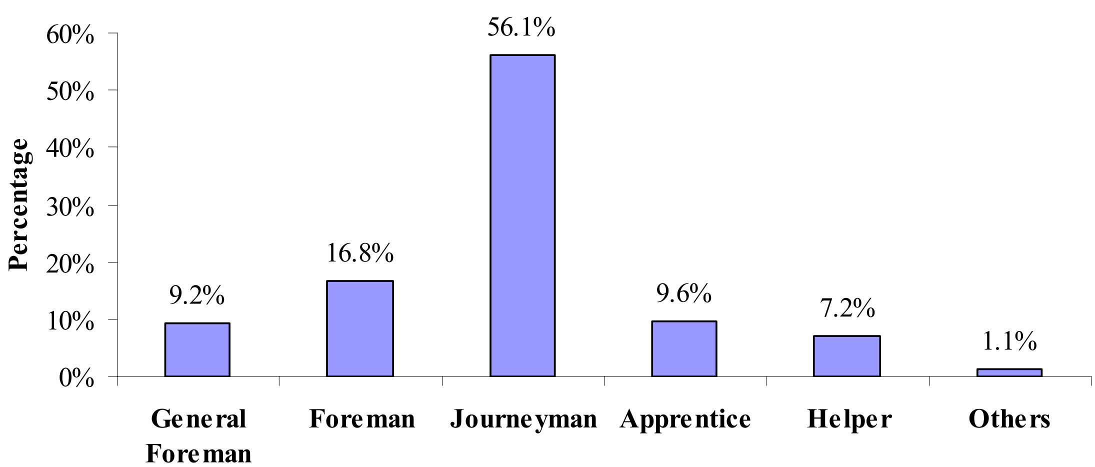


Figure 5. 4: Position of the Respondents

The respondents were grouped into six categories based on their ages. Figure 5.5 shows the distribution of the six age groups. The group of respondents between 41 to 50 years old accounted for 29.3% of the sampled respondents, followed by the group of workers between 31 and 40 years old (25.0%), and the group of workers between 51 and 60 years old (22.7%). Around 17.1% of the respondents were between 21 and 30 years old. Only 2.3% of respondents were younger than 20. The average age of the sampled respondents is 42.

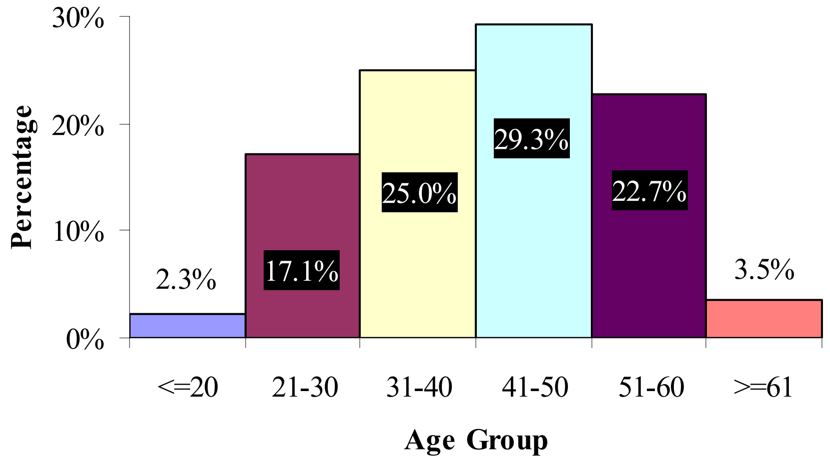


Figure 5. 5: Distribution of Age Groups

Figure 5.6 presents the educational background of the respondents. The total number of the respondents for all the education options is larger than the sample size because some respondents graduated from both high school and vocational school. Also some respondents chose both vocational school and college. Among the 1904 valid responses on the educational background question, around 67.5% graduated from high school, and 37.1% graduated from vocational or technical school. Another 9.6% of respondents graduated from colleges. Only 12.7% of the respondents reported that they did not graduate from high school.

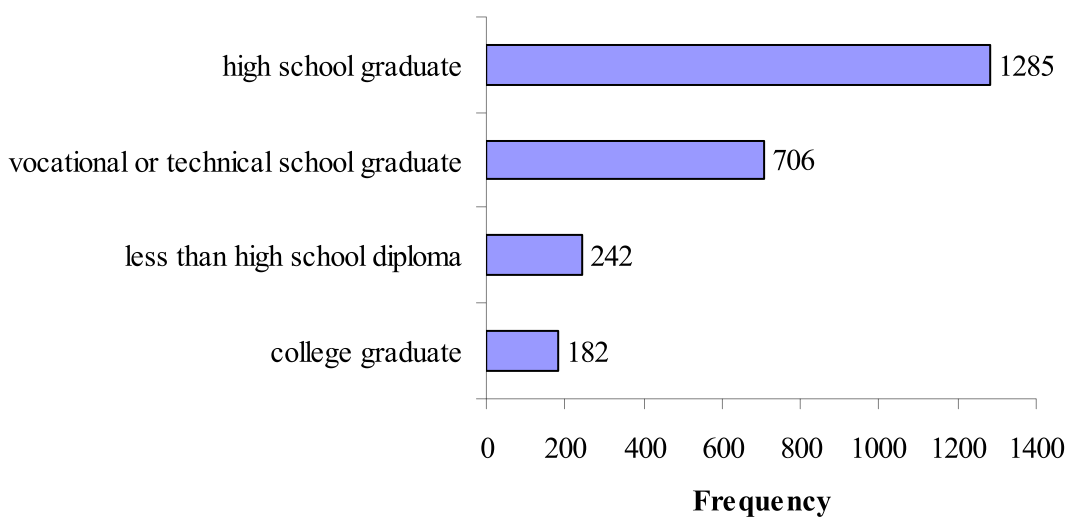


Figure 5. 6: Education Background

Figure 5.7 presents the distribution of respondents by their primary language. Spanish accounted for 10.4%, which represents the growth of the Hispanic population in the construction industry. In 2005, 23% of the employees in the U.S. construction industry were Hispanic or Latino (BLS 2006). The discrepancy may be due to the employment practices and the geographic distribution of the projects sampled by this research. There were about 3.0% of the respondents whose primary language was American native (Navajo), German, French, or Arabic.

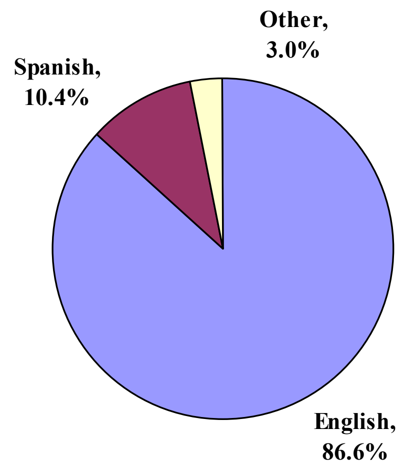


Figure 5. 7: Primary Language of the Respondents

By comparing this study with previous CII research (CII, RT-182, 2003), sampled craft workers in this research fairly present the construction work force employed on industrial projects by CII contractors. In addition, this research has a significant large sample, which makes it rational to draw conclusions about craft training in the construction industry.

5.1.1 Off-the-Job Training Rate

The RT-215 survey asked workers to indicate whether they completed a formal off the job craft training program, such as a union apprenticeship program, a NCCER apprenticeship program, or an ABC apprenticeship program. The RT-231 researchers grouped the workers based on their union status, their race and their trade, and then identified how the off the job training rate is affected by these factors.

(1) Union Workers versus Open Shop Workers

The researchers find that on average 30.0% of open shop workers complete off job training, which is much lower than union workers, who have 73.7% of their workers completing off job training (Table 5.1).

Table 5. 1: Off the Job Training Rates Sorted by Union Status

off the job craft training program	Open Shop	Union
Yes	30.0%	73.7%
No	70.0%	26.3%

The study uses a Chi-square test to further investigate whether the difference between union and open shop workers is significant. According to Table 5.2, the Chi-square test shows the differences between off the job training rates for open shop workers and union workers are statistically significant, which means that union workers have a statistically significant higher off job training rate than open shop workers.

Table 5. 2: Chi-Square Test for Union Status

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	367.486(b)	1	**.000**
Likelihood Ratio	380.353	1	.000
N of Valid Cases	1926		

(2) Different Trade Groups

The RT-231 study identified the average off job training rate for different construction trades using the RT-215 data. Civil trade includes carpentry, masonry, painting, insulation, roofing, waterproofing, plastering, drywall, lathering, concrete work, acoustical tile and glazing, structural steel, iron work and reinforcing, equipment operation and maintenance, general labor and warehouseman. Piping trade includes pipefitting and pipe welding. Other mechanical covers plumbing, boilermaker, millwright, and sheet metal work. Electrical trade refers to electrical work and instrumentation. The study finds that electricians have the highest off job training rate at 60.3%, followed by piping workers at 57.9%, and other mechanical workers at 55.7% (Table 5.3).

Table 5. 3: Off the Job Training Rates Sorted by Trades

Off the job craft training program	Civil	Other Mechanical	Piping	Electrician	Average
Yes	44.3%	55.7%	57.9%	60.3%	51.4%
No	55.7%	44.3%	42.1%	39.7%	48.6%

The RT-231 study again used a Chi-square test to further investigate whether the difference between union and open shop workers was significant. According to Table 5.4, the Chi-square test shows the differences between off the job training rates for different trade workers are statistically significant.

Table 5. 4: Chi-Square Test for Trades

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	39.109	3	0.000
Likelihood Ratio	39.260	3	0.000
N of Valid Cases	1951		

5.1.2 Availability of Training among Different Demographic Groups

The RT-215 survey asked workers to indicate their agreement on the statement that "There is no opportunity for skills training on this project" based a scale 1 to 7, where 1 represents strongly disagree and 7 represents strongly agree.

The RT-231 researchers grouped the survey respondents based on their union status, race and trades and then identified how the availability of craft training is affected by these factors.

(1) Union Workers versus Open Shop Workers

For the impact of union status on availability of training opportunities, the researchers find that open shop workers have an average agreement of 3.33 to the statement, "There is no opportunity for skills training on this project," which is a little bit lower than union workers (Table 5.5). The results mean that union workers agree more than non-union workers that there were no training opportunities in their project at the time of the survey.

Table 5. 5: Workers' Perception of Training Availability Sorted by Union Status

Union Status	N	Mean	Std. Deviation	Std. Error Mean
Open Shop	952	3.33	2.07	0.07
union	920	3.37	1.91	0.06

The study used a T-test to further investigate whether the difference between union and open shop workers was significant. According to Table 5.6, by assuming the union group and the open shop group have different variances, the T-test shows that the difference between the two groups regarding the availability of craft training is not statistically significant. So based on workers' perception, craft training is equally available to both union workers and open shop workers.

Table 5. 6: T-tests for Workers' Perception of Training Availability (Union Status)

Variance Assumption	Levene's Test for Equality of Variances		t-test for Equality of Means				
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Equal variances assumed	14.11	**.000**	-.51	1870	.61	-.047	.092
Equal variances not assumed			-.51	1866.48	**.61**	-.047	.092

(2) Whites versus Hispanics

For the impact of race on availability of training opportunities, the researchers found that Hispanic workers have an average agreement of 3.896 to the statement, "There is no opportunity for skills training on this project," which is higher than white workers (Table 5.7).

Table 5. 7: Workers' Perception of Training Availability Sorted by Race

Union Status	N	Mean	Std. Deviation	Std. Error Mean
Hispanic Workers	182	3.90	2.21	0.16
White Workers	1638	3.31	1.96	0.05

The study used a T-test to further investigate whether the difference between Hispanic and White workers is significant. According to Table 5.8, by assuming Hispanic workers and White workers have different variances, the T-test shows that the difference between two groups regarding the availability of craft training is statistically significant. So based on the workers' perception, craft training is not equally available to Hispanic and white workers. Hispanic workers tend to believe there were fewer training opportunities for them compared to White workers on their projects at the time of survey.

Table 5. 8: T-tests for Workers' Perception of Training Availability (Race)

Variance Assumption	Levene's Test for Equality of Variances		t-test for Equality of Means				
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Equal variances assumed	7.31	.01	3.77	1818	.000	.58	.15
Equal variances not assumed			3.42	213.78	**.001**	.58	.17

(3) Different Trade Groups

For the distribution of the training opportunities among workers in different trades, the researchers find that Civil workers have an average agreement of 3.425 to the statement, "There is no opportunity for skills training on this project," which was a higher than any other trade (Table 5.9).

Table 5. 9: Workers' Perception of Training Availability Sorted by Trades

Trade	Mean	N	Std. Deviation
Civil	3.43	925	2.03
Other Mechanical	3.34	209	1.89
Piping	3.38	455	2.00
Electrician	3.23	311	2.00
Average	3.37	1900	2.00

The study used an ANOVA to further investigate whether the differences between trade workers are significant. According to Table 5.10, the differences between different trades regarding the availability of craft training are not statistically significant. So based on workers' perception, craft training was equally available to workers in different trades.

Table 5. 10: T-tests for Workers' Perception of Training Availability (Trades)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	8.887	3	2.96	0.74	0.53
Within Groups	7599.290	1896	4.01		
Total	7608.177	1899			

5.1.3 Availability of Incentives to Seek Training among Different Demographic Groups

The RT-215 survey asked workers to indicate their agreement on the statement that "Craftsmen have no incentive on this project to seek additional training or certifications" based a scale of 1 to 7, where 1 represents strongly disagree and 7 represents strongly agree. The RT-231 researchers grouped the workers based on their union status, race and trades and then identified how availability of incentive to seek craft training is affected by these factors.

(1) Union Workers versus Open Shop Workers

For the impact of union status on availability of incentives to seek training, the researchers find that open shop workers have an average agreement of 4.246 to the statement, "Craftsmen have no incentive on this project to seek additional training or certifications," which was higher than union workers (Table 5.11). The results mean that more open shop workers than union workers agree that there is less incentives to seek training on their project.

Table 5. 11: Workers' Perception of Availability of Incentives to Seek Training Sorted by Union Status

Union Status	N	Mean	Std. Deviation	Std. Error Mean
Open Shop Workers	4.246	2.03	0.07	4.25
Union Workers	3.919	1.98	0.07	3.92

The study uses T-test to further investigate whether the difference between union and open shop workers was significant. According to Table 5.12, by assuming union group and open shop group have equal variance, T-test shows that the difference between trade groups regarding the availability of incentive to seek craft training is statistically significant. Based on workers' perceptions, union workers had significantly more incentive to seek craft training than open shop workers on their projects at the time of the survey.

Table 5. 12: T-tests for Workers' Perception of Availability of Incentives to Seek Training (Union Status)

Variance Assumption	Levene's Test for Equality of Variances		t-test for Equality of Means				
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Equal variances assumed	3.45	0.06	3.51	1858	**<u>0.00</u>**	0.33	0.09
Equal variances not assumed			3.52	1857.65	0.00	0.33	0.09

(2) Whites versus Hispanics

For the impact of race on availability of incentives to seek training, the researchers find that Hispanic workers have an average agreement of 4.146 to the statement, "Craftsmen have no incentive on this project to seek additional training or certifications," which is slightly higher than

White workers (Table 5.13).

Table 5. 13: Workers' Perception of Availability of Incentives to Seek Training Sorted by Race

Union Status	N	Mean	Std. Deviation	Std. Error Mean
Hispanic Workers	178	4.15	2.10	0.16
White Workers	1630	4.07	2.00	0.05

The study uses a T-test to further investigate whether the difference between Hispanic and White workers was significant. According to Table 5.14, by assuming Hispanic and White workers have equal variance, T-test shows that the difference between trade groups regarding the availability of incentive to seek craft training was statistically significant. So based on workers' perception, White workers had significantly more incentive to seek craft training than Hispanic workers on their projects at the time of the RT-215 survey.

Table 5. 14: T-tests for Workers' Perception of Availability of Incentives to Seek Training (Race)

Variance Assumption	Levene's Test for Equality of Variances		t-test for Equality of Means				
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Equal variances assumed	2.38	0.12	0.46	1806	**0.65**	0.07	0.16
Equal variances not assumed			0.44	213.66	0.66	0.07	0.17

(3) Different Trade Groups

For the availability of incentives to seek training among workers in difference trades, the researchers found that other mechanical workers have an average agreement of 4.211 to the statement, "Craftsmen have no incentive on this project to seek additional training or certifications," which is slight higher than other workers (Table 5.15). The results mean that more mechanical workers than other trade workers agreed that there were no incentives to seek training on their projects at the time of the survey.

Table 5. 15: Workers' Perception of Availability of Incentives to Seek Training Sorted by Race

Trade	Mean	N	Std. Deviation
Other Mechanical	4.21	209	1.90
Piping	4.16	453	2.03
Electrician	4.15	310	2.04
Civil	4.03	915	2.03
Total	4.10	1887	2.02

The study used a one-way ANOVA to further investigate whether the difference between workers in different trades is significant. According to Table 5.16, ANOVA shows that the difference between trade groups regarding the availability of incentives to seek craft training is not statistically significant. So based on workers' perception, workers in different trades do not have significant difference regarding availability of incentive to seek craft training on their projects.

Table 5. 16: T-tests for Workers' Perception of Availability of Incentives to Seek Training (Trades)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	9.64	3	3.21	0.79	**0.50**
Within Groups	7654.03	1883	4.07		
Total	7663.67	1886			

5.1.4 Craft Training and Workers' Pride

The survey asked workers to indicate their agreement on the statement that "All of the craftsmen have pride in their work" based a scale of 1 to 7, where 1 represents strongly disagree and 7 represents strongly agree.

The researchers grouped the workers based on their off the job training experience and then identified how off the job training affects workers' pride in the job. Table 5.17 shows that for the workers completing off the job training, the rate of pride is 4.936, which is higher than workers without off the job training.

Table 5. 17: Rate of Pride in Work Sorted by Training Experience

Off Job Training	N	Mean	Std. Deviation	Std. Error Mean
No	906	4.58	1.95	0.07
Yes	967	4.94	1.91	0.06

The study used a T-test to further investigate whether the difference in job pride between workers with and without training is significant. According to Table 5.18, by assuming workers with or without training have equal variance, the T-test shows that the difference between workers with or without training regarding the availability of incentive to seek craft training is statistically significant. So based on workers' perception, workers completing off the job training have significantly more pride in their work than workers without training.

Table 5. 18: T-tests for Workers' Pride in Work

Variance Assumption	Levene's Test for Equality of Variances		t-test for Equality of Means				
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Equal variances assumed	2.55	0.11	-3.96	1871	**0.00**	-0.35	0.09
Equal variances not assumed			-3.96	1857.43	0.00	-0.35	0.09

5.1.5 Correlations between Training and Workers' Perceptions of Productivity and Management

The survey asked workers to rate how well the current project is being managed and the overall productivity of the current project, with 1 being the worst job and 7 being the best job. A Pearson correlation analysis was performed to identify the relationship between workers' perception of availability of training, availability of health and safety training and availability of incentives to seek training with their perceptions of project's management and productivity.

As mentioned in the previous sections, a greater value in training availability, availability of health and safety training and availability of incentives to seek training means that more workers believe there is **no training** on the project. Table 5.19 shows that the correlations between workers' perception of the availability of training, the availability of health and safety training, and the availability of incentives to seek training with their perceptions of project's management and productivity are statistically significant. The negative correlation coefficients mean that if the higher value of training availability (which means worker actually believe less training is available on the project), the lower the value in the evaluation of management of the project and overall productivity. Table 5.19 shows that if a worker believes that there are more opportunities available for craft training, health and safety training and incentives to seek training, he/she will also believe that the project is being better managed and experiencing higher productivity compared to his or her previous projects.

Table 5. 19: Pearson Correlation Coefficient Matrix

	Statistics	Training Availability	Availability of Health and Safety training	Availability of Incentives to Seek Training
Evaluation of management of the project	Pearson Correlation	-0.08	-0.15	-0.16
	Sig. (2-tailed)	**0.00**	**0.00**	**0.00**
	N	1877.00	1875.00	1866.00
Evaluation of the overall productivity	Pearson Correlation	-0.05	-0.14	-0.14
	Sig. (2-tailed)	**0.02**	**0.00**	**0.00**
	N	1872.00	1870.00	1861.00

5.1.6 Summary

Based on the analysis of CII research project Work force Review of Construction Productivity, the study finds that according to workers' perceptions:

(1) Off the job Training Rate

- Off job training is not distributed equally among workers having different demographic backgrounds.
- White workers have a significantly higher rate of completing off the job training than Hispanic workers;
- Union workers have a significantly higher rate of completing off the job training than open shop workers;
- Electricians have a significantly higher rate of completing off the job training than other trades, and Civil workers have a significantly lower rate of completing off the job training than other trades.

(2) Availability of Craft Training

- The availability of craft training in a project is equal for union workers and open shop workers
- The availability of craft training in a project is equal for workers of different construction trades

- The availability of craft training in a project is not equal for White and Hispanic workers. Hispanic workers perceive that they have fewer opportunities to receive training.

(3) Availability of Incentives to Seek Training

- The availability of incentives to seek craft training in a project is not equal for union workers and open shop workers. Union workers have more incentives to seek training.
- The availability of incentives to seek craft training in a project is equal for White and Hispanic workers.
- The availability of incentives to seek craft training in a project is equal for workers in different construction trades.

(4) Training with Pride in Work

- Workers completing off job training have more pride in their work than those without training

(5) Training with Project Management and Productivity

- There are significant correlations between workers' perception of availability of training, availability of health and safety training and availability of incentives to seek training with their perceptions of project's management and productivity. If a worker believes that there are more opportunities available for craft training, health and safety training and incentives to seek training, he/she will also believe that the project is being better managed and experiencing higher productivity.

5.2 Analysis of Data from CII Research RT182 Addressing the Shortage of Skilled Craft Workers

As a part of the research efforts undertaken for the CII research project RT-182 "Addressing Shortage of Skilled Craft Workers in the U.S.", researchers interviewed a sample of 862 construction workers. The RT-182 researchers created a set of survey forms, collecting data which they inputted into a database that calculated Tier I and Tier II implementation scores based on metrics developed in the study. These forms were intended to be used during on-site survey and interview sessions with the craft and supervisory level work force. Two forms collected this information: (1) the Individual Skill Assessment, and (2) the Background Questionnaire. The Individual Skills Assessment surveyed the skill level and experience of the journey-level work force. The survey also collected information about craft certifications, technical training, and administration skills. The Background Questionnaire gathered information on the demographic background (education, language, age, etc.) of the workers. A third survey form, the Management Practices Questionnaire, was used to collect information on the project level management practices. All of the forms were created with the input of senior industry advisors and tested on a pilot project to ensure their feasibility.

During the interview, researchers collected demographic information, such as workers' training hours, training types, hourly wages and career satisfaction. The study used this data to identify the impact of training on a worker's income and career satisfaction in the construction industry. First, a brief discussion of the social and demographic attributes of the 862 construction workers interviewed by the CII RT182 research was presented as follows.

Data was gathered from 19 site visits to industrial-type projects scattered around the nation. Members of a Center for Construction Industry Studies (CCIS) research steering committee participated in the survey. At each project site, researchers randomly selected apprentices, journeymen, foremen, and project managers to complete the survey.

Union workers were the majority at 4 of the 19 projects in the survey set. The total number of workers on unionized projects in the set is 215, which is equivalent to approximately 25% of the overall group of interviewed workers. The percentage of union workers among the total interviewed workers was close to the data reported by the Center to Protect Workers' Rights CPWR (2002), which reports that 19% of construction employees are union-members, and higher than the data reported by U.S. BLS in 2000 that 19% of work force in construction were union members (Srour 2006).

The average age of the surveyed workers in this study was 40, which is slightly higher than the national average for construction workers in Center for Worker's Right (CPWR) survey (2002), which is 38.7 years. This can be attributed to the fact that the RT-182 study aimed at surveying workers at the journeyman level and above only. These workers were typically older than apprentices and helpers. The average age of union workers in the survey was 42.5 years, whereas the average age of non-union workers was 39.2 years. Union workers generally had more years of experience at the craftsman level than non-union workers (17.7 years on average as compared to 11.3 for non-union workers). Union workers received an average of 85.66 hours of craft training in the 3 years prior to the RT-182 study, whereas non-union workers received on average 58 hours of training during the same time period. The difference in training hours between union and non-union workers was statistically significant at a level of 0.05.

Eighteen per cent of the RT-181 surveyed workers consider Spanish as their first language, and 12.8% have Mexican origins. These figures are consistent with the current national average of Hispanic construction workers, which is 17% (BLS 2004). The national average of Hispanics in the US work force is 10.9% (CPWR 2002).

Only 1.7% of the surveyed workers were female, which is significantly lower than the figure reported by the CPWR (2002) of 9%. This is possibly due to the fact that the CPWR figure includes administrative-staff jobs, which comprise 47% of female construction jobs.

5.2.1 Impact of Craft Training on Worker's Hourly Wage

The RT-182 data contains information regarding worker's training hours over the past three years, their hourly pay rate, as well as other social demographic information. The RT-231 study used the RT-182 data to establish a multiple regression model (5.1) in order to identify the impact of craft training on workers' hourly wage.

$$W=\alpha + \beta\times T + \sum \lambda_i \times X_i \quad (5.1)$$

Where: W is worker's hourly pay rate, T is total training hours a worker received in the previous three years, and X_i are independent variables including years of experience at apprentice level, journeyman level, and foreman level, time in present company, age, number of crafts a worker can perform, and what type of formal training a worker received.

The results of the regression analysis are shown in Table 5.20. The RT-231study found that total hours of training had a positive impact on the workers' pay rate, and 100 hours of training can raise hourly pay approximately 10 cents if other independent variables are fixed. Other independent variables that can increase worker's hourly pay rate include years of experience at journeyman and foreman level, time in present company, and age. For the impact of different types of formal training, the RT-231 study found that if other independent variables are fixed, a worker with union apprenticeship training earned 3.6 dollars more in hourly pay than a worker without apprenticeship training. Completing company non-union apprenticeship training could raise the hourly pay by about 1.11 dollars.

Table 5. 20: Full Model of Multiple Regression Analysis (R^2=0.308)

Independent Variables	Regression Coefficient	Std. Error	T-Value	P-Value
Constant	15.78	0.51	30.72	0.00
Years of experience at apprentice level	-0.02	0.04	-0.47	0.64
Years of experience at journeyman level	0.02	0.02	1.02	0.31
Years of experience at foreman level	0.15	0.03	4.93	0.00
Time in present company	0.04	0.02	2.62	0.01
Hours of craft training over past 3 years	0.00	0.00	4.19	**0.00**
Age	0.03	0.02	2.03	0.04
Number of Crafts	-0.03	0.05	-0.50	0.62
NCCER Training	0.15	0.30	0.50	0.62
Basic Military training in construction	-0.83	0.75	-1.11	0.27
Military "C" school training in a craft	-0.39	0.81	-0.48	0.63
Vocational program	0.49	0.31	1.61	0.11
Union apprenticeship training	3.60	0.34	10.74	**0.00**
Company non-union apprenticeship training	1.11	0.50	2.21	**0.03**
company craft certification	0.40	0.35	1.15	0.25
Total years of craft experience	0.02	0.01	1.45	0.15

The RT-231 study found that some independent variables were not significant in the model. Next a backward selection regression analysis was performed to remove those insignificant independent variables from the original full model. The final reduced model is shown in Table 5.21. The study found that if other variables are fixed, the more experience a worker has at the foreman level, the higher the hourly pay a worker received. Older workers have slightly higher hourly pay than younger workers. As for the impact of training on the workers' hourly pay rate, if other variables are fixed, 100 hours of formal training can raise their hourly pay 10 cents. Different types of formal training had very different impacts on the workers' hourly pay. Among seven surveyed formal training types, union apprenticeship training, company non-union apprenticeship training and vocational training can significantly raise worker's hourly pay by 3.58 dollars, 1.15 dollars and 0.54 dollars respectively.

Table 5. 21: Reduced Model of Multiple Regression Analysis (R^2=0.292)

Independent Variables	Regression Coefficient	Std. Error	T-Value	P-Value
Constant	15.55	0.45	34.88	0.00
Years of experience at foreman level	0.15	0.03	4.89	0.00
Time in present company	0.04	0.02	2.70	0.01
Hours of craft training over past 3 years	0.00	0.00	4.17	0.00
Age	0.04	0.01	3.14	0.00
Vocational program	0.54	0.30	1.81	0.07
Union apprenticeship training	3.58	0.32	11.07	0.00
Company non-union apprenticeship training	1.15	0.49	2.34	0.02
Total years of craft experience	0.02	0.01	1.94	0.05

Next, the RT-231 study grouped the craft workers based on their primary trade. Total workers in the survey were divided into civil workers, piping workers, electricians and other mechanical workers. Following similar procedures, the study established a regression model to investigate the impact of training on the hourly wage of different trades. The study found the impact of training on hourly wage varied for different trades. If other variables are fixed, 100 hours of formal training can raise the hourly wage of electricians by 1 dollar, of a civil worker by 10 cents, and of other mechanical workers by 5 cents. The data did not reveal a statistically significant impact of training on piping worker's hourly wage.

5.2.2 Impact of Training on Worker's Career Satisfaction

The RT-181 survey asked respondents to rate their career satisfaction based on a 1 to 5 scale, with 1 standing for very dissatisfied and 5 standing for very satisfied. The RT-231 study calculated the average career satisfaction index for workers having received formal training and for workers having never received formal training. The results are listed in Table 5.22. The workers with formal training had a higher average career satisfaction index than workers without formal training.

Table 5. 22: Career Satisfaction Rates by Worker's Training Experience

Groups	N	Mean	Std. Deviation	Std. Error Mean
Workers without formal training	403	**3.44**	1.15	0.06
Workers with formal training	447	**3.71**	1.00	0.05

Next, the RT-231 study used a T-test to compare the average career satisfaction index between the two groups (Table 5.23). The results showed that the difference were highly statistically significant, which means that the career satisfaction index of workers with formal training experience is higher than those without formal training.

Table 5. 23: T-test Results on Career Satisfaction Rates

Mean Difference	Std. Error	t	df	Sig. (2-tailed)	95% Confidence Interval of the Difference	
-0.27	0.07	-3.61	802.56	0.00	-0.41	-0.12

The RT-231 study also sorted career satisfaction rates by the different formal training methods. The results showed that workers receiving union apprenticeship training had the highest career satisfaction rate and workers completing company non-union apprenticeship training had the second highest career satisfaction rate (Table 5.24).

Table 5. 24: Career Satisfaction Rates Sorted by Training Methods

Training Methods	Career Satisfaction Rates
Union apprenticeship training	3.97
Company non-union apprenticeship training	3.86
Company craft certification	3.67
NCCER Training	3.66
Vocational program	3.63
Basic Military training in construction	3.57
Military "C" school training in a craft	3.55

5.2.3 Summary

Using the RT-182 data, the RT-231 researchers find that the craft training can increase the salary of a worker. On average, 100 hours of craft training can raise an hourly wage by 10 cents. Different types of training have quite different impacts on a worker's wage. Completion of union apprenticeship training, company non-union apprenticeship training and vocational training can raise a worker's hourly pay by 3.58 dollars, 1.15 dollars and 0.54 dollars respectively. The impact of training on wages varies for different trades. The study found the impact of training on hourly wage varied for different trades. If other variables are fixed, 100 hours of formal training can raise the hourly wage of electricians by 1 dollar, of civil workers by 10 cents, and of other mechanical workers by 5 cents.

The RT-231 researchers also found that craft training can raise the career satisfaction of workers. Workers completing craft training have significantly greater career satisfaction than workers without craft training. The impact of training on career satisfaction varies for different types of training. Workers with union apprenticeship training have greater satisfaction with construction than workers receiving other types of training.

5.3 Analysis of CCIS Research Data on Craft Workers' Experiences with and Attitudes Towards Multiskilling

This previous research was sponsored by the Alfred P. Sloan Foundation's Center for Construction Industry Studies (CCIS) at the University of Texas at Austin. The research aimed to determine construction craft worker's attitudes towards and experiences with the labor utilization strategy known as multiskilling. Over 1,100 craft workers across the United States were surveyed as part of the CCIS research effort.

The average age of the CCIS respondents is 39.3 years with a standard deviation of 11.2, which corresponds to the national average for construction workers in Center for Worker's Right (CPWR) survey (2002) which is 38.7 years. 33% workers were union members and 67% were not. The percent of union workers in the survey respondents were higher than 19% national average (CPWR 2002).

5.3.1 Why Craft Workers Leave the Construction Industry

Among 1,013 workers who answered the question "Are you going to leave the construction industry within next year?", 144 workers (13.9%) indicated that they would. The CCIS survey further investigated the reason causing workers to leave construction. Figure 5.8 shows that the top three reasons are poor pay, a dislike of frequent layoffs and lack of benefits.

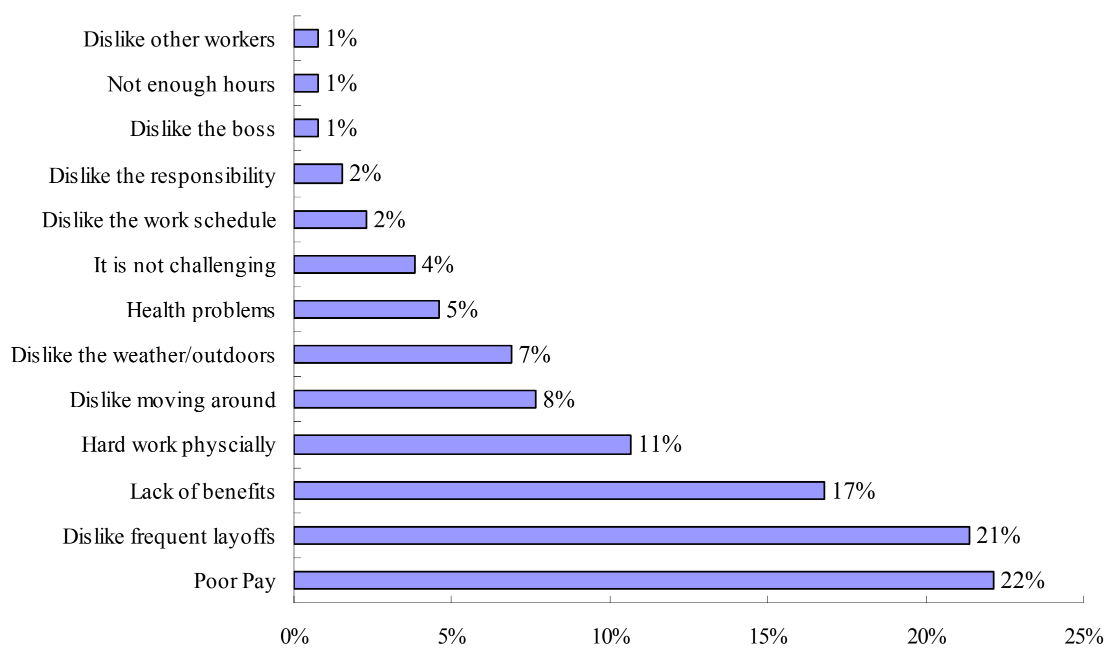


Figure 5. 8: Reasons for Leaving the Construction Industry (Haas et al 1999)

5.3.2 The Impact of Current Craft Training on Workers' Attitude towards Construction Careers

The survey investigated how workers acquired the skills in their primary trade by asking them to choose only one training source from a list of common training programs. Figure 5.9 shows that 48.35% of workers acquired skills from informal on the job training, 20.72% of workers from union apprenticeship training and 13.82% of workers from company provided training. The CCIS results show that in construction, informal on-the-job training is the major method for workers obtaining their skills.

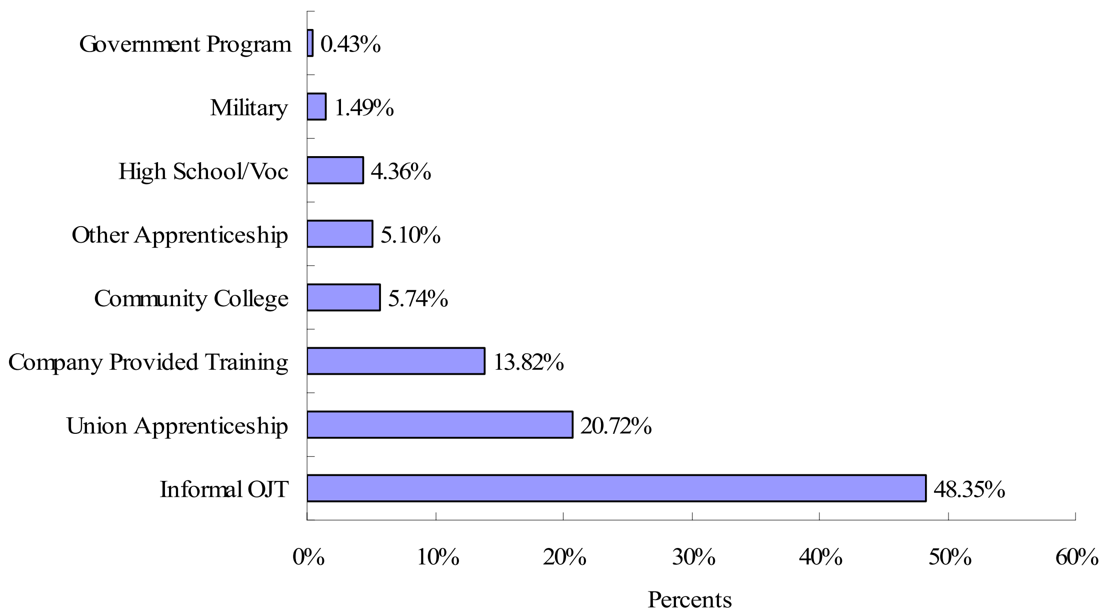


Figure 5. 9: Primary Training (Haas et al 1999)

The survey also acquired the workers' attitudes towards the construction industry by asking workers to rate their agreement on fifteen statements on a scale of one to five. A response of one represents strongly disagree and five represents strongly agree. The eighteen statements cover the major aspects regarding the attitudes towards construction, which include:

- I enjoy my work;
- I would like a more challenging job;
- I enjoy working on my current project;

- I work too many hours each week;
- I enjoy working outdoors;
- I should receive better benefits for my work;
- I like my boss. I receive good pay for my work;
- I am given responsibility at work;
- I would like to work more;
- I receive good benefits for my work;
- I should receive more pay for my work;
- I enjoy my work schedule;
- I am given too much responsibility at work;
- My job challenges me. I get plenty of hours to work;
- I enjoy working with the other workers; and
- I enjoy working for my current company.

The RT-231 researchers used an average score of eleven statements (Table 5.25) to establish a comprehensive career satisfaction index (CSI) for each worker (Equation 5.1).

$$\text{Career Satisfaction Index} = \frac{\sum_{i=1}^{11} S_i}{11} \quad \ldots\ldots(5.2)$$

Table 5. 25: Statements Used to Build Career Satisfaction Index

Notation	Statements
S_1	I enjoy my work.
S_2	I enjoy working on my current project
S_3	I like my boss.
S_4	I receive good pay for my work.
S_5	I am given responsibility at work.
S_6	I receive good benefits for my work.
S_7	I enjoy my work schedule.
S_8	My job challenges me.
S_9	I get plenty of hours to work.
S_{10}	I enjoy working with the other workers
S_{11}	I enjoy working for my current company.

Next the study compared the average of CSI of workers receiving different types of training. The study found that the workers receiving union apprenticeship training had the highest CSI (Table 5.26).

Table 5. 26: Career Satisfaction Index Sorted by Types of Craft Training

Types of Training	Number of Responses	Career Satisfaction Index
Union Apprenticeship	195	4.10
Government Program	4	4.00
Community College	54	3.82
Military	14	3.79
Informal on-the-job Training	455	3.73
Company Provided	130	3.73
Other Apprenticeship	48	3.72
High School/VOC	41	3.68

The RT-231study performed an ANVOA to identify whether the training types have a significant impact on workers CSI values. Table 5.27 shows that different types of training have a significant impact on workers' CSI value.

Table 5. 27: ANOVA for Career Satisfaction Index

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	21.50	7.00	3.07	6.55	0.00
Within Groups	437.53	933.00	0.47		
Total	459.03	940.00			

As a follow-up analysis, least square comparison tests were performed by RT-231 researchers to determine which training types had significant differences between each other regarding the

CSI value. In Table 5.28, the training types sharing the same letter do not have a significant difference in CSI value at a level of 0.05. The results show that only workers receiving union training have a significantly higher CSI values than other types of training.

Table 5. 28: A Hierarchy of Career Satisfaction

Types of Training	Career Satisfaction Index	Hierarchy
Union Apprenticeship	4.10	A
Government Program	4.00	B
Community College	3.82	B
Military	3.79	B
OJT	3.73	B
Company Provided	3.73	B
Other Apprenticeship	3.72	B
High School/VOC	3.68	B

5.3.3 The Impact of Additional Craft Training on Workers' Attitude towards Construction Careers

The survey also included questions which asked the workers what their attitudes towards the construction career would be if they could receive training and obtain additional skills. Fourteen statements were included, and workers were asked to rate their agreement on a scale of 1 to 5. A response of one represents strongly disagree and five represents strongly agree. T-tests were used to compare the average score of each statement with *3* (Neutral). Table 5.29 shows the test results.

Table 5. 29: Workers' Attitude towards Construction Career after Multiskilled

Statements	Mean (M)	M-3	T-value
I would enjoy my work more.	3.77	0.77	20.92**
I would work on the same project longer.	3.51	0.51	13.19**
I would have more responsibility with my job.	3.59	0.59	15.52**
My job would be more mentally challenging	3.66	0.66	16.95**
I would receive better pay for my work.	3.52	0.52	11.60**
My work would be more rewarding	3.59	0.59	14.81**
I would receive better benefits for my work.	3.11	0.11	2.65*
My boss would expect more work form me.	3.30	0.30	7.49**
I would get to work more hours.	3.16	0.16	4.13**
I would work for the same company longer.	3.60	0.60	15.15**
I would be forced to work more hours.	*2.70*	*-0.30*	*-8.07***
My work would be more physically demanding.	*2.89*	*-0.11*	*-2.72**
I would receive the same pay.	*2.93*	*-0.07*	*-1.65*
I would have a better work schedule.	*2.79*	*-0.21*	*-5.71***

* The difference is significant at the level 0.05

** The difference is significant at the level 0.01

The T-tests results show that ten of the average scores are significantly higher than *3* (neutral), which indicates workers agree with these statements. Workers believe that training would:

- Allow them to enjoy their work more;
- Stay on a project longer;
- Allow for more responsibility with their job;
- Offer a more challenging job;
- Provide better pay for their work;
- Provide for more rewarding work; and
- Allow workers to work for the same company longer.

Although the scores may seem indecisive numerically, a frequency distribution diagram indicates otherwise. Figure 5.10 illustrates the frequency distributions of respondent answers for each statement. The RT-231study found that the percentage of workers who strongly disagree /disagree (scale 1 and 2) only accounts for very small proportion of the workers.

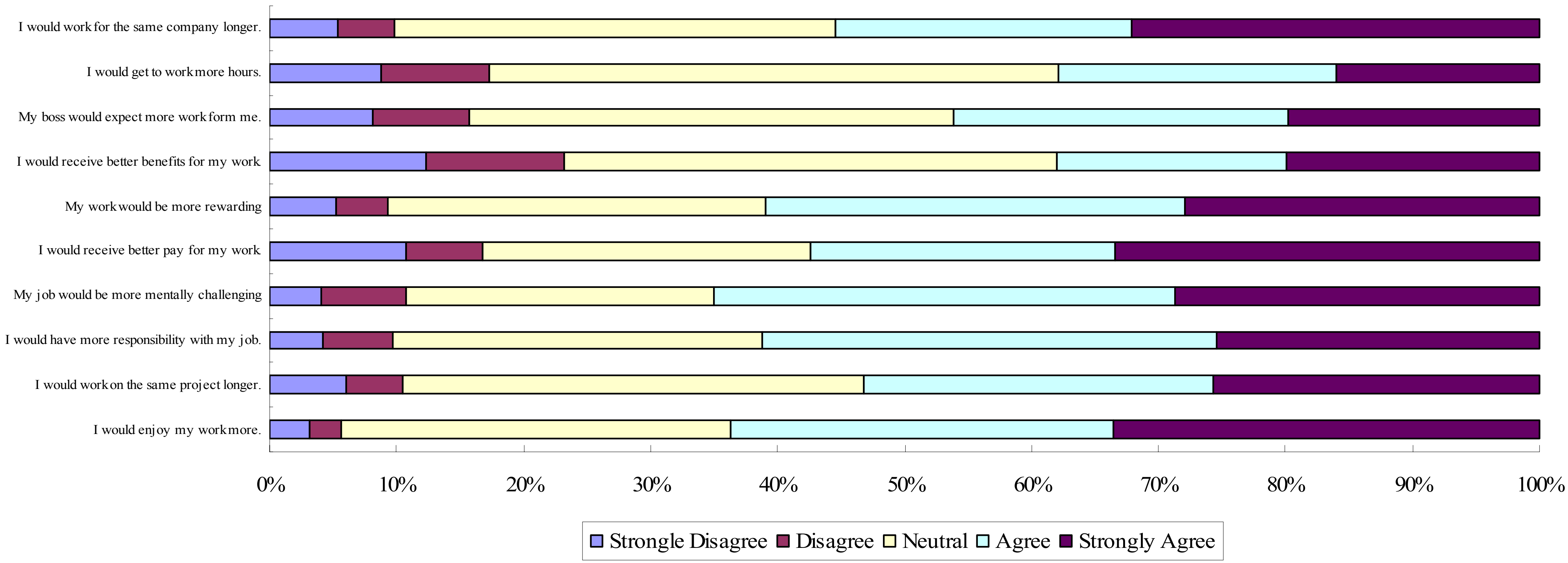


Figure 5. 10: Proportions of Workers' Ratings

Four average scores are lower than *3* and three of them significantly lower according to T-tests, which indicate that workers disagree with the following statements that training would:

- Force workers to work more hours;
- Cause more physically demanding from the work;
- Receive the same pay; and
- Have a better work schedule.

5.3.4 The Best Methods to Learn Construction Skills from the Workers' Perspectives

The CCIS survey asked workers to choose the best ways to learn construction skills based on their experience. The RT-231 study found that 35.6% of workers chose informal on-the-job training as the best way to acquire craft skills, 27.1% of workers chose company provided training and 22.4% of workers chose union apprenticeship training (Figure 5.11).

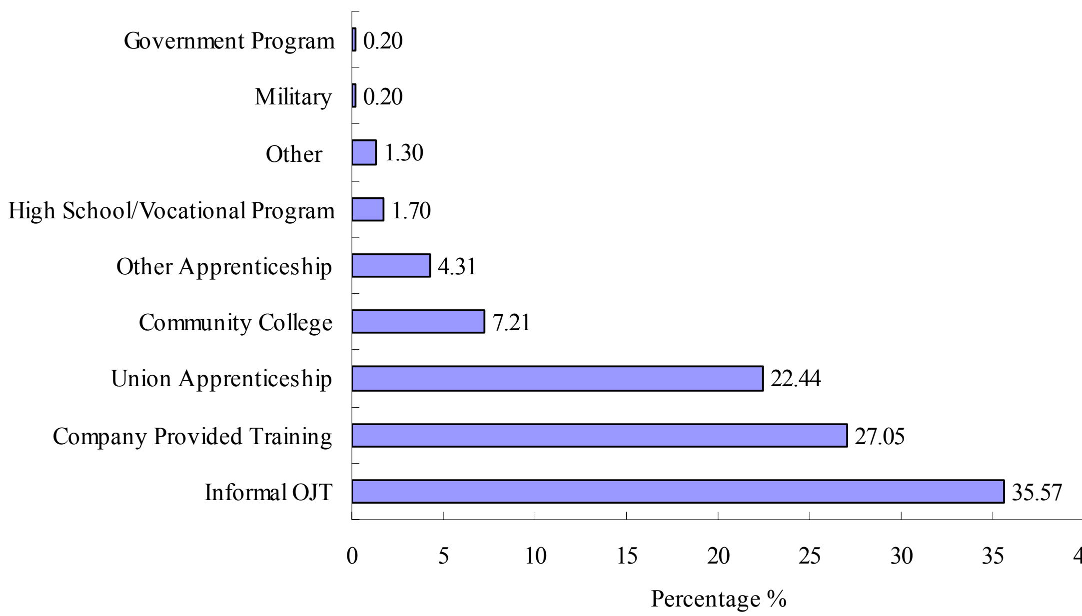


Figure 5. 11: Best Ways to Acquire Craft Skills (Haas et al 1999)

5.3.5 Summary

The RT-231 researchers identified the career satisfaction of workers receiving different types of craft training. Workers receiving union apprenticeship training have a greater satisfaction with construction than workers receiving other types of training. The results echo the findings in the RT-182 data analysis. The survey respondents strongly welcome craft training and the opportunity to acquire additional skills. They believe that training can allow them to enjoy their work more, to stay on a project longer, to allow for more responsibility with their job, to offer a more challenging job, to provide better pay for their work, to provide for more rewarding work, and to allow workers to work for the same company longer. Among different types of training, on-the-job training (OJT) is completed by majority of craft workers.

5.4 Analyze Data of National Longitudinal Survey for Youth

The National Longitudinal Survey of Youth (NLSY) is a dataset of 12,686 young men and women who were between the ages of 14 and 22 in 1979 and who have been interviewed annually since that year. “Training” is one of the sections in the NLSY survey, which collects information about formal and informal training received by individuals. In general, the “Training” section of each NLSY79 questionnaire:

- Collects information on each respondent’s participation in a training program since the date of the last interview; and
- Confirms and updates information on the training programs in which each respondent was enrolled on the date of last interview.

A key feature of the NLSY is that it collected information in an event history format, in which dates were collected for the beginning and ending of important life events. In particular, the start and end dates of all jobs were recorded, as well as the timing of the training programs. Based on the timing of these events, it is possible to create measures of training received on a current job, along with measures of training received prior to the current job. Meanwhile, the NLSY collected information regarding individual demographic characteristics, employment history and income, which allows the research to compare the training characteristics between groups having different demographic backgrounds and to establish a regression model to evaluate the returns of training.

5.4.1 Formal Training Rates for Construction Workers

Before the 1988 survey, the training received by a survey participant had to be longer than one month before it was recorded in the NLSY. As a result, this training duration restriction may eliminate some task training received by individuals. However, since 1988 the training duration restriction has been removed in the survey. The respondents were asked to report about all types of training since the last interview, regardless of duration.

The RT-231 study identified the percent of construction workers receiving formal training from 1988 to 2002. Figure 5.12 shows the numbers fluctuate from 7% to 19.8%.

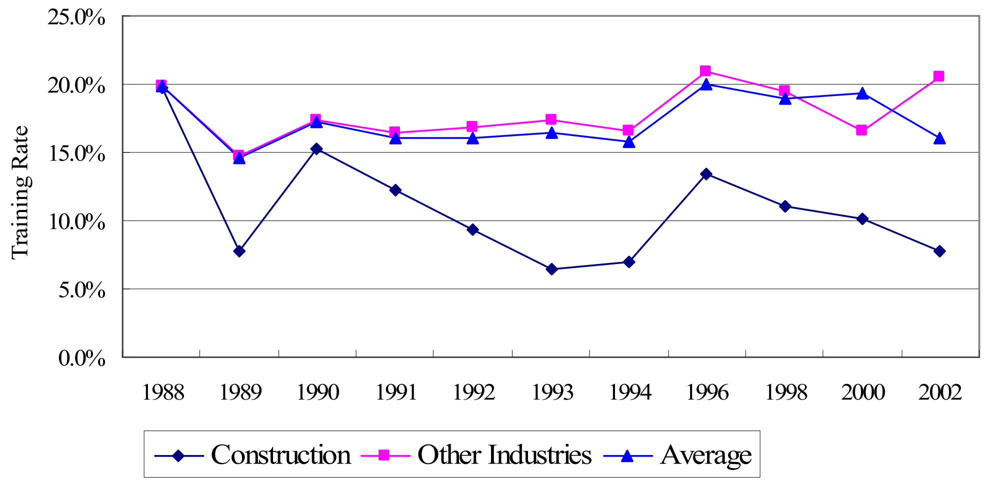


Figure 5. 12: Training Percentage from 1988 to 2002

The RT-231 study also found that the percentage of workers receiving formal training in construction is lower than the percentage of workers receiving formal training in other industries. The results echoed the findings from The survey of Employer-Provided Training (SEPT, 1995), that formal training only accounts for a small portion of total training hours for construction industry workers and a large portion of training in construction is informal training.

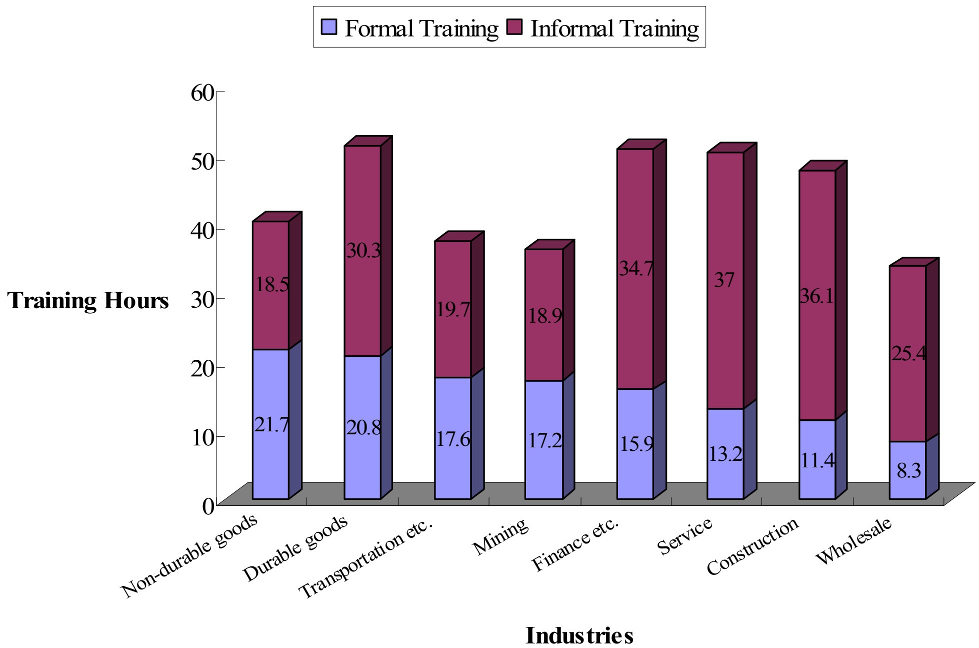


Figure 5. 13: Composition of Training Hours

5.4.2 Usefulness of Formal Training

The NLSY asked those who received formal training to indicate whether or not the training was useful in their job. The RT-231 researchers grouped the participants according to their industry. The usefulness of training in the construction industry was measured and compared with other industries. The study found that the rates of construction workers finding formal training useful in their work was quite high, from 74.8% in year 1992 to 100% in year 1991. There are some trivial differences between construction workers and other industry workers regarding the usefulness of formal training, but the Chi-square tests do not show that the differences are statistically significant.

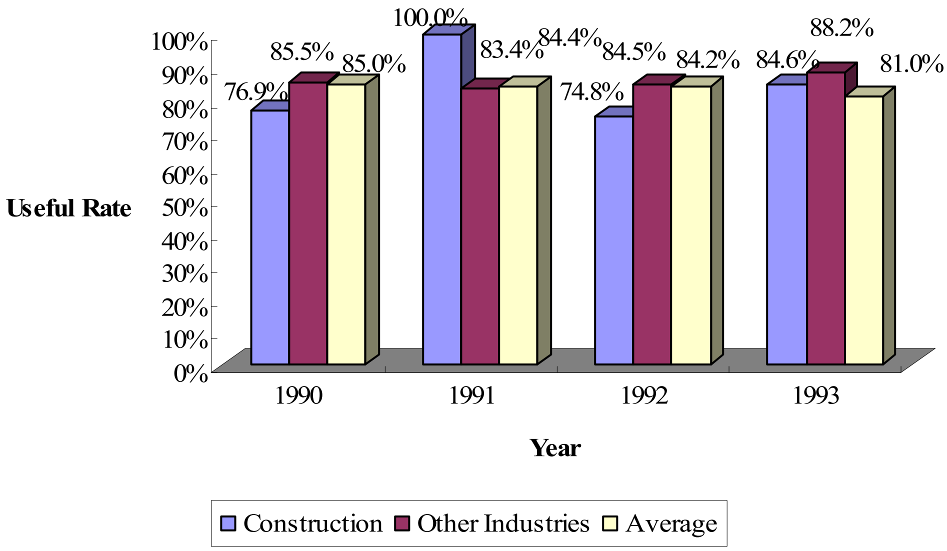


Figure 5. 14: Percents of Workers Believing Training is Useful

5.4.3 Usefulness of Informal Training

In the 1993 survey, the NLSY collected data about evaluations of informal training, such as time spent with *supervisors* and *coworkers* on learning new skills. The survey asked: "*How many of the skills that you learned during the time that you spent with your supervisors/coworkers do you think would be useful in doing a different kind of work for your current employer?*" Respondents were asked to choose one of the following five options: "all help", "more than half help", "about half help", "less than half help" and "non-help". A weighted average rate was calculated by RT-231 study in Table 5.30. If 0 represents that skills learned from supervisors are not helpful and 1 represents that all skills learned from supervisors are helpful, the average usefulness rating of new skills learned by construction workers from their supervisor is 0.685 and the average usefulness rating of skills learned from coworkers is 0.641. These results indicate that craft workers generally agree that skills learned from informal training are helpful.

Table 5. 30: Usefulness of Informal Training I

Options	Percent (1)	Weight (2)	Weighted Score (1)×(2)
Informal Training from Supervisors			
All Help	48.8%	1	0.49
More than Half Help	11.3%	0.75	0.08
About Half Help	17.5%	0.5	0.09
Less than Half Help	10.0%	0.25	0.03
Non-help	12.5%	0	0
		Average Rate	0.685
Informal Training from Coworkers			
All Help	35.1%	1	0.35
More than Half Help	18.9%	0.75	0.14
About Half Help	24.3%	0.5	0.12
Less than Half Help	10.8%	0.25	0.03
Non-help	10.8%	0	0
		Average Rate	0.641

Figure 5.15 shows that 48.8% of craft workers believe that the informal training of supervisors is ALL HELPFUL, which is higher than the 35.1% of craft workers who believe that the informal training from their co-workers is ALL HELPFUL. A Chi-square test shows that the difference between the two ratios is significant at a level of 0.05.

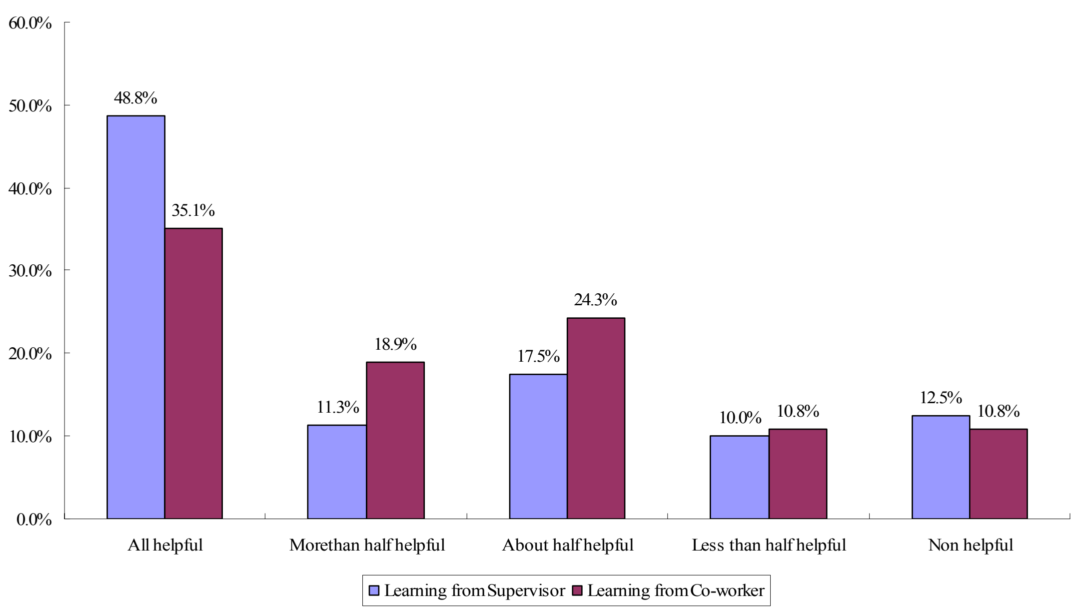


Figure 5. 15: Percents of Workers Believing Informal Training is Useful I

The NLSY survey also asked: "*How many of the skills that you learned during the time that you spent with your supervisors/coworkers do you think would be useful in doing a same kind of work* *for an employer other than the current one?* Survey respondents were asked to choose one of the following five options: "all help", "more than half help", "about half help", "less than half help" and "non-help". A weighted average rate was again calculated by RT-231 study (Table 5.31). The average rate of construction workers regarding the usefulness of skills learned from supervisors to do the same kind of work for a different employer was 0.794, and the average rate of usefulness of skills learned from coworkers was 0.818.

Table 5. 31: Usefulness of Informal Training II

Options	Percent (1)	Weight (2)	Weighted Score (1)×(2)
Informal Training from Supervisors			
0.6	1	0.6	0.60
0.138	0.75	0.1035	0.14
0.163	0.5	0.0815	0.16
0.038	0.25	0.0095	0.04
0.063	0	0	0.06
		Average Rate	0.79
Informal Training from Coworkers			
All Help	0.568	1	0.57
More than Half Help	0.162	0.75	0.12
About Half Help	0.243	0.5	0.12
Less than Half Help	0.027	0.25	0.01
Non-help	0	0	0
		Average Rate	0.82

Figure 5.15 shows that 60.0% of craft workers believe that the informal training of supervisors was ALL HELPFUL in doing the same kind of work for a different employer, which is higher than the 56.8%% of craft workers believing the same regarding the informal training from coworkers. However, the difference between the two ratios was not statistically significant.

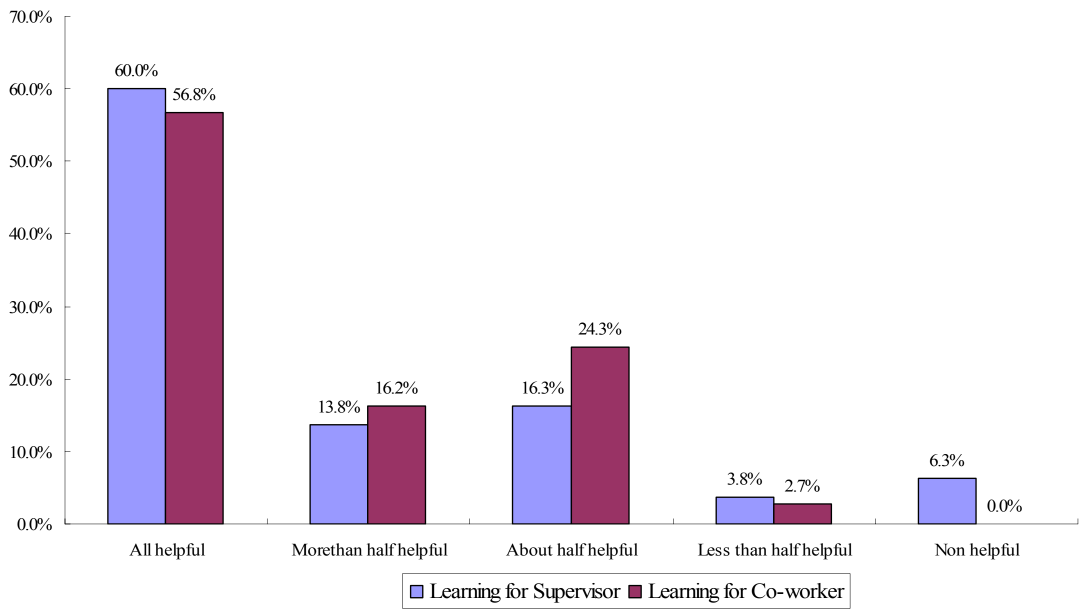


Figure 5. 16: Percents of Workers Believing Informal Training is Useful II

Comparing Table 5.30 and 5.31, the RT-231 study also finds that workers believe that the informal training from supervisors and coworkers is more useful when doing the same kind of job for a different employer than when doing a different job for a current employer.

5.4.4 Effects of Training on Wages Growth

The NLSY collected data on respondents' hourly pay rates and total income over two consecutive surveys. The analyses attempted to identify the relationship between the changes of hourly pay rate / total income and the training received using two consecutive surveys. Data from years 1998 and 2000 was used, and the sample consisted of people from construction related jobs.

Table 5.32 shows that individuals in construction who did not receive training between 1998 and 2000 experienced an average $2.28 increase in their hourly pay rate, meanwhile other respondents who had received training over the same time period experienced an average increase of $5.42.

Table 5. 32: Hourly Pay Rate Changes between 1998 and 2000

Groups	N	Mean ($)
People who did not have training	43	$2.28
People who had training	6	$5.42
Total	47	$2.67

The ANOVA results in Table 5.33 indicate that the difference in hourly pay between individuals receiving and others not receiving training was statistically significant.

Table 5. 33: ANOVA for Hourly Pay Rate Changes

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	51.89	1	51.89	3.74	0.06
Within Groups	652.26	47	13.88		
Total	66425439896	181			

Meanwhile, table 5.34 shows that NLSY survey respondents who did not receive training between 1998 to 2000 experienced an average $4099.88 increase in annual income, and other respondents did receive training over the same time period experienced an average increase of $11,540.48.

Table 5. 34: Total Income Changes between 1998 and 2000

Groups	N	Mean ($)
People who did not have training	161	4099.88
People who had training	21	11540.48
Total	182	4958.41

The ANOVA results in Table 5.35 indicate that the difference in the change in annual pay between individuals receiving and others not receiving training was statistically significant at a level of 0.1.

Table 5. 35: ANOVA for Total Income Pay Rate Changes

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1028465545	1	1028465545	2.38	0.09
Within Groups	65396974351	180	363316524.2		
Total	66425439896	181			

5.4.5 Summary

Based on the analysis of NLSY data, the RT-231 study found that:

- Construction workers have a lower formal training rate than other industry workers;
- A high percent of construction workers agree that both formal and informal training are very helpful in their work;
- Training can significantly increase the hourly pay rate and annual income of construction workers.

CHAPTER 6: ANALYSIS OF WORKER'S PERFORMANCE IN NATIONAL CRAFT ASSESSMENT AND CERTIFICATION PROGRAM

6.1 Introduction of National Craft Assessment and Certification Program (NCACP)

The National Center for Construction Education and Research (NCCER) administers the National Craft Assessment and Certification Program (NCACP) to assess the knowledge competence level of construction craft workers. The core competencies for all assessments are NCCER's Contren® Learning Series standardized curricula. The assessments used by the NCCER were developed under test guidelines endorsed by the American Psychological Association. The NCCER certification program consists of both written and performance skill verification. Successful completion of both written and performance certification by an individual earns the designation of certified plus. Written assessments are administered in either two formats: a paper/pencil version or a computer-based version. Performance assessments are administrated under the observation of a NCCER Certified Performance Evaluator. The assessments may be used for both pre- and post-employment testing. Based on the results of the assessments, a training prescription is provided to all assessed workers. A worker who receives a score above the cut point of a craft assessment is classified as a *PASS*, otherwise training is recommended.

NCACP can provide assessments in the following construction crafts:

- Boiler Technician
- Carpentry Level One
- Commercial Carpentry
- Commercial Electrician
- Concrete Finisher
- Construction Technology
- Core: Introductory Craft Skills
- Electrical Level One
- Electronic Systems Technician
- Finish Carpentry
- Form Carpentry
- Frame Carpentry
- Heavy Equipment Operator Level One
- HVAC
- Industrial Boilermaker
- Industrial Carpentry
- Industrial Electrician
- Industrial Insulation
- Industrial Ironworker
- Industrial Maintenance: Electrical
- Industrial Maintenance: Mechanical
- Industrial Millwright
- Industrial Painter
- Industrial Pipe Fitter
- Instrumentation Fitter
- Instrumentation Technician
- Masonry Level One
- Mobile Crane Operator
- Reinforcing Iron and Rebar
- Rigging Fundamentals
- Rigging
- Scaffold Builder

Meanwhile NCCER also provides assessments on the skills of pipeline workers (Table 6.1).

Table 6. 1: NCCER Pipeline Assessment

Gas	o Gas Maintenance Technician o Gas Pipeline Operations o Abnormal Operating Conditions-Gas
Liquid	o Field and Control Center Operations Technician o Mechanical Pipeline Technician o Abnormal Operating Conditions-Control Center o Abnormal Operating Conditions-General
Liquid and Gas	o Electrical and Instrumentation Pipeline Technician o Corrosion Prevention Field Technician 1-Installation o Corrosion Prevention Field Technician 1-Measurement o Corrosion Prevention Field Technician 2 o Corrosion Prevention Field Technician 3 o NDT: Radiographic Film Interpretation of Pipeline Welds o Pipeline Maintenance Technician

Before a written assessment is administered, information is collected regarding the participants' demographic information and their basic working and training histories (Table 6.2). The database used by the RT-231 study contains information on the participants who took a NCACP written certification exam between 2000 and 2006, and it contained a total of 131,968 records.

Table 6. 2: Information Contained in the NCACP Database

Variable Name	Variable Description
Gender	Male/Female
Race	White/Black/American Indian/Asian or Pacific Islander/Hispanic/Other
Curriculum used	NCCER/Union/Other/No Formal Training
Training provider	Association/Local/Contractor/School
Years of experience	How many years of experience in the job
Experience type	Industrial/Commercial/Residential/Liquid Pipeline/Gas Pipeline
Experience Nature	Construction/Maintenance/Pipeline
Test Sore	The score a worker received in the assessment
Test Results	Pass/Training Recommended
Test Place	The zip code of the test center

Of the 131,968 records contained in the NCACP database, 66,410 involved construction craft assessments and the remaining involved pipeline assessments. The analyses described below focused only on the construction craft assessments.

Based on the NCACP data, the RT-231 study first identified the geographic and demographic characteristics of the NCACP participants. Next, the study compared the performance of participants who have different demographic backgrounds and who work in different construction trades. The study identified the following factors affecting craft worker's performance in the assessments:

- Work Experience;
- Race;
- Training Curriculum, and
- Training Providers.

Linear Regression models and Logistic regression models were established to measure the effects of each factor on the workers' performance in the NCACP.

6.2 The Geographic Characteristics of the NCACP Participants

The NCACP data contained the zip code of the test center where a worker took the assessment. Based on this information, the research located the state where each worker took the assessment. Researchers identified the distribution of NCACP participants and the distribution of passing rates across states.

6.2.1 The Geographic Location of the Number of Participants in NCACP

The study found that the geographical locations of craft workers taking skills assessment were concentrated along the US Gulf Coast. Specifically, the results show that 54.84% of the workers took the assessments in Texas, and 23% of the workers took assessment in Louisiana (Figure 6.1 and Table 6.3).

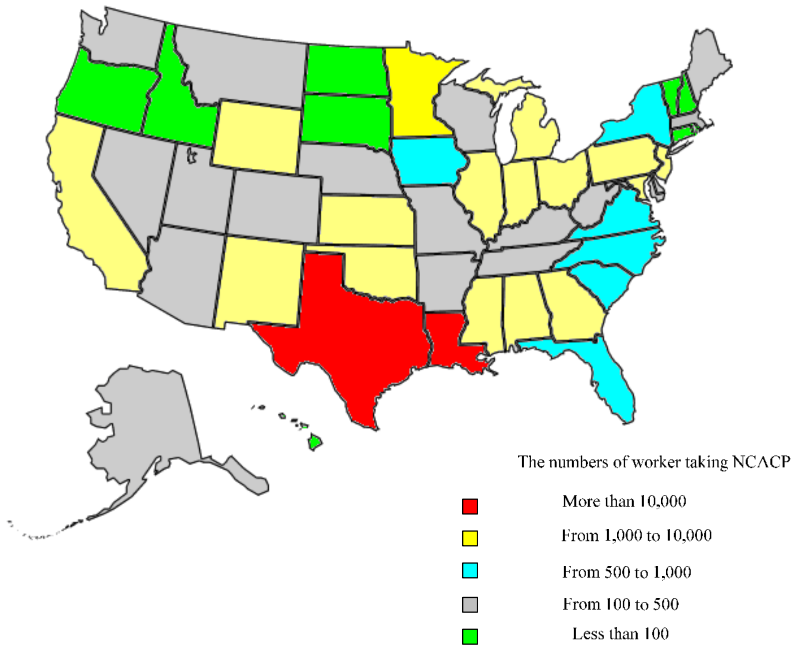


Figure 6. 1: Location of Workers Taking the NCACP Assessment

Table 6. 3: The Number of Construction Workers Taking NCACP Assessment in Each State

State	Number	Percent (%)	State	Number	Percent (%)
Texas	37,514	54.84	Nebraska	96	0.15%
Louisiana	16,273	23.79	Minnesota	95	0.15%
California	2,168	3.17	Indiana	94	0.14%
Mississippi	1,020	1.49	Arizona	93	0.14%
Oklahoma	910	1.33	Utah	76	0.12%
Illinois	862	1.26	Idaho	61	0.09%
Georgia	855	1.25	Kentucky	58	0.09%
Ohio	646	0.94	Kansas	55	0.08%
South Carolina	546	0.80	New York	44	0.07%
Florida	511	0.75	Pennsylvania	40	0.06%
Alabama	292	0.43	Vermont	31	0.05%
North Carolina	292	0.43	Wisconsin	29	0.04%
Michigan	272	0.40	Wyoming	28	0.04%
Tennessee	262	0.38	DC	25	0.04%
Maine	241	0.35	New Mexico	25	0.04%
Delaware	228	0.33	Arkansas	24	0.04%
Maryland	209	0.31	New Hampshire	24	0.04%
Massachusetts	200	0.29	Missouri	23	0.04%
Virginia	190	0.28	Oregon	20	0.03%
New Jersey	187	0.27	Iowa	12	0.02%
Colorado	157	0.23	Connecticut	6	0.01%
Alaska	154	0.23	Rhode Island	2	0.00%
Nevada	131	0.19	Hawaii	0	-
West Virginia	128	0.19	North Dakota	0	-
Montana	109	0.16	South Dakota	0	-

6.2.2 Comparison of Passing Rates of US States

The passing rate of the NCACP written assessment varied by state, ranging from 17.24% to 70.31%, with an average 44.56% among all 50 states and the District of Columbia (Table 6.4).

Table 6. 4: The Passing Rate of NCACP Assessment Sorted by States

State	Passing Rate	State	Passing Rate
West Virginia	70.31%	Texas	45.70%
Oklahoma	65.82%	Washington	45.09%
Michigan	65.07%	Ohio	45.05%
Montana	64.22%	Alabama	44.86%
Arkansas	62.50%	Missouri	43.48%
Georgia	59.18%	South Carolina	43.41%
Idaho	57.38%	Louisiana	42.88%
Virginia	56.32%	Indiana	42.55%
New Mexico	56.00%	Delaware	42.11%
Oregon	55.00%	Colorado	41.40%
Florida	54.60%	Illinois	39.44%
New York	54.55%	Maryland	39.23%
Utah	52.63%	New Jersey	38.50%
Vermont	51.61%	Maine	35.68%
Connecticut	50.00%	Kansas	34.55%
Iowa	50.00%	Arizona	32.26%
Kentucky	50.00%	California	30.86%
New Hampshire	50.00%	Wisconsin	27.59%
Wyoming	50.00%	Pennsylvania	27.50%
Nevada	49.62%	Alaska	23.38%
Tennessee	49.62%	Minnesota	14.74%
Massachusetts	49.50%	Washington DC	12.00%
North Carolina	48.97%	Rhode Island	0.00%
Mississippi	48.14%		
Nebraska	46.88%		

6.3 Demographic Characteristics of the NCACP Participants

6.3.1 Ethnic Background

Based on the NCACP data, the research found that 60.74% of workers taking the NCACP assessment were White. Hispanics accounted for 25.36%, followed by Blacks at 10.9%, American Indians at 1.4% and Asians at 0.70% (Figure 6.2). According to the Bureau of Labor Statistics report (BLS 2006), 69.9% of the construction work force is White, 23.0 % Hispanic and 5.9% black in 2005. Comparing the ethnic composition of the construction work force and the ethnic composition of NCACP participants, the study found that the percentage of White workers taking the NCACP was lower than the percentage of White workers in the construction work force. On the other hand, the percentages of Hispanic and Black workers taking the NCACP were higher than the percentages of these workers in the construction work force.

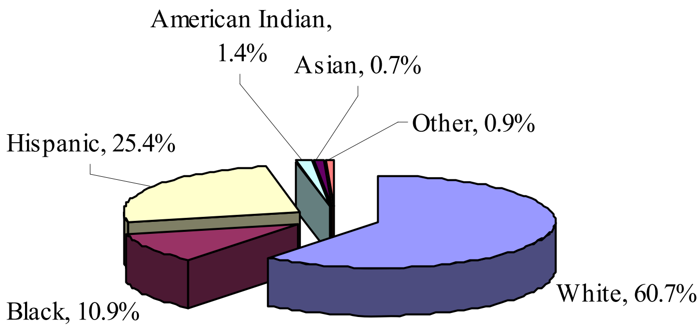


Figure 6. 2: Distributions of NCACP Participants by Race

6.3.2 Gender

The research found that males were predominant in the NCACP; only 2.12% of the workers completing the NCACP were female (Figure 6.3). However, CII (Haas, 2003) reported that women only account for 9% of construction occupations; 47% of women in construction hold clerical or support positions and only 2% of journey-level workers are women. Therefore, the gender composition of the NCACP database does mirror the gender composition of the national construction work force.

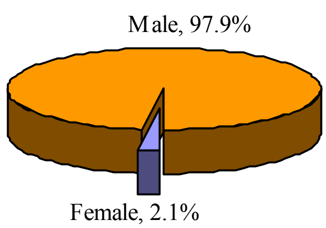


Figure 6. 3: Distributions of NCACP Participants by Gender

6.3.3 Work Experience

The NCACP data showed the workers averaged 9.23 years of construction work experience. The RT-231 study grouped the workers based on their years of work experience (Figure 6.4).

Among workers taking the NCACP, 44.7% of workers had less than 5 years experience in construction, 21.1% had five to ten years experience, 13.5% had ten to fifteen years experience, 8.7% had fifteen to twenty years experience, 5.6% had twenty to twenty-five years experience, 4.1% had twenty-five to thirty years experience and 2.3% had more than thirty years experience.

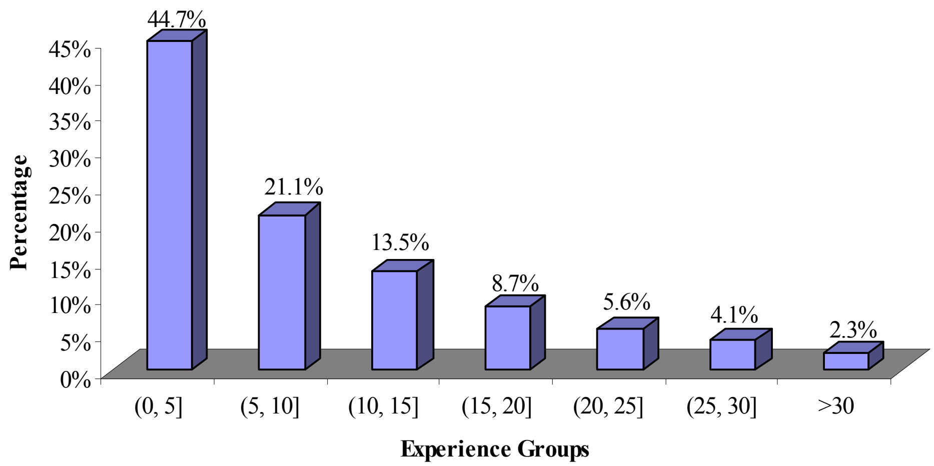


Figure 6. 4: Distributions of NCACP Participants by Work Experience

6.3.4 Construction Trades

The RT-231 study identified that forty-five skill assessment exams, which were administrated in the NCACP for construction craft workers, involved 19 construction trades. The study grouped workers according to the trade in which an assessment was taken by the worker. Table 6.5 and 6.6 show the details about trade grouping and the number of workers in each trade.

Table 6. 5: Construction Trades in the NCACP (1)

Construction Trade	Skill Assessment Exams	Number of Workers Attended	Number of Workers in the Trade
Boilermaker	Boiler Technician	1059	7579
	Industrial Boilermaker I	2834	
	Industrial Boilermaker II	3686	
Carpenter	Carpentry Level One	28	4819
	Commercial Carpentry	382	
	Finish Carpentry	65	
	Form Carpentry	125	
	Frame Carpentry	42	
	Industrial Carpentry I	2898	
	Industrial Carpentry II	1279	
Concrete Finisher	Concrete Finisher	119	119
Crane Operator	Mobile Crane Operator	945	945
Electrician	Commercial Electrician I	224	10936
	Commercial Electrician II	73	
	Electronic Systems Technician	249	
	Industrial Electrician I	6631	
	Industrial Electrician II	3321	
	Industrial Maintenance: Electrical I	181	
	Industrial Maintenance: Electrical II	257	
Instrument Fitter	Instrumentation Fitter I	1013	1467
	Instrumentation Fitter II	330	
	Instrumentation Fitter III	124	
Instrument Technician	Instrumentation Technician I	1330	2245
	Instrumentation Technician II	441	
	Instrumentation Technician III	474	
Insulation	Industrial Insulation I	2284	3152
	Industrial Insulation II	868	
Millwright	Industrial Millwright I	3230	4737
	Industrial Millwright II	1507	

Table 6. 6: Construction Trades in the NCACP (2)

Construction Trade	Skill Assessment Exams	Number of Workers Attended	Number of Workers in the Trade
Pipe Fitter	Industrial Pipe Fitter I	11233	16453
	Industrial Pipe Fitter II	5220	
Reinforcing Rodman	Reinforcing Iron and Rebar	87	87
Rigger	Rigging Fundamentals	1482	1523
	Rigging	36	
	Pilot Specialized Rigging	5	
Ironworker	Industrial Ironworker I	2426	3714
	Industrial Ironworker II	1288	
Painter	Industrial Painter I	2197	2986
	Industrial Painter II	789	
Scaffold Builder	Scaffold Builder	6231	6231
Mechanical	Industrial Maintenance: Mechanical I	722	1081
	Industrial Maintenance: Mechanical II	359	
HVAC	HVAC	336	336
	Total	68410	68410

Pipe fitter, electrician and boilermaker were the three largest construction trades represented in the NCACP database. They account for 24.1%, 16.0% and 11.1% of the total workers respectively (Figure 6.5).

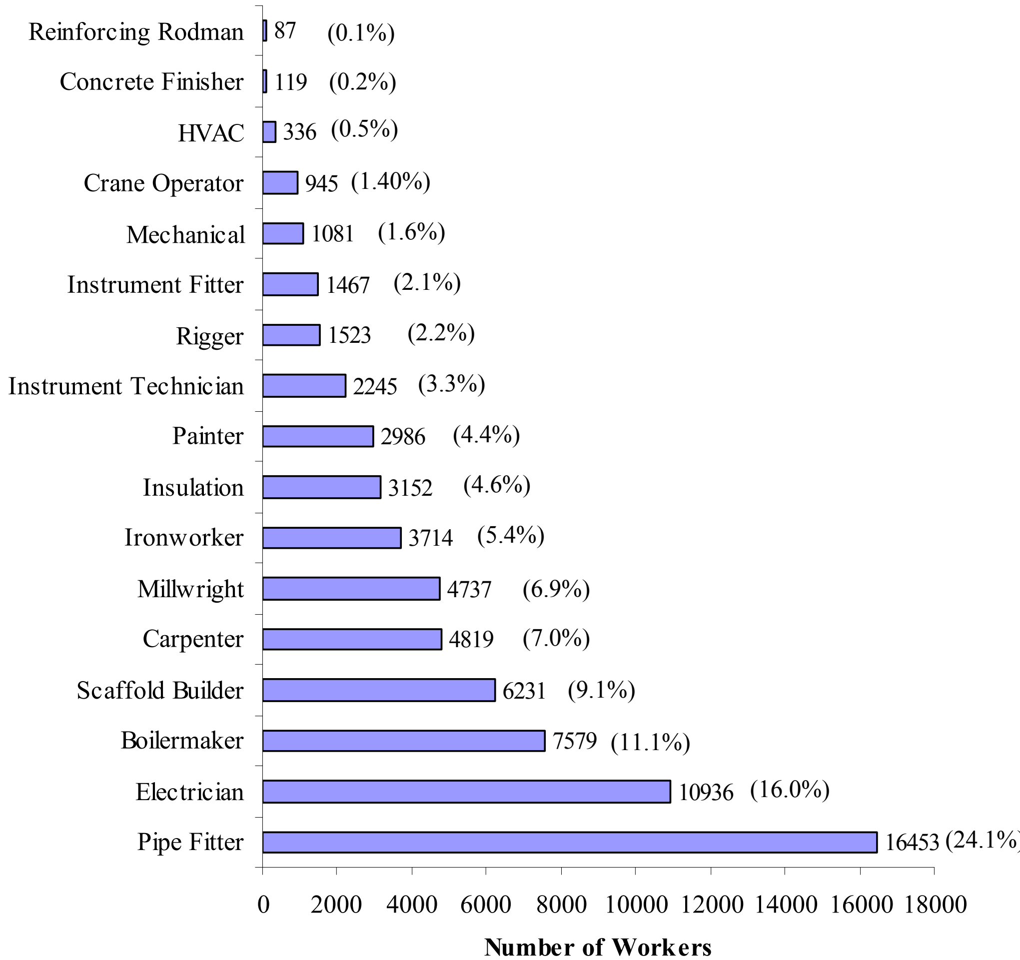


Figure 6. 5: Number of NCACP Participants by Trades

6.4 Types of Training Received by NCACP Participants

The study analyzed the training experience of the NCACP participants and identified how race and years of experience were associated with the type of training curriculum and training providers utilized by the participants.

6.4.1 Training Curriculum

The NCACP asked workers to choose the training curriculum they used to complete their formal training, which included NCCER, training in a union program, other curriculums or no formal training. Other curriculums may be specific to a particular contractor or vendor. The NCACP data shows that 28.8% of the workers taking the NCACP assessments chose NCCER as their training curriculum, 4.7% of the workers used a union training curriculum, 26.6% of workers used training curriculums other than NCCER and union, and 39.8% of the workers took the assessment without having formal training (Figure 6.6).

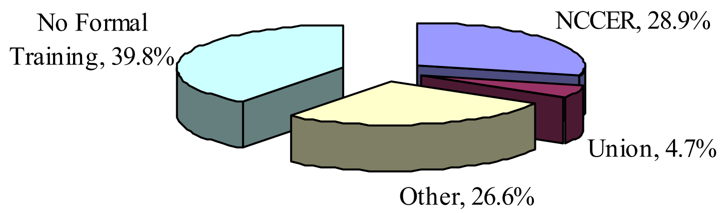


Figure 6. 6: Distribution of Training Curriculum

The study further analyzed the effect of work experience on training experience. The workers were regrouped based on years of experience, which was discussed in Section 6.3.3. The percentages of workers receiving formal training and non-formal training within each experience group are shown in Table 6.7.

Table 6. 7: Percent of Types of Training Sorted by Work Experience

Years of Experience	Without Formal Training		Formal Training		Total
	Number	Percentage	Number	Percentage	
(0, 5]	7915	45.6%	9447	54.4%	17362
(5, 10]	5345	41.7%	7459	58.3%	12804
(10, 15]	3038	37.5%	5065	62.5%	8103
(15, 20]	1781	34.6%	3366	65.4%	5147
(20, 25]	994	29.9%	2334	70.1%	3328
(25, 30]	688	28.2%	1751	71.8%	2439
>30	384	27.7%	1002	72.3%	1386
Total	20145	39.8%	30424	60.2%	50569

Based on Table 6.7, the percentages of workers receiving formal training ascended as the years of experience increased. Intuitively, a worker having more work experience in construction has had greater opportunities to receive formal training compared to workers with less experience. Table 6.8 shows the results of the Chi-square test, which compared the percentages of workers receiving formal training within each experience group. The results indicated that the difference of percentages between different experience groups was significant at a level of 0.01.

Table 6. 8: Test of the Percentage of Types of Training between Work Experiences

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	697.19	6	0.00
Likelihood Ratio	710.45	6	0.00
Linear-by-Linear Association	684.59	1	0.00
N of Valid Cases	50569		

Next, the study analyzed the effect of race on receiving training. The percentages of workers receiving formal training and non-formal training within each race category are shown in Table 6.9.

Table 6. 9: Percentage of Training vs. No Training Sorted by Race

Race	Without formal Training		Formal Training		Total
	Number	Percentage	Number	Percentage	
White	10186	37.6%	16877	62.4%	27063
Hispanic	4942	43.7%	6372	56.3%	11314
Black	1830	38.5%	2928	61.5%	4758
Total	16958	39.3%	26177	60.7%	43135

According to Table 6.9, White workers have the highest percentage formal training, and the Hispanic workers have the lowest percentage. Table 6.10 shows the results of the Chi-square test, which compared the percentages of workers receiving formal training within each race. The results indicated that the differences of percentages between different races were significant at a level of 0.01.

Table 6. 10: Test of the Percentage of Types of Training between Races

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	123.72	2	0.00
Likelihood Ratio	122.85	2	0.00
Linear-by-Linear Association	35.23	1	0.00
N of Valid Cases	43135		

For workers receiving formal training, 47.4% used a NCCER training curriculum, 8.0% of used a union curriculum, and 44.7% used some sort of other curriculum (Table 6.11). The study identified the percentages of major races using each formal training curriculum and found that only 2.3% of Hispanic workers used a union curriculum, which was much lower than the total average of 8.0%. 57.4% of Hispanic workers receiving formal training used a NCCER curriculum, which was higher than the total average 47.4%, and 40.3% of Hispanic workers receiving formal training used some sort of other curriculums, which is higher than the average 44.7%. For White workers, 43.6% of those receiving formal training used a NCCER curriculum, which is lower than the total verage 47.4%, 10.1% of them receiving formal training used a union curriculum, which is higher than the total average 8.0%, and 46.3% of them receiving formal training used one of the other curriculums, which is higher than the total average 44.7%. While the relative differences between races are intriguing, the absolute measures are assumed to be skewed considering that the NCACP assessment system is designed for the NCCER curriculum.

Table 6. 11: Percentage of Types of Training by Race

Race	**NCCER**		**Union**		**Other**		**Total**
	Number	**Percent**	**Number**	**Percent**	**Number**	**Percent**	
White	7365	43.6%	1706	10.1%	7806	46.3%	16877
Hispanic	3655	57.4%	147	2.3%	2570	40.3%	6372
Black	1378	47.1%	238	8.1%	1312	44.8%	2928
Total	12398	47.4%	2091	8.0%	11688	44.7%	26177

The study further determined the statistical significance of the difference between the percentages of workers from different races using a curriculum (P_1) and the percentage of total worker using the same curriculum (P_0) by using method of hypothesis test of two proportions. The study calculated Z statistics based on Equation 6.1[3] for each pair of proportions and listed them in the Table 6.12. The Z statistics show that for White workers, the percentages of Whites using union and other curriculums were significantly higher than the average percentages of the total workers using union and other curriculums. For Hispanic workers, the results show the exact opposite pattern; the percentage of Hispanics using a NCCER curriculum was significantly higher than the average percentage of total workers using a NCCER curriculum. For Black workers, the percentage of Blacks using a curriculum did not have a significant difference from the average percentages of the total workers using the same curriculum.

[3] When comparing two proportions, Let P_0 denote the proportion of individuals in the first population for whom a certain statement is true, and let P_1 denote the proportion of individuals in the second population for whom the statement is true. The study wants to conduct a level α test of

$$H_0 : P_0 = P_1 \text{ against } H1 : P_0 \neq P_1.$$

Here, P_0 denotes the fraction of workers using a certain training curriculum among those taking assessment and P_1 denotes the fraction of workers using a certain training curriculum among those passing assessment. The test statistics approximately follows normal distribution and can be determined by the following equation when the sample size is large (more than 30).

$$Z = \frac{P_1 - P_0}{\sqrt{P_1(1-P_1)/n_1 + P_0(1-P_0)/n_0}} \quad \text{.........(6.1)}$$

Where: n_0 and n_1 are sample sizes of two groups.

The test statistics approximately follows normal distribution with mean 0 and variance 1. At a level of 0.05, if $|Z|>1.96$, the study will reject H_0 and believe two proportions are not equal. At a level of 0.01, if $|Z|>2.576$, the study will reject H_0 and believe two proportions are not equal.

Table 6. 12: Z-Statistics for Proportion of Workers by Training Curriculum and Race

	NCCER	Union	Other
White	-7.58**	7.41**	3.26**
Hispanic	14.45**	-22.55**	-6.28**
Black	-0.31	0.26	0.16

* The difference of two proportions is significant at the level 0.05
** The difference of two proportions is significant at the level 0.01

Based on the analysis, the RT-231 study found that:

- Workers with more years of experience in construction had a significantly higher percentage of having received formal training.
- White workers had the highest percentage of those receiving formal training, and the Hispanic workers had the lowest. The difference between the percentages of receiving formal training of White, Black and Hispanic workers were statistically significant.
- The percentage of White workers using a union curriculum was statistically significantly higher than the percentage of union curriculums used by all workers, and the percentage of White workers using a NCCER curriculum was statistically significantly lower than the percentage of NCCER curriculums used by all workers.
- The percentage of Hispanic workers using a union curriculum was statistically significantly lower than the percentage of union curriculums used by all workers, and the proportion of Hispanic workers using a NCCER curriculum was statistically significantly higher than the percentage of NCCER curriculums used by all workers.

6.4.2 Training Provider

The RT-231 study focused on workers who had received formal training and identified where the workers received their training. The NCACP asked workers to choose the training providers from a list consisting of contractor training, association training, school training and local union training. Association training includes training programs offered by organizations such as the Associated Builders and Contractors (ABC) and the Associated General Contractor (AGC). School training includes community colleges, vocational institutes or independent trade schools. Based on the data, the study found that the majority (66.2%) of the NCACP participants obtained training from contractors, 15.2% of the participants were trained by schools, 11.3% of the participants were trained by associations, and 7.2% were by local unions (Figure 6.7).

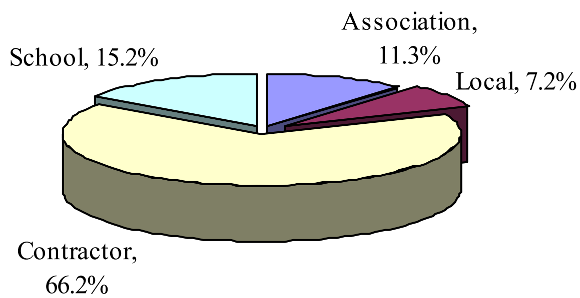


Figure 6. 7: Distributions of Training Providers

Next, the RT-231 study identified the percentages of workers in each race trained by different training providers (Table 6.13). The study found that for White and Black workers, the percentage of the NCACP participants trained by associations, local union and schools was higher than the overall average percentage of workers trained by associations (13.8%), contractors (8.8%) and schools (18.3%). For the Hispanic workers, the percentage of them trained by contractors was higher than the overall average percentage of workers trained by contractors (59.2%).

Table 6. 13: Percentage of Workers by Training Providers and Races

Race	Association		Contractor		Local		School	
	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
White	2296	14.6%	8656	54.9%	1690	10.7%	3137	19.9%
Hispanic	652	11.0%	4343	73.1%	245	4.1%	701	11.8%
Black	408	15.2%	1444	53.7%	215	8.0%	622	23.1%
Total	3356	13.8%	14443	59.2%	2150	8.8%	4460	18.3%

The RT-231 study calculated Z statistics based on Equation 6.1 for each pair of proportions and listed them in the Table 6.14. The Z statistics show that for White workers, the percentage of them trained by local unions was statistically significantly higher than the overall average percentage, and the percentage of them trained by contractors was statistically significantly lower than the overall average. The percentage of Hispanic workers trained by contractors was statistically significantly higher than the average, and the percentage of Hispanic workers trained by associations, local unions and schools was statistically significantly lower than the average. The percentage of Black workers trained by schools was statistically significantly higher than the average, and the percentage of Black workers trained by contractors was statistically significantly lower than the average.

Table 6. 14: Z-Statistics for Proportion of Workers by Training Providers and Races

	Association	Contractor	Local	School
White	0.85	-6.40**	1.96*	1.75
Hispanic	-2.04**	17.70**	-3.32**	-4.80**
Black	0.76	-3.98**	-0.41	2.72**

* The difference of two proportions is significant at the level 0.05
** The difference of two proportions is significant at the level 0.01

6.5 The Factors Affecting Workers' NCACP Scores

Using the NCCER data, the study identified the effect of race, work experience, training curriculum and training provider on a worker's test score in the NCACP assessments.

6.5.1 The Effect of Race on NCACP Score

The study found that different racial groups had very different performances on the NCACP (Table 6.15). The overall average score for workers taking the NCACP assessment is 67.02. White workers have the highest average score of 70.39, and Black workers have the lowest average score, at 57.58.

Table 6. 15: Average Score of Different Ethnic Groups

Race	Average Score	N	Std. Deviation
White	70.39	30306	13.63
Hispanic	63.39	12642	15.45
Black	57.58	5450	16.02
American Indian	64.75	714	15.48
Asian	59.66	348	15.58
Other	64.92	432	16.27
Total	67.02	49892	15.14

Next the RT-231 study focused on comparing the average scores between major racial groups (White, Hispanic and Black) (Table 6.16). A One-way ANOVA test in Table 6.16 shows that average scores are statistically significantly different between racial groups.

Table 6. 16: ANOVA for Different Ethnic Groups

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	996223.84	2.00	498111.92	2400.44	0.00
Within Groups	10042362.29	48395.00	207.51		
Total	11038586.13	48397.00			

The following pair-wised comparison analyses were performed to compare the average scores between any of two major racial groups in order to identify which ethnic groups have statistically significant differences in their NCACP assessment scores (Table 6.17). The results in Table 6.17 shows that the average score of White workers is significantly higher than the average score of

Black and Hispanic workers, and the average score of Hispanic workers is significantly higher than that of Black workers.

Table 6. 17: Multiple comparison for Different Racial Groups

(I) Race	(J) Race	Mean Difference (I-J)	Std. Error	Sig.
White	Hispanic	7.00*	0.15	0.00
	Black	12.81*	0.21	0.00
Hispanic	White	-7.00*	0.15	0.00
	Black	5.81*	0.23	0.00
Black	White	-12.81*	0.21	0.00
	Hispanic	-5.81*	0.23	0.00

* The mean difference is significant at the .05 level.

6.5.2 The Effect of Work Experience on NCACP Score

The RT-231 study identified the impact of work experience on the average scores of workers. After grouping the workers based on years of work experience in construction, the study found that as the years of work experience increased, the average score increased as well. The results are shown in the Figure 6.8, where the average score of the group having five to ten years work experience was 4.33 points higher than the group having less than five years work experience. However, the average score of the group having ten to fifteen years work experience was 2.97 points higher than the group having five to ten years work experience, which indicates a diminishing effect of work experience on the assessment scores.

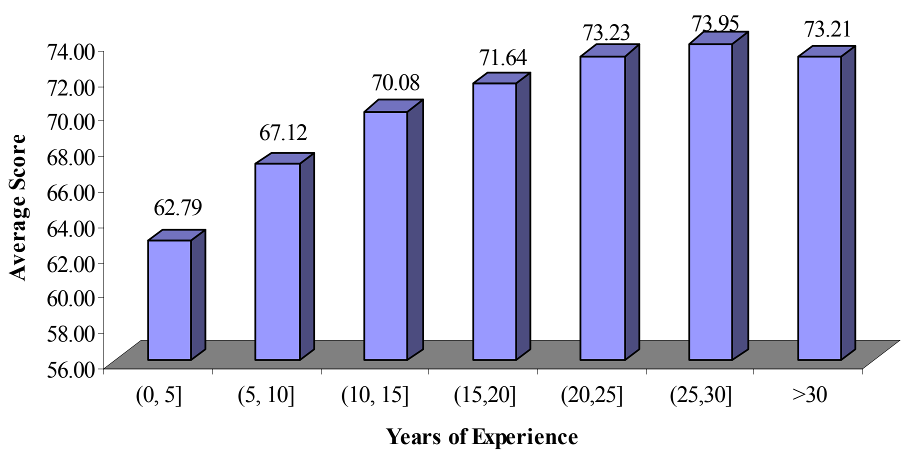


Figure 6. 8: Average NCACP Score by Experience

According to the Figure 6.9, the relationship between years of working experience and average score followed an exponential power function. The study used a non-linear regression method to identify the regression function as

$$Y = 57.913\ X^{0.071}$$

Where Y is the average score and X is years of working experience. The regression function has a R^2 value equal to 0.833, which means 83.3% of the variance within the average score can be explained by the regression function.

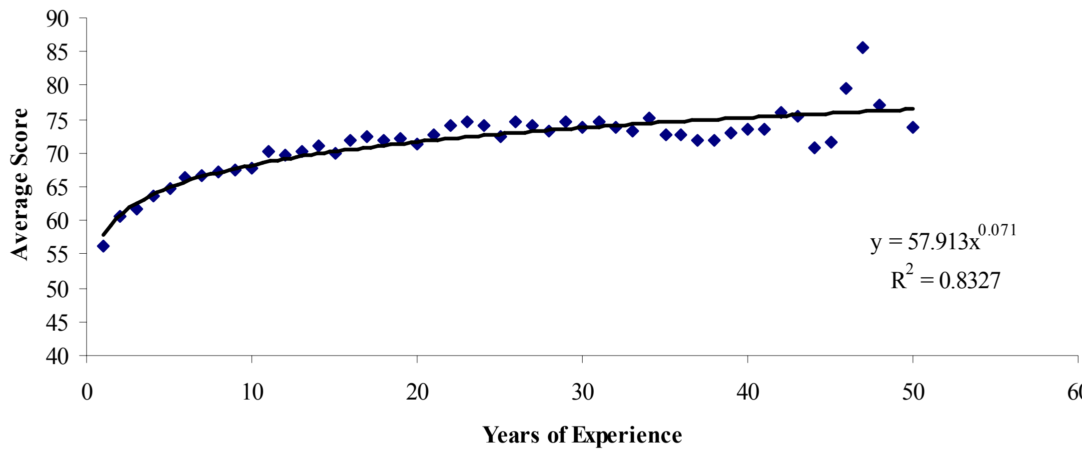


Figure 6. 9: Relationship between Years of Experience and Average NCACP Score

6.5.3 The Effect of Training Experience on NCACP Score

The study identified the impact of training experience on workers' average scores on the NCACP by comparing the average scores of workers using different training curriculums and different training providers.

6.5.3.1 The Effect of Training Curriculum on the NCACP Score

The average score for all workers taking the NCACP assessment was 66.75. For those who used the NCCER, union or another curriculum, the average score was 67.74, 71.96 and 68.02 respectively (Figure 6.10). For those who had no formal training experience, the average score was 64.57.

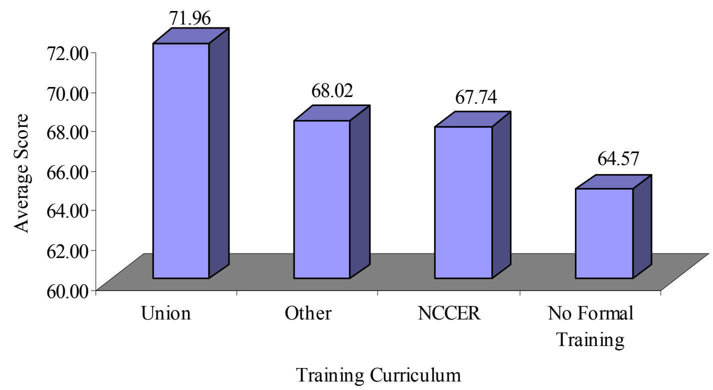


Figure 6. 10: Average NCACP Score by Training Curriculum

Next, the study used a One-way ANOVA to test whether or not there was a statistically significant difference between the average scores of groups using different training curriculums (Table 6.18).

Table 6. 18: ANOVA for Different Curriculums

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	194930.82	3	64976.94	285.61	0.00
Within Groups	11479939.76	50460	227.51		
Total	11674870.57	50463			

Table 6.18 shows that the average scores among groups of workers using different training curriculums have a statistically significant difference. In order to test the difference of the average scores between any two groups, the study performed follow-up tests (post-hoc tests, Table 6.19) using pair-wised multiple comparisons.

Workers using a union training curriculum had the highest average score, which was 4.23 points higher than workers using the NCCER curriculum, 3.94 points higher than workers using other training curriculums, and 7.39 points higher than workers without formal training. The difference in average scores between union training curriculum workers and other groups was statistically significant at a level of 0.05.

Workers without formal training had the lowest average score. It was 3.16 points lower than workers using a NCCER curriculum, 7.39 points lower than workers using a union training curriculum, and 3.45 points lower than workers using another training curriculum. The difference in average scores between workers without formal training and other groups is statistically significant at a level of 0.05.

Table 6. 19: Multiple Comparisons for Different Curriculums

(I) Training	(J) Training	Mean Difference (I-J)	Std. Error	Sig.
NCCER	Union	-4.23*	0.34	0.00
	Other	-0.29	0.18	0.11
	No Formal Training	3.16*	0.16	0.00
Union	NCCER	4.23*	0.34	0.00
	Other	3.94*	0.34	0.00
	No Formal Training	7.39*	0.33	0.00
Other	NCCER	0.29	0.18	0.11
	Union	-3.94*	0.34	0.00
	No Formal Training	3.45*	0.17	0.00
No Formal Training	NCCER	-3.16*	0.16	0.00
	Union	-7.39*	0.33	0.00
	Other	-3.45*	0.17	0.00

* The mean difference is significant at the .05 level.

Based on the Table 6.19, the study found that the differences between the average scores of workers using two different curriculums were statistically significant above the 95% confidence level, except for the difference between workers using the NCCER curriculum and those using "Other" curriculums. Based on the average scores, the study sorted the different training curriculums in three levels (Table 6.20), where the average scores of training curriculums not having statistically significant differences were assigned the same letter.

Table 6. 20: The Average NCACP Score Sorted by Training Curriculum

Training Curriculum	Mean	N	Std. Deviation
Union	71.96 **(A)**	2350	13.46
Other	68.02 **(B)**	13432	15.04
NCCER	67.74 **(B)**	14587	14.14
No Formal Training	64.57 **(C)**	20095	15.94
Total	66.75	50464	15.21

6.5.3.2 The Effect of Training Provider on NCACP Score

For the workers receiving formal training before they took the NCACP, the study identified the training organizations from which each individual obtained their formal training. The study analyzed the relation of the training organizations and the workers' average score in the NCACP. The average score for all workers receiving formal training was 68.32. Workers trained by a local union training center had the highest average score of 71.80, followed by those trained by associations at 69.67 and those trained in schools at 68.42 (Figure 6.11). Workers trained by contractors had the lowest score at 67.47.

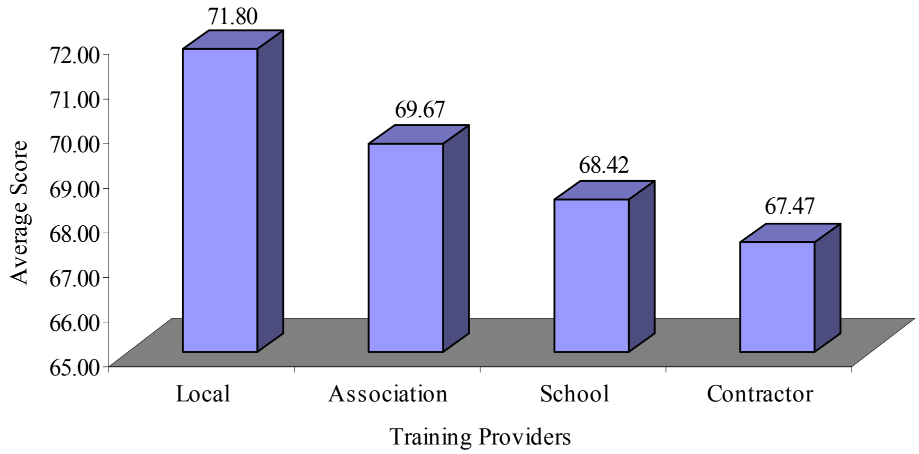


Figure 6. 11: Average NCACP Score by Training Providers

Next, the study used a One-way ANOVA to test whether or not there was a statistically significant difference between the average scores of groups of workers who were trained by different training organizations. Table 6.21 shows that there was a statistically significant difference between the average scores of groups of workers trained by different training providers. In order to test the difference in the average scores of any two groups, the study performed follow-up tests (post-hoc tests) using the pair-wised multiple comparisons.

Table 6. 21: ANOVA for Different Training Providers

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	48773.47	3	16257.82	78.26	0.00
Within Groups	5870918.20	28260	207.75		
Total	5919691.67	28263			

The follow up analyses were performed to compare the average scores between any two training organizations in order to identify whether or not the training organizations have significant differences in average scores. The results in Table 6.22 show that among the four training organizations in the survey, i.e. associations, local union, contractors and schools, the differences between the average scores of any of two training organizations were statistically significant.

Table 6. 22: Multiple Comparisons for Different Training Providers

(I) Trained	(J) Trained	Mean Difference (I-J)	Std. Error	Sig.
Association	Contractor	2.20*	0.26	0.00
	Local Union	-2.13*	0.37	0.00
	School	1.25*	0.30	0.00
Contractor	Association	-2.20*	0.26	0.00
	Local Union	-4.33*	0.31	0.00
	School	-0.95*	0.23	0.00
Local Union	Association	2.13*	0.37	0.00
	Contractor	4.33*	0.31	0.00
	School	3.38*	0.35	0.00
School	Association	-1.25*	0.30	0.00
	Contractor	0.95*	0.23	0.00
	Local Union	-3.38*	0.35	0.00

* The mean difference is significant at the .05 level.

Based on the average scores, the study sorted the different training organizations in four levels (Table 6.23), where the average score of training curriculums not having statistically significant differences were assigned the same letter.

Table 6. 23: Average Scores of Different Training Providers

Trained	Mean	N	Std. Deviation
Local Union	71.80 **(A)**	2438	13.73
Association	69.67 **(B)**	3873	13.47
School	68.42 **(C)**	5301	14.95
Contractor	67.47 **(D)**	16652	14.55
Total	68.32	28264	14.47

6.6 Multiple Regression Models to Predict Workers' NCACP Scores

Based on the previous analysis, the study identified the factors affecting workers' NCACP scores, which included race, work experience and training experience. Next the study established multiple regression models to quantitatively analyze the effect of these factors on an individual worker's NCACP score.

Two models were established by the study. The first model was used to quantitatively identify the impact of work experience, training experience and race on workers' test scores. The second model was used to further analyze the impact of formal training on those who received it by partitioning the training curriculum and training organizations.

6.6.1 Multiple Regression Model: Work Experience, Race and Training

Regression Model I aimed to quantitatively identify the impact of years of work experience, training experience and race on a worker's test score. The model's dependent variable was the worker's test score in the NCACP, and the independent variables included the worker's years of work experience, his or her race, his or her training experience and the interaction terms between work experience, race and training experience. The study first identified whether interactions existed between work experience, race and training experience on workers' test scores.

6.6.1.1 Identify the Interactions between Work Experience, Race and Training Experience

(1) Interaction between Work Experience and Race

The study determined the average scores of workers under different work experience groups and racial groups. Figure 6.12 shows that for workers in different work experience groups, the differences in average scores between non-White workers and White workers were almost constant, which means that the impact of race on worker's test score was the same for different work experience groups. As a result, the RT-231 study concluded that there was no interaction between years of work experience and race regarding the impact on workers' test scores.

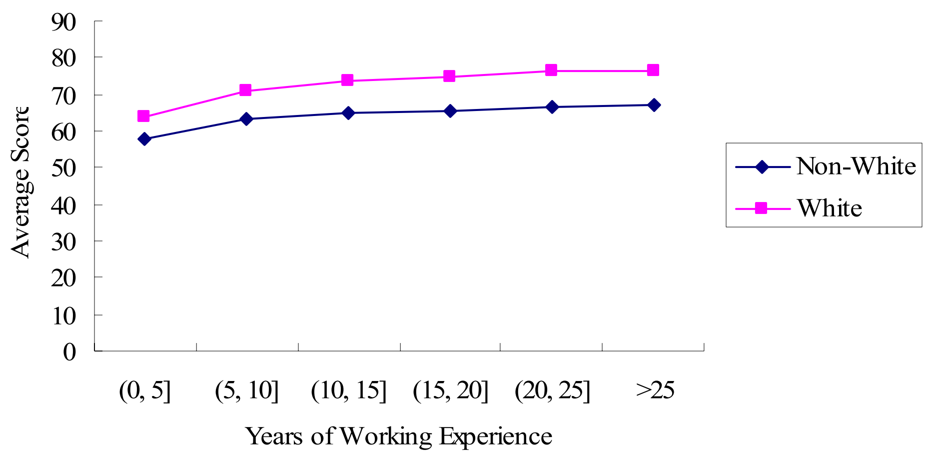


Figure 6. 12: Interactions between Race and Years of Work Experience

(2) Interaction between Race and Training Experience

The RT-231 study determined the average scores of workers in different training experiences and racial groups. Figure 6.13 shows that the differences in average scores between non-White workers and White workers were almost constant regardless of having or not having formal training, which indicated that there was no interaction between training experience and race regarding the impact on worker's test score.

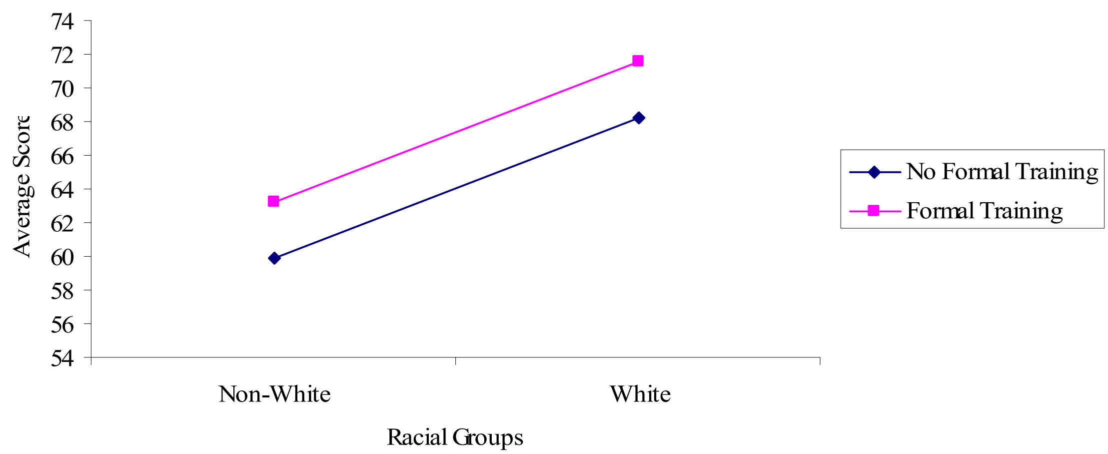


Figure 6. 13: Interactions between Race and Training Experience

(3) Interaction between Working Experience and Training Experience

The study determined the average scores of workers under different training and work experience groups. Figure 6.14 shows that for workers in different work experience groups, the differences in average scores between workers having formal training and those not having formal training were again almost constant, which indicates no interaction between training and work experience regarding the impact on a worker's test score.

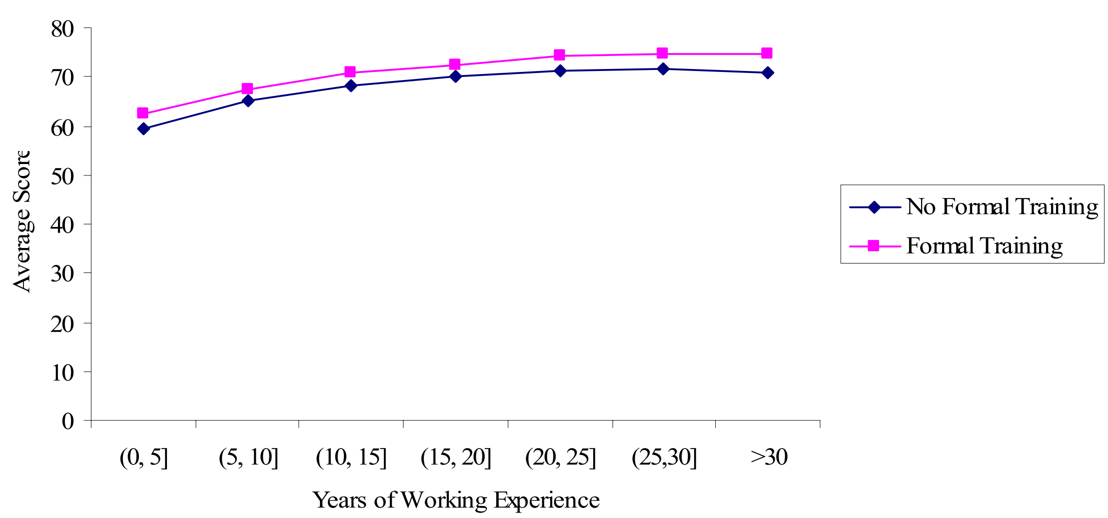


Figure 6. 14: Interactions between Work Experience and Training Experience

6.6.1.2 Multiple-Regression Analysis

Based on the previous analysis, there were no interactions between work experience, training experience and race, so the interaction terms were not included in the multiple-regression model. The final model established by the study is as follow:

$$S = \alpha + \beta_1 Y + \beta_2 T + \beta_3 R$$

Where

S: a worker's test score in the NCACP;

Y: Years of working experience;

T: a dummy variable, if a worker received formal training T=1, otherwise T=0;

R: a dummy variable, if a worker is white R=1, otherwise R=0;

Table 6. 24: Estimation of Regression Coefficients

	Coefficients	B	Std. Error	T	Sig.
$\hat{\alpha}$	(Constant)	56.22	0.15	385.58	0.00
$\hat{\beta}_1$	Years of experience	0.46	0.01	59.58	0.00
$\hat{\beta}_2$	Training	2.42	0.14	17.66	0.00
$\hat{\beta}_3$	Race	7.09	0.14	51.49	0.00

All three independent variables had a P-value approximately equal to 0 indicating that there were statistically significant in the regression model (Table 6.24). The overall model significance is shown in Table 6.25. The R^2 of the model is 0.392, which means 39.2% variance in the test score can be explained by the model. The P-value for the whole model was approximately equal to 0, which meant that the overall model was statistically significant.

Table 6. 25: ANOVA Table of Regression Model

	Sum of Squares	df	Mean Square	F	Sig.
Regression	1570090	3	523363.30	2678.832	0
Residual	8662314	44338	195.37		
Total	10232404	44341			

The results show that if we fix other variables,

- Increasing 1 years working experience raised the test score by 0.46 point on average;
- Receiving formal training raised the test score 2.42 points on average, which means that having formal training had the same impact on the NCACP score as working another 5.3 years; and
- A white worker's test score was 7.09 points higher than a non-white worker's score, on average.

6.6.2 Multiple Regression Model: Training Curriculum and Training Organizations

The regression model II aimed to quantitatively compare the impact of different training curriculums and training organizations on the test scores of workers receiving formal training. In the model, the dependent variable was the workers' NCACP test score, and the independent variables included a worker's years of work experience, his or her race, training curriculums, training organizations, and interaction terms between working experience, race and training experience. Once again, the study first identified whether there were interactions between work experience, race, training curriculum and training organizations on worker's test score.

6.6.2.1 Identify the Interactions between Factors Affecting Worker's Test Score

Considering the work experience was a continuous variable in the model, the RT-231 study first conducted an analysis of covariance (ANCOVA[4]) in order to identify the possible interactions between each of the factors. In the ANCOVA model, NCACP test scores were the dependent variable, and race, training curriculum and training organization were independent variable modeled as categorical variables, and years of working experience was also an independent variable modeled. Because years of experience is a continuous variable, it was treated as the covariate in the ANCOVA. Based on Table 6.26, the study found that years of work experience, race, training curriculum and training organizations were statistically significant in the model, which meant that these factors had significant impacts on the workers' test scores. For the interaction between factors, only the interaction between training curriculum and training organizations were significant in the model.

Table 6. 26: ANCOVA Table

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1011363.142	32	31605.098	171.818	0.000
Intercept	11927334.489	1	11927334.489	64841.726	0.000
Years of Working Experience	428132.546	1	428132.546	2327.498	**0.000**
Race	48044.843	1	48044.843	261.191	**0.000**
Training Curriculum	38422.260	3	12807.420	69.626	**0.000**
Training Organization	3282.013	3	1094.004	5.947	**0.000**
Race × Training Curriculum	648.854	3	216.285	1.176	0.317
Race × Training Organization	978.163	3	326.054	1.773	0.150
Training Curriculum × Training Organization	28152.324	9	3128.036	17.005	**0.000**
Race × Training Curriculum × Training Organization	1248.208	9	138.690	0.754	0.659
Error	5848358.731	31794	183.945		
Total	153543965.986	31827			

[4] **ANCOVA** is a general linear model with one continuous explanatory variable and one or more categorical factors. ANCOVA is a merger of ANOVA and regression for continuous variables. ANCOVA tests whether certain factors have an effect after removing the variance for which quantitative predictors (covariates) account. The inclusion of covariates can increase statistical power because it accounts for some of the variability.

(1) Interaction between Race and Training Curriculums

The study determined the average scores of workers under different training curriculums and racial groups. Figure 6.15 shows that for different racial groups, the differences in average scores between different training curriculums were almost constant, which meant that the impact of race on a worker's test score was the same for workers using different training curriculums, indicating that no interaction existed.

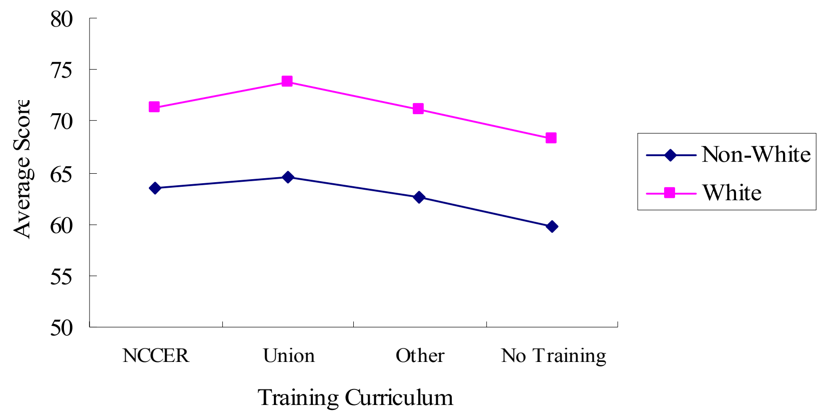


Figure 6. 15: Interactions between Race and Training Curriculum

(2) Interaction between Race and Training Organizations

The study determined the average scores of workers under different training organizations and racial groups. Figure 6.16 shows that for different racial groups, the differences in average scores between different training organizations were again almost constant, which means that the impact of race on worker's test score was the same for workers trained by different organizations and that no interaction existed.

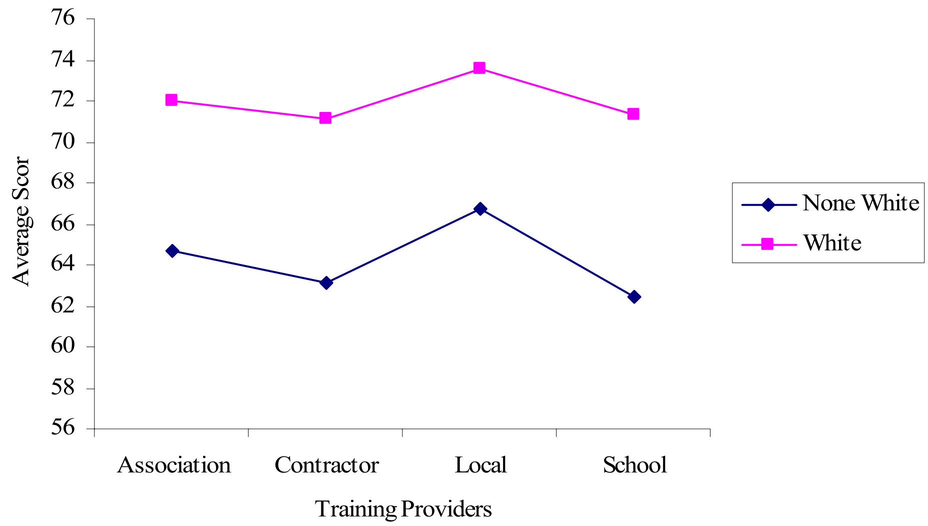


Figure 6. 16: Interactions between Race and Training Providers

(3) Interaction between Training Curriculum and Training Organization

The study determined the average scores of workers using different training curriculums and training organizations. The Figure 6.17 shows that for workers using difference training curriculums, the differences in average scores greatly varied between each training organization, which means that the impact of the training organization on a worker's test score was different among workers trained by different organizations. As a result, the regression model included an interaction between training curriculum and organization regarding the impact on a worker's test score.

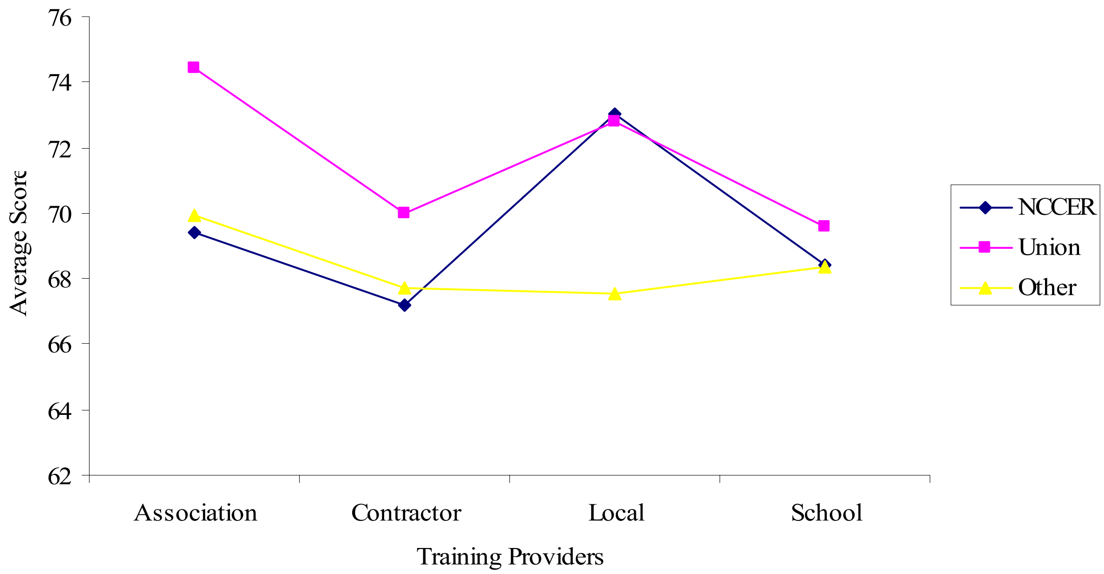


Figure 6. 17: Interactions between Training Providers and Training Curriculum

6.6.2.2 Multiple Regression Analysis

Based on the previous analysis, an interaction only existed between training curriculums and organizations. The study first established a model, which further partitioned the training curriculum in order to compare the effectiveness of different training curriculums on raising workers' scores on the NCACP assessment.

$$S = \alpha + \beta_1 Y + \beta_2 R + \sum \beta_{3,n} T_i$$

Where:

S: a worker's test score in the NCACP;

Y: Years of working experience;

R: a dummy variable, if a worker is white R=1, otherwise R=0;

T_i: a dummy variable i=1 to 3 representing NCCER, Union and Other curriculum, if a worker used certain curriculum T_i=1, otherwise T_i=0; and

α, β_1, β_2, and $\beta_{3,n}$: regression coefficients and n=1 to 3.

Table 6. 27: Estimation of Regression Coefficients

		B	Std. Error	t	Sig.
$\hat{\alpha}$	(Constant)	56.16	0.15	382.50	0.00
$\hat{\beta}_1$	Experience	0.46	0.01	59.27	0.00
$\hat{\beta}_2$	White	7.14	0.14	51.70	0.00
$\hat{\beta}_{3,1}$	NCCER	2.85	0.16	17.46	0.00
$\hat{\beta}_{3,2}$	Union	1.77	0.33	5.42	0.00
$\hat{\beta}_{3,3}$	Other	2.05	0.17	12.33	0.00

The results (Table 6.27) show that if other factors are fixed, using the *NCCER Curriculum* could increase a test score by 2.85 points on average, which was the most effective way to increase the test score through training. The study also found that using "*Other" training Curriculums* could increase the test score by 2.05 points on average, and using a Union Curriculum could increase the score by 1.77 points on average.

The significant model results are shown in Table 6.28. The model was highly significant with a F-value of 1,612.99 and P-value approximate equal to 0. The R^2 of the model was 0.392, which meant 39.2% variance in test score can be explained by the model.

Table 6. 28: ANOVA Table of Regression Analysis

	Sum of Squares	df	Mean Square	F	Sig.
Regression	1,574,850	5	314,97	1,612.99	0
Residual	8,657,554	44,336	195.27		
Total	10,232,404	44,341			

Next, the study established a model which included the interaction terms of training curriculum and training organization in order to evaluate the effectiveness of the different combination of the two. Because the training curriculum included NCCER training, union curriculums and other curriculums, and training organizations included association, contractor, local union, and school training, the total number of interactions terms was 12.

The final model established by the study is as follows:

$$S = \alpha + \beta_1 Y + \beta_2 R + \sum \beta_{3,n} T_i P_j$$

Where:

S: a worker's test score in the NCACP;

Y: Years of working experience;

T_i: a dummy variable i=1 to 3 representing NCCER, Union and Other curriculum, if a worker used a certain curriculum T_i=1, otherwise T_i=0;

P_j: a dummy variable j=1 to 4 representing Association, Contractor, Local union and School, if a worker trained by certain organization P_j=1, otherwise P_j=0;

R: a dummy variable, if a worker is white R=1, otherwise R=0;

α, β_1, β_2, and $\beta_{3,n}$: regression coefficients and n=1 to 12.

The results of the regression analyses are shown in Table 6.29.

Table 6. 29: Estimation of Regression Coefficients

	Coefficients	B	Std. Error	t	Sig.
α	(Constant)	56.17	0.15	377.84	0.00
$\hat{\beta}_1$	Years of Experience	0.47	0.01	58.49	0.00
$\hat{\beta}_2$	White	7.02	0.14	49.68	0.00
$\hat{\beta}_{3,1}$	NCCER ×Association	3.91	0.29	13.47	0.00
$\hat{\beta}_{3,2}$	NCCER ×Contractor	2.36	0.19	12.49	0.00
$\hat{\beta}_{3,3}$	NCCER ×Local	7.15	0.77	9.35	0.00
$\hat{\beta}_{3,4}$	NCCER ×School	4.19	0.52	8.06	0.00
$\hat{\beta}_{3,5}$	Union ×Association	3.36	1.35	2.49	0.01
$\hat{\beta}_{3,6}$	Union ×Contractor	0.30	0.83	0.36	0.72
$\hat{\beta}_{3,7}$	Union ×Local	2.29	0.39	5.89	0.00
$\hat{\beta}_{3,8}$	Union ×School	0.40	1.19	0.34	0.74
$\hat{\beta}_{3,9}$	Other ×Association	2.73	0.57	4.81	0.00
$\hat{\beta}_{3,10}$	Other ×Contractor	2.36	0.20	11.63	0.00
$\hat{\beta}_{3,11}$	Other ×Local	-1.14	0.70	-1.62	0.11
$\hat{\beta}_{3,12}$	Other ×School	1.96	0.25	7.73	0.00

The results showed that if other variables are fixed,

- Each increase of 1 year in work experience will raise the predicted NCACP test score by 0.47 point on average;
- A White worker's test score is 7.02 points higher than a Non-white on average; and
- The effect of training curriculum and training organization under different combinations on the NCACP test score are sorted by descending as follow (Table 6.30):

Table 6. 30: Estimation of Coefficients of Interaction Terms

Interaction Terms	$\beta_{3,n}$	Std.	t	Sig.
NCCER×Local	7.15	0.77	9.35	0.00
NCCER×School	4.19	0.52	8.06	0.00
NCCER ×Association	3.91	0.29	13.47	0.00
Union×Association	3.36	1.35	2.49	0.01
Other×Association	2.73	0.57	4.81	0.00
Other×Contractor	2.36	0.20	11.63	0.00
NCCER×Contractor	2.36	0.19	12.49	0.00
Union×Local	2.29	0.39	5.89	0.00
Other×School	1.96	0.25	7.73	0.00
Union×School	0.40	1.19	0.34	0.74
Union×Contractor	0.30	0.83	0.36	0.72
Other×Local	-1.14	0.70	-1.62	0.11

The results show that if other factors are fixed, using a *NCCER curriculum* and being trained by a *Local union* could increase a test score by 7.15 points, which is the most effective way to increase the test score through training. The analyses also indicate that using one of the "*Other"* training curriculums and being trained by a *Local* organization *decreases* the test score by 1.14 points, but this specific result was not statistically significant.

Since not all of the factors were significant in the model, the study removed those non-significant factors by using a stepwise selection procedure, which produced the final regression results shown in Table 6.31.

Table 6. 31: ANOVA of Regression Analysis

	Sum of Squares	Df	Mean Square	F	Sig.
Regression	1,526,586	11	138,780.54	712.18	0.000
Residual	8,278,137	42,481	194.87		
Total	9,804,723	42,492			

The overall model was highly significant with F-value 712.181 and P-value approximately equal to 0 (Table 6.31). The R^2 of the model was 0.395, which means a 39.5% variance in test score can be explained by the model.

The final regression coefficients are listed in the Table 6.32. After the stepwise selection, all independent variables left in the model were significant at a level of 0.05.

Table 6. 32: Estimation of Coefficients of Final Regression Model

	Coefficients	B	Std.	t	Sig.
α	(Constant)	56.16	0.15	379.03	0.00
β_1	Years of Experience	0.47	0.01	58.76	0.00
β_2	White	7.02	0.14	49.67	0.00
$\beta_{3,3}$	NCCER×Local	7.17	0.77	9.37	0.00
$\beta_{3,4}$	NCCER×School	4.20	0.52	8.10	0.00
$\beta_{3,1}$	NCCER×Association	3.93	0.29	13.57	0.00
$\beta_{3,5}$	Union×Association	3.39	1.35	2.51	0.01
$\beta_{3,9}$	Other×Association	2.75	0.57	4.85	0.00
$\beta_{3,10}$	Other×Contractor	2.38	0.20	11.80	0.00
$\beta_{3,2}$	NCCER×Contractor	2.37	0.19	12.69	0.00
$\beta_{3,7}$	Union×Local	2.31	0.39	5.97	0.00
$\beta_{3,12}$	Other×School	1.98	0.25	7.85	0.00

Based on the regression results, the following conclusions can be reached:

- Craft training can increase a worker's score in the skill assessment. If other variables are fixed, the increases in test score from training ranged from 1.98 points to 7.02 points on average, which depended on the different combination of training curriculums and training organizations;

- The impact of training on the workers' test score varied when using different combinations of training curriculum and training organization. It shows that combining the *NCCER curriculum* with a *local union training* was the most effective way to increase a worker's test score;
- An increase of 1 years in working experience raised the test score by 0.47 points on average if other variables are fixed; and
- A White worker's test score was 7.02 points higher than a non-white on average if other variables are fixed.

6.7 Factors Affecting Workers' Passing Rate

Based on the difficulty of each assessment and the workers' performances on the assessments, NCCER established a cut score for each assessment as a passing grade. If a worker's test score was above the passing grade, certification would be issued. Otherwise, the NCCER would recommend the worker attend training and take a test again. Next, the study identified the factors effecting the passing rates of the NCACP. Since a higher score will definitely increase the probability of passing an exam, the passing rate was highly related with the NCACP's average score.

6.7.1 The Effect of Race on Passing Rate

The study found that different racial groups had very different performances in the NCACP. The average passing rate overall for workers taking the NCACP assessment was 44.9%. White workers have the highest average passing rate at 53.6%, and Black workers have the lowest at 22.6% (Figure 6.18).

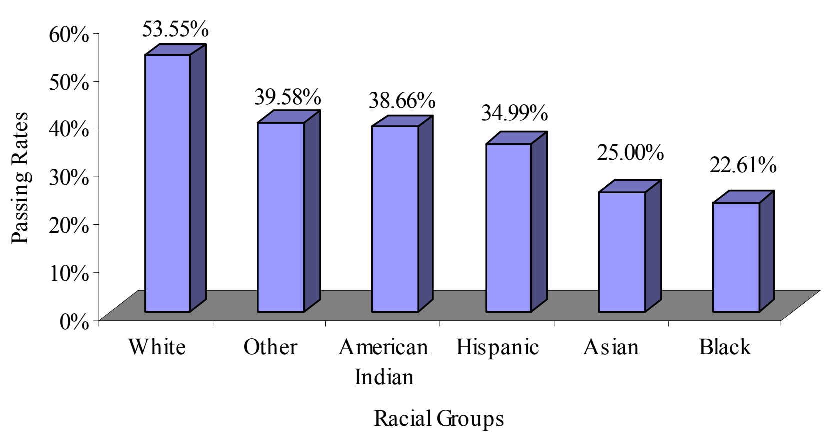


Figure 6. 18: Passing Rates Sorted by Ethnic Groups

Next, the study compared the passing rates between racial groups. Chi-Square test (Table

6.33) showed that the difference in passing rates between racial groups was statistically significant.

Table 6. 33: Test of Difference between Passing Rates of Racial Groups

Tests	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2588.76	5	0.00
Likelihood Ratio	2677.44	5	0.00
Linear-by-Linear Association	1796.77	1	0.00
N of Valid Cases	50005		

6.7.2 The Effect of Work Experience on Passing Rate

The study identified the impact of work experience on workers' passing rate of the NCACP. After grouping the workers based on the years of work experience in construction, the study found that as the years of work experience increased, the passing rates increased (Figure 6.19).

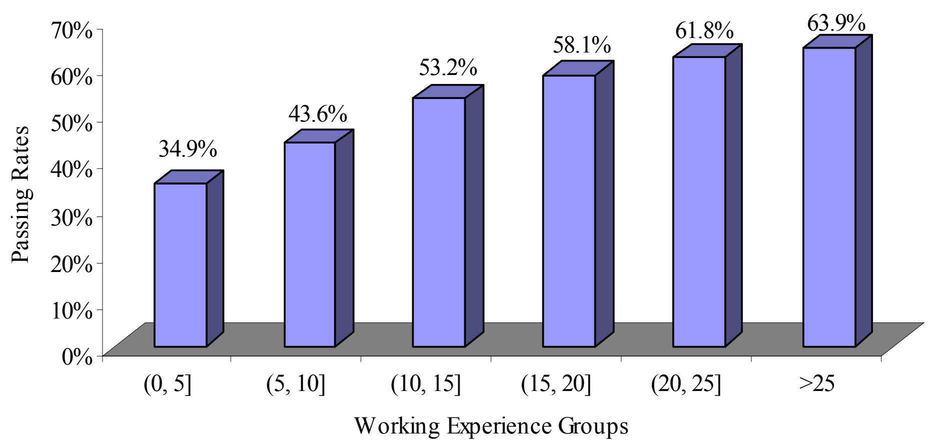


Figure 6. 19: Passing Rates Sorted by Work Experience

Next the study compared the passing rates between working experience groups. Chi-Square test (Table 6.34) showed that the difference in passing rates between work experience groups was statistically significant.

Table 6. 34: Test of Differences between Passing Rates of Work Experience Groups

Tests	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3018.82	5	0
Likelihood Ratio	3034.25	5	0
Linear-by-Linear Association	2803.76	1	0
N of Valid Cases	68410		

6.7.3 The Effect of Training on Passing Rate

The study identified the impact of training experience on workers' passing rates of the NCACP by comparing the passing rates of workers using different training curriculums and trained by different training providers.

6.7.3.1 The Effect of Training Curriculum on the Passing Rates

The average passing rate for all workers taking the NCACP assessment was 44.3%. For those who used the union, other or NCCER curriculum, the passing rate was 60.0%, 47.7% and 45.5% respectively (Figure 6.20). For those who had no formal training experience, the passing rate was only 39.4%.

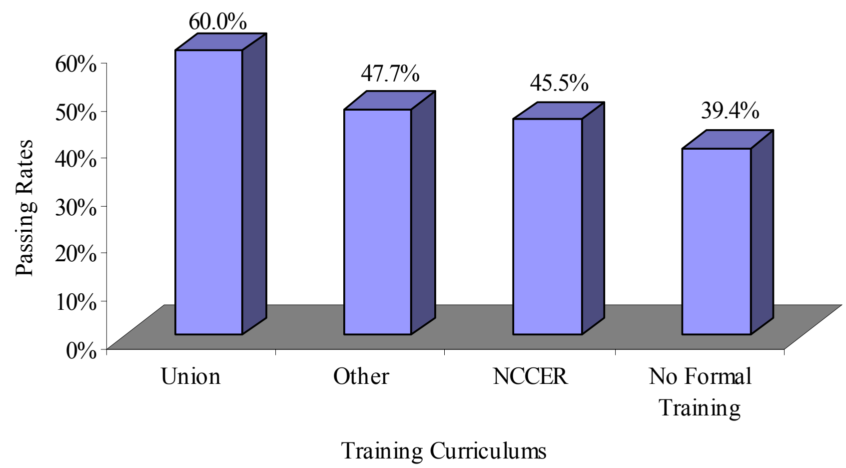


Figure 6. 20: Passing Rates Sorted by Training Curriculum

Next, the study used Chi-Square test to examine whether or not there was a statistically significant difference in passing rates between groups of workers who used different training curriculums (Table 6.35). Table 6.35 shows that the there was a statistically significant difference between passing rates among groups of workers using different training curriculums.

Table 6. 35: Test of Difference between Passing Rates of Training Curriculums

Tests	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	496.95	3	0.00
Likelihood Ratio	496.79	3	0.00
Linear-by-Linear Association	148.92	1	0.00
N of Valid Cases	50569		

6.7.4 The Effect of Training Provider on the Passing Rates

For the workers receiving formal training before they took the NCACP, the study identified the training organizations from which each individual obtained their formal training. The study analyzed the impact of the training organizations on workers' passing rates in the NCACP.

The passing rate for all workers receiving formal training was 48.0%. Workers trained by Local agencies had the highest passing rate of 60.3%, followed by those trained by associations at 50.5% and those trained in schools at 48.8% (Figure 6.21). Workers trained by contractors had the lowest passing rate of 45.3%.

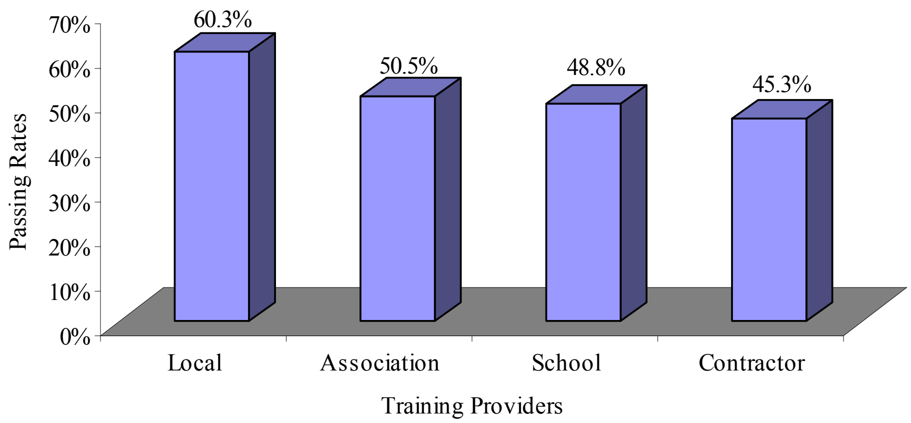


Figure 6. 21: Passing Rates Sorted by Training Providers

Next, the study used a Chi-Square test to examine whether or not there was a statistically significant difference between the passing rates of groups of workers who were trained by different training organizations. Table 6.36 shows that the passing rates between groups of workers trained by different training organizations were statistically significantly different.

Table 6. 36: Chi-Square Test for Different Training Providers

Tests	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	207.06	3	0.00
Likelihood Ratio	207.66	3	0.00
Linear-by-Linear Association	13.58	1	0.00
N of Valid Cases	28314		

6.7.5 Use of Logistic Regression Analysis to Predict the Probability of a Worker Passing the NCACP

Based on the previous analysis, the study identified the factors affecting the workers' passing rates in the NCACP, which included work experience, race and training experience. Next the study established a logistical regression model to quantitatively analyze the effects of these factors on the probability of an individual worker passing the NCACP.

Two models were established by the study. The first model was used to quantitatively identify the impact of work experience, training curriculum and race on the probability of a worker passing the test. The second model was used to further analyze the impact of training on passing probability by partitioning training curriculum and training organizations.

6.7.5.1 Multiple Logistic Regression Model I

Logistic regression model I aimed to quantitatively identify the impact of work experience, training experience and race on the probability of a worker passing the test. In the model, the dependent variable was the test result of the NCACP, with 1 standing for passing and 0 for not passing. The independent variables included workers' years of work experience, race and training experience. Based on the previous analysis, there were no interactions between work experience, training experience and race, so in the logistic regression model, the interaction terms were not included.

The final model established by the study is as follows:

$$\log it\hat{P} = \alpha + \beta_1 Y + \beta_2 T + \beta_3 R$$
$$\hat{P} = \frac{\exp(\alpha + \beta_1 Y + \beta_2 T + \beta_3 R)}{1 + \exp(\alpha + \beta_1 Y + \beta_2 T + \beta_3 R)}$$

Where:

P: the probability of a worker passing the test;

Y: Years of work experience;

T: a dummy variable, if a worker received formal training T=1, otherwise T=0;

R: a dummy variable, if a worker is White R=1, otherwise R=0;

Table 6. 37: Estimation of Coefficients in Logistic Regression

Parameter	DF	Estimate	Std.	Wald Chi-Square	Pr > ChiSq	Exp(B)
Intercept	1	-1.42	0.02	3643.30	<.0001	-
Experience	1	0.05	0.00	1969.36	<.0001	1.06
Training	1	0.22	0.02	112.03	<.0001	1.25
Race	1	0.79	0.02	1408.88	<.0001	2.19

Interpreting the coefficients

The partial slope coefficient for work experience (β_1) may be interpreted as follows. Consider two workers such that the work experience of the first is one year greater than the second, but the two workers have the same race and training background, $\exp(\beta_1)$ =1.055 is the odds ratio[5] for the two workers passing the NCACP. So with the other variables being fixed, each additional year of work experience can increase the odd of passing the NCACP by 1.055.

[5] Let P_1= probability of Worker 1 passing the NCACP and P_2= probability of Worker 2 passing the NCACP. The odd of Worker 1 passing the NCACP is defined as $P_1/(1-P_1)$ and the odd of Worker 2 passing the NCACP is defined as $P_2/(1-P_2)$. The odds ratio of two workers passing the NCACP is defined as $\frac{P_1/(1-P_1)}{P_2/(1-P_2)}$.

The partial slope coefficient for training curriculum (β_2) may be interpreted as follows. Consider two workers such that the first worker is White and the second is not White, but the two workers have the same race and training background, $\exp(\beta_2)$ =2.194 is the odds ratio for the two workers passing the NCACP. So with the other variables being fixed, the odds of a White worker passing the NCACP is 2.194 times of a non-White worker.

The partial slope coefficient for race (β_3) may be interpreted as follows. Consider two workers such that the first had formal training and the second did not have formal training, but the two workers have the same race and years of working experience, $\exp(\beta_3)$ =1.254 is the odds ratio for the two workers passing the NCACP. So with the other variables being fixed, receiving formal training can increase the odds of a worker passing the NCACP by 1.254.

Test for a Partial Slope Coefficien*t*

Based on Table 6.37, all partial slope coefficients had a P-vale approximately equal to 0, so they were significant at a level of 0.05.

Test for Model Significance

With P-values approximately equal to 0, the model was significant whether researchers used a Likelihood Ratio test, a Score test or a Wald test. The C-value in Table 6.38 is similar to the R^2 in the linear regression and provides a summary of measure of model goodness. With value of 0.683, C-value indicated good model fitness. Considering the following prediction rule:

- If $\hat{P} \geq 0.5$, the study predicts that the individual will pass the NCACP;
- If $\hat{P} < 0.5$, the study predicts that the individual will not pass the NCACP.

Based on Table 6.38, the correct classification rate was 64.5%.

Table 6. 38: Goodness of Logistic Regression Model

Prob Level	Correct (%)		Test	Chi-Square	DF	Pr>ChiSq
0.3	55.6		**Likelihood Ratio**	4421.04	3	**<.0001**
0.4	61.7		**Score**	4250.70	3	**<.0001**
0.5	**64.5**		**Wald**	3886.67	3	**<.0001**
0.6	61.5					
0.7	58.5		**C Value**	**0.683**		

Overall, the results show that,

- Increasing the years of work experience can raise the probability of a worker passing the NCACP. If other variables are fixed for two workers, the odds ratio of one worker whose year of work experience is 1 year greater than the other, is 1.055 on average;

- Receiving training can raise the probability of a worker passing the NCACP. If other variables are fixed for two workers, the odds ratio of one worker who had formal training but the other did not, is 1.245 on average; and
- White workers have a higher probability of passing the NCACP. If other variables are fixed for two workers, the odds ratio of one White worker against a non-White, is 2.194.

6.7.5.2 Multiple Logistic Regression Model II

Regression Model II quantitatively compared the impact of different training curriculums and training organizations on the probability of a worker passing the NCACP for those who received formal training. The dependent variable was the test result of the NCACP, with 1 standing for passing and 0 for not passing. The independent variables included workers' years of work experience, race, training curriculum and training organization. Based on the previous analyses, the interaction variables between training curriculum and training providers were added. Because the training curriculum included NCCER, union curriculums and other curriculums, and training organization included association training, contractor training, local training and school training, the total number of interactions terms was 12.

The final model established by the RT-231 study as follows:

$$\mathbf{logit\ P = \alpha + \beta_1 Y + \beta_2 R + \sum \beta_{3,n} T_i P_j}$$

$$\hat{P} = \frac{\exp(\alpha + \beta_1 Y + \beta_2 R + \sum \beta_{3,n} T_i P_j)}{1 + \exp(\alpha + \beta_1 Y + \beta_2 R + \sum \beta_3 T_i P_j)}$$

Where:

P: the probability of a worker passing the test;

Y: Years of working experience;

R: a dummy variable, if a worker is white R=1, otherwise R=0;

T_i: a dummy variable i=1 to 3 representing NCCER, Union and Other curriculum, if a worker used certain curriculum T_i=1, otherwise T_i=0;

P_j: a dummy variable j=1 to 4 representing Association, Contractor, Local and School, if a worker trained by certain organization P_j=1, otherwise P_j=0; and

α, β_1, β_2, and $\beta_{3,n}$: regression coefficients and n=1 to 12.

Table 6. 39: Estimation of Coefficients in Logistic Regression

Coefficients	B	S.E.	Wald	df	Sig.	Exp(B)
experience	0.05	0.00	1843.93	1	0	1.06
white	0.78	0.02	1300.25	1	0	2.17
nccer×association	0.34	0.04	61.60	1	0	1.41
nccer×contractor	0.16	0.03	31.17	1	0	1.17
nccer×local	1.01	0.12	70.73	1	0	2.73
nccer×school	0.35	0.08	20.29	1	0	1.42
union×associaton	0.54	0.21	6.48	1	0.01	1.72
union×contractor	0.14	0.13	1.27	1	0.26	1.15
union×local	0.33	0.06	29.50	1	0	1.38
union×school	0.12	0.18	0.45	1	0.50	1.13
other×association	0.21	0.09	6.31	1	0.01	1.24
other×contractor	0.22	0.03	51.59	1	0	1.25
other×local	-0.07	0.11	0.42	1	0.52	0.93
other×school	0.23	0.04	35.75	1	0	1.26
Constant	-1.42	0.02	3482.38	1	0	0.24

The results (Table 6.39) showed that if other variables are fixed,

- Increasing years of work experience can raise the probability of a worker passing the NCACP. If other variables are fixed for two workers, the odds ratio of one worker whose year of work experience is 1 year greater than the other, is 1.056 on average;
- White workers have a higher probability of passing the NCACP. If other variables are fixed for two workers, the odds ratio of one White worker against a non-White, is 2.173.
- Using the NCCER curriculum with local organizational training was the most effective way to increase the probability of passing the NCACP. If other variables are fixed for two workers, one worker who used the NCCER training curriculum and was trained by a local union but the other did not, the odds ratio of them passing the NCACP is 2.731 on average; and
- The effect of the different combinations of training curriculum and training organization on passing probability were sorted descending in Table 6.40:

Table 6. 40: Coefficients of Interaction Terms

Coefficients	B	S.E.	Wald	df	Sig.	Exp(B)
nccer×local	1.01	0.12	70.73	1	0	2.73
union×associaton	0.54	0.21	6.48	1	0.01	1.72
nccer×school	0.35	0.08	20.29	1	0	1.42
nccer×association	0.34	0.04	61.60	1	0	1.41
union×local	0.33	0.06	29.50	1	0	1.38
other×school	0.23	0.04	35.75	1	0	1.26
other×contractor	0.22	0.03	51.59	1	0	1.25
other×association	0.21	0.09	6.31	1	0.01	1.24
nccer×contractor	0.16	0.03	31.17	1	0	1.17
union×contractor	0.14	0.13	1.27	1	0.26	1.15
union×school	0.12	0.18	0.45	1	0.50	1.13
other×local	-0.07	0.11	0.42	1	0.52	0.93

Test for Model Significance

With P-values approximately equal to 0, the model was significant whether researchers used a Likelihood Ratio test, a Score test or a Wald test. The C-value in Table 6.41 is similar to the R^2 in linear regression and provides a summary of measure of model goodness. With value of 0.685, C-value indicated a good model fitness. Considering the following prediction rule:

- If $\hat{P} \geq 0.5$, the study predicts that the individual will pass the NCACP;
- If $\hat{P} < 0.5$, the study predicts that the individual will not pass the NCACP.

Based on Table 6.41, the correct classification rate was 64.6%.

Table 6. 41: Goodness of Logistic Model

Prob Level	Correct (%)		Test	Chi-Square	DF	Pr>ChiSq
0.3	55.5		**Likelihood Ratio**	4314.31	14	<.0001
0.4	61.9		**Score**	4143.61	14	<.0001
0.5	64.6		**Wald**	3779.63	14	<.0001
0.6	61.7					
0.7	58.6		**C Value**	**0.685**		

6.8 Summary

The following conclusions are drawn based on the analyses of the NCACP datasest:

- The percentage of the White workers receiving formal training was significantly greater than the percentage of Hispanic and Black workers receiving formal training;
- White workers had significantly more work experience than the Hispanic and Black workers;

- White workers were highly concentrated in the construction trades which require more technical skills, such as electricians, piping and millwrights, and the Hispanic workers were highly concentrated in the construction trades which require less technical skills such as insulation workers, painters and scaffold builders;
- Formal training can significantly boost workers' scores and passing rates in skill assessment exams and different combinations of curriculum and training institutes have different effects on workers' performance. Using the NCCER curriculum and local training had the most significant increase of worker's test score and passing probability in NCACP.
- Work experience had a positive effect on workers' performance in the skill assessment exam. The longer work experience in construction, the higher score and the greater probability of passing in NCACP.
- Race had a tremendous impact on workers performance in the skill assessment exam. White workers had significantly higher scores and passing rates than any other race, whether researchers compare groups having formal training or without formal training (Figure 6.22).

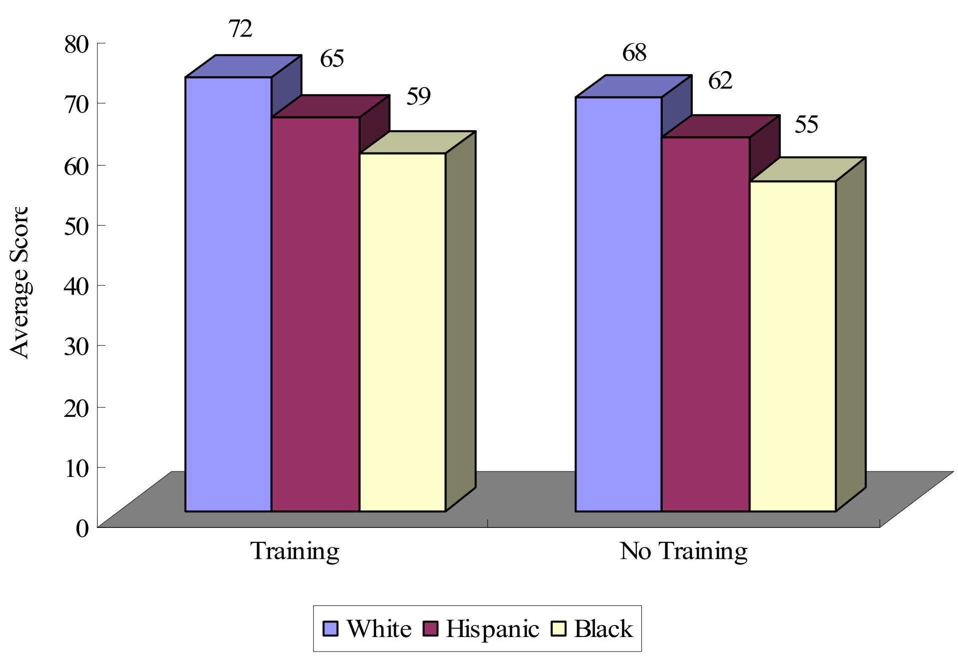


Figure 6. 22: Average Scores among Difference Racial Groups

Figure 6.22 shows that the average score of White workers without training is even higher than the Hispanic or the Black worker with formal training.

CHAPTER 7: ANALYSIS OF THE RT 231 CRAFT TRAINING SURVEY

RT231 developed a survey regarding craft training, which aimed to identify the effectives of existing craft training efforts. The survey was completed by a national sample of training directors and construction managers who were closely involved with construction craft training efforts within their organization. This chapter presents the results of the RT-231 survey. First, demographic information on the participants in the survey is provided in detail. Next, this chapter analyzes the major issues relevant to construction craft training, such as the importance of training subjects, craft engagement and training, the ratio of formal classroom training and on-the-job training (OJT), and the major barriers to advancing formal training program. Analyses also examined the difference of these issues among different groups of respondents, based on demographic information such as union vs. non-union and heavy/light vs. building industry. Third, this chapter examines and quantifies the perceptions regarding the effectiveness of existing construction craft training based on the survey data, resulting in the foundational business case study of benefit cost analyses on construction craft training, which is presented in the next chapter.

The survey was sent out to 150 members of the Associated Builder and Contractor (ABC) and the Construction Industry Institute (CII) member companies, and 93 complete surveys were collected and used in the study. The data was manually entered into a spreadsheet and analyzed using SPSS 12.0 (Statistical Package of Social Sciences) and SAS 9.0 (Statistical Analysis System).

7.1 Demographic Information of Survey Respondents

The craft survey started in April 2006 and ended in December 2006. The geographic locations of the respondents are shown in Figure 7.1.

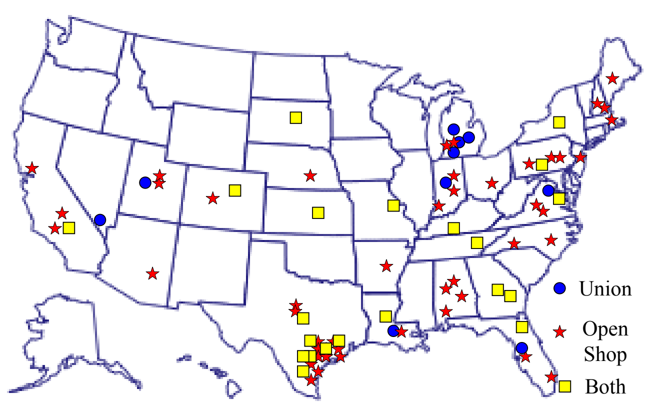


Figure 7. 1: Geographic Location of Survey

(a) The Positions and Experience of Respondents

The majority of survey respondents were construction company site managers, training directors and human resource managers. Figure 7.1 shows the composition of the positions of the respondents involved in the survey. 27.96% of the survey respondents were construction site managers, 19.35% were training directors, 9.68% were human resource managers, 2.15% were project control engineers, and 2.15% were estimators. Other positions, making up 38.71% of the respondents, included project managers, operation managers, risk managers, presidents and vice presidents.

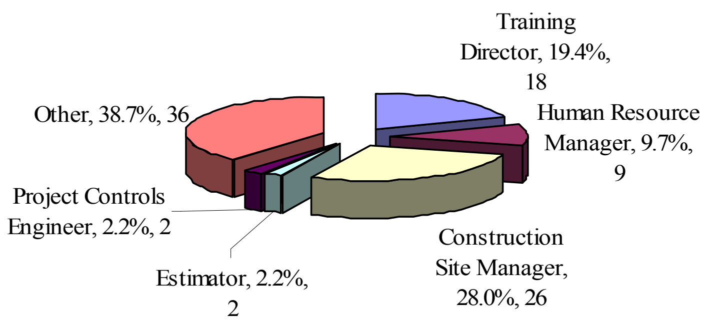


Figure 7. 2: Composition of Respondents

The respondents averaged 23.4 years of experience in the construction industry. Figure 7.3 indicates that 23.7 % of respondents had between 25 and 30 years of experience in construction, and only 3.2% of respondents had less than five years experience in construction.

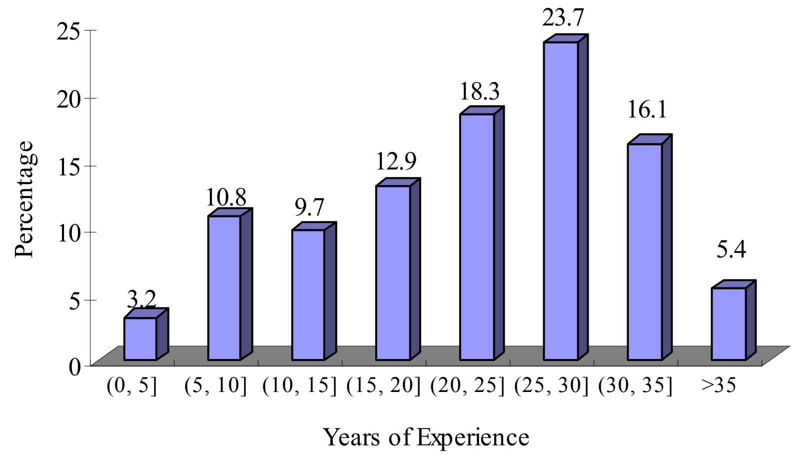


Figure 7. 3: Respondents' Work Experience in the Construction Industry

The respondents averaged 12.8 years of experience in their respective current positions. Figure 7.4 indicates that 37.6 % of respondents had between 5 and 15 years experience in their current positions, 22.6 % of respondents had between 15 and 25 years experience in their current positions, and 35.5 % of respondents had less than five years experience in their current positions.

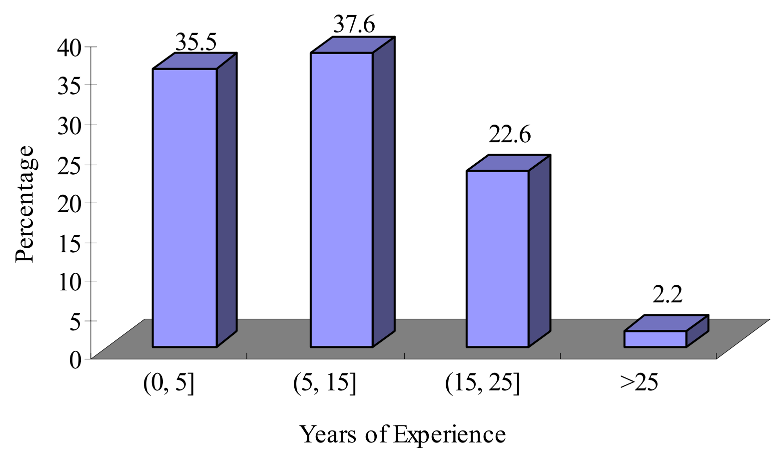


Figure 7. 4: Respondents' Years in Current Position

(b) Characteristics of Surveyed Organizations

73.56 percent of the respondents worked for construction firms, 11.49 % of the respondents worked for owners, and 16.09 % of respondents identified themselves as working for other types of organizations, which included engineering design firms and maintenance service companies

(Figure 7.5).

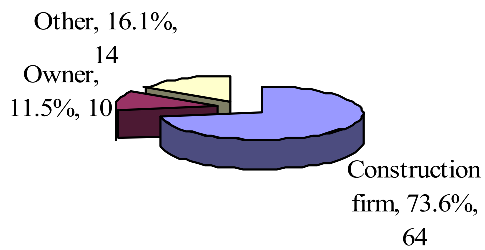


Figure 7. 5: Organization Types

The survey also collected information regarding the types of industry sector for which respondents' companies were involved. The data showed that 59.1 percent of the companies were in the heavy/light industry sector, and 40.9 percent of the companies were in the building sector.

The union status of the respondent companies participating in the survey is presented in Figure 7.6. Around 53.76 percent of the companies primarily used an open shop work force, 12.90 percent used a union work force, and 33.33 percent of companies indicated using both open shop and union work forces. The percentage of company using a union work force in the survey was very close to the percentage of companies using a union work force in the whole construction industry (13.5%) in U.S in 2005 (Srour et al 2006).

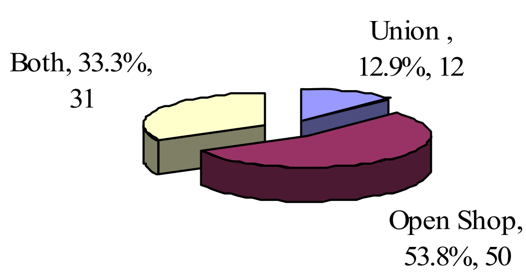


Figure 7. 6: Work force Used by the Organizations in the Survey

Based on the demographic information of the survey respondents, the study found that the respondents had extensive construction experience and were experts in the craft training area. Meanwhile, the ratios of owner vs. contractor, industry sector vs. building sector and union vs.

open shop fairly reflected the reality in construction as a whole.

7.2 Current State of Craft Training in America

This survey of construction training aimed to identify the current state of craft training in North America. Several key questions can be answered through analysis of the survey data, such as what subjects are considered most needed in craft training, what factors hindered the implementation of craft training, what trades get the most training, and the completion rate of crafts entering training programs.

Formal Training and On-the-Job Training

Craft training currently exists both informally (on-the-job training) and formally (classroom) in North America. However, not all on-the-job training is informal. Training on the job can be formalized through mentoring and through providing performance feedback to the trainee. The research examined data from the Survey of Employer Provided Training (SEPT), which was conducted by the U.S. Bureau of Labor Statistics in 1995. The SEPT survey involved approximately 1,000 private nonagricultural business establishments and examined different aspects of training, including the type of training (formal or informal) provided to employees. The SEPT survey found that 76% of the training provided in the construction industry was informal. Only the retail sales industry reported a higher percentage of informal training.

The Construction Craft Training Survey also examined the percentage of total formal and informal training hours provided in construction and found that similar percentages of formal and informal training still exist, at least among the surveyed companies.

Figure 7.7 shows the percentage of the total training hours completed through formal classroom instruction and On-the-job training (OJT) in major construction trades, which includes Civil, Electrician, Piping, Other Mechanical, and Equipment Operator and Maintenance. In addition to formal classroom training and OJT, other training types reported by respondents included methods such as computer-based self studies, home curriculums, and self studies.

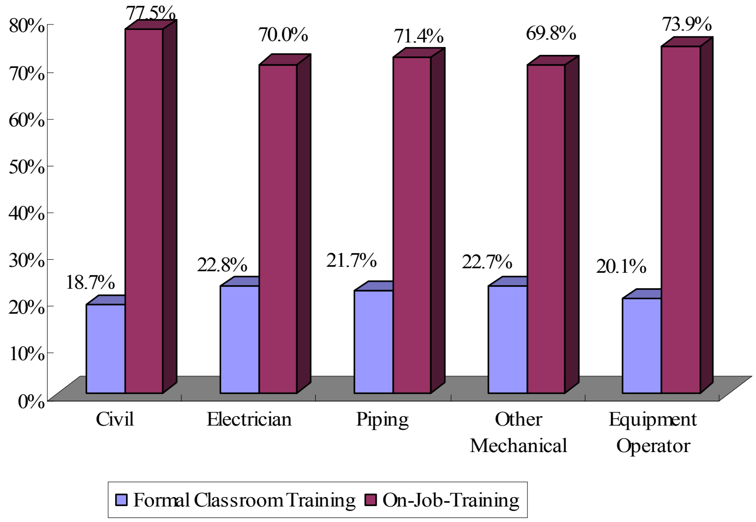


Figure 7. 7: Percentage of Formal and OJT Training by Trades

The study found that for craft training in all major trades, the proportion of OJT is greater than formal classroom training. The study performed paired comparisons between the percentages of formal classroom training and OJT for any of two trades, and found that:

- Compared with other trades, Electricians had a significantly higher percentage of training time devoted to formal classroom training and a lower percentage of training time devoted to OJT; and
- Civil workers had a significantly higher percentage of training time spent in OJT and a lower percentage of time spent in formal classroom training compared with other trades.

A Paired T-test generated a hierarchy of the amount of formal training and OJT among major construction trades. The trades having different letters have a statistically significant difference (level 0.05) between their percentages of formal training or OJT. For example, Civil workers have a significantly higher percentage of OJT than other trades, and Equipment Operator/Maintenance, Piping and Other Mechanical have the same level of OJT.

Table 7.1 and 7.2 show the hierarchy of the amount of formal training and OJT among major construction trades. The trades having different letters have statistically significant difference (level 0.05) between their percentages of formal training.

Table 7. 1: Hierarchy of Formal Training among Major Construction Trades

Formal Training	Percentage	Hierarchy
Electrician	22.05%	A
Other Mechanical	21.65%	A
Piping	20.96%	B
Equipment Operator and Maintenance	19.63%	B
Civil	18.68%	B

Table 7. 2: Hierarchy of OJT among Major Construction Trades

On-the-job Training	Percentage	Hierarchy
Civil	77.46%	A
Equipment Operator and Maintenance	74.26%	B
Piping	71.90%	B
Other Mechanical	70.44%	B
Electrician	70.49%	C

Topics Taught in Craft Training

Most craft training programs cover core skills, such as basic math, blueprints, tools, safety, and communication. The Construction Craft Training Survey asked industry experts to rank eight core topics (Table 7.3), which are usually coved in a core introductory craft skills curriculum to be completed by all individuals during their first year, regardless of their desired trade. The experts ranked the training topics based on a scale 1 to 5, where 1 represents unimportant and 5 represents very important.

Table 7. 3: Core Craft Training Subjects

Basic safety	Examining OSHA regulations, introducing common job-site hazards and protections such as lockout/tagout, fall protection, scaffolding, working at elevations, cranes & derricks, hearing protection, ladders, confined space entry, personal protective equipment, and HazCom
Construction Math	Reviewing basic math functions such as adding, subtracting, dividing, and multiplying whole numbers, fractions, decimals, the metric system, and basic geometry
Introduction to Hand Tools	Reviewing common hand tools such as hammers, saws, levels, pullers, vises, and clamps including their proper and safe use
Introduction to Power Tools	Reviewing common power tools such as drills, saws, grinders, and sanders including their proper and safe use
Introduction to Blueprints	Examining different types of blueprint drawings including civil, architectural, structural, mechanical, plumbing/piping, and electrical
Basic Rigging	Examining use of ropes, chains, hoists, loaders, and cranes to move material and equipment throughout a job site)
Communication Skills	Examining the use of verbal and written communication with co-workers and supervisors
Basic Employability Skills	Reviewing effective relationship skills, self-presentation, and key workplace issues such as sexual harassment, stress, substance abuse, and consistent attendance

Table 7.4 shows the average rating of training subjects sorted from high to low. The rating ranges from 3.81 to 4.93, which indicates that respondents believed that all eight currently taught core training topics were pretty important. However, there were differences in importance between training subjects. Basic safety training, with the highest average rating, was regarded as the most important subject. Introduction to blueprint, with the lowest average rating, was believed less important than other subjects.

Table 7. 4: Average Importance Rating of the Training Subjects

Training Subjects	Average Rating	Standard Deviation
Basic Safety	4.93	0.288
Introduction to Power Tools	4.33	0.725
Construction Math	4.20	0.784
Basic Employability Skills	4.18	0.824
Introduction to Hand Tools	4.15	0.807
Communication Skills	4.04	0.785
Basic Rigging	3.95	0.930
Introduction to Blueprint	3.81	0.933

The study performed a paired T-test to identify whether the difference in average rating between any of two subjects was statistically significant. Table 7.5 displays the T-test matrix, which shows the average difference and P-value between the ratings of any two subjects. The statistically significant differences are highlighted.

Table 7. 5: Paired T-test Matrix for Craft Training Subjects

	Basic Safety	Introduction to Power Tools	Construction Math	Basic Employability Skills	Introduction to Hand Tools	Communication Skills	Basic Rigging
Introduction to Power Tools	0.609						
P-Value	0.000						
Construction Math	0.739	0.130					
P-Value	0.000	0.241					
Basic Employability Skills	0.750	0.141	0.011				
P-Value	0.000	0.160	0.922				
Introduction to Hand Tools	0.783	0.174	0.043	0.033			
P-Value	0.000	**0.003**	0.676	0.738			
Communication Skills	0.891	0.283	0.152	0.141	0.109		
P-Value	0.000	0.009	0.136	0.113	0.305		
Basic Rigging	0.989	0.380	0.250	0.098	0.207	0.098	
P-Value	0.000	0.000	**0.044**	0.400	0.051	0.400	
Introduction to Blueprints	1.121	0.516	0.374	0.374	0.341	0.231	0.143
P-Value	0.000	0.000	0.001	**0.006**	**0.008**	0.052	0.247

Next, the study identified the hierarchy of importance for core training subjects, which is shown in Table 7.6. The core training subjects are listed in descending order according to their rating. Identical letters for any two subjects indicates that their ratings of importance do not have a statistically significant difference, at a level of 0.05. For example, basic safety training is significantly more important than any other subjects, and introduction to power tools, construction math and basic employability skills have the same level of importance.

Table 7. 6: Importance Rating Hierarchy of the Training Subjects

Training Subjects	Rating	
Basic Safety	4.93	A
Introduction to Power Tools	4.33	B
Construction Math	4.20	B
Basic Employability Skills	4.18	B
Introduction to Hand Tools	4.15	B
Communication Skills	4.04	C
Basic Rigging	3.95	C
Introduction to Blueprints	3.81	C

Next, the study compared the rating of training subjects between organizations using an open shop work force and those using a union work force. Table 7.7 shows that the organizations using an open shop work force had a higher average rating in all of the core training subjects except basic rigging. The T-test shows that the differences were statistically significant in introduction to hand tools and power tools and communication skills.

Table 7. 7: T-test Results between Open Shop and Union Respondents

	t-value	df	Sig. (2-tailed)	Mean Difference Open Shop - Union
Basic Safety	1.291	60	0.202	0.127
Construction Math	0.882	60	0.381	0.237
Introduction to Hand Tools	2.952	60	**0.004**	0.757
Introduction to Power Tools	2.588	60	**0.012**	0.587
Introduction to Blueprint	1.046	59	0.300	0.315
Basic Rigging	-0.065	60	0.948	-0.020
Communication Skills	2.122	60	**0.038**	0.533
Employability Skills	1.066	60	0.291	0.280

Completion Rates of Craft Training in Different Trades

The study surveyed the percentage of workers in major construction trades who completed full craft qualification through either the completion of written and performance certification exams and/or an apprentice program after starting the training program. Figure 7.8 shows that workers in Equipment Operator and Maintenance training curriculums had the highest completion rate at 60.5%, and workers in Civil and Electrician training programs had the lowest completion rate of 54.3%. Overall the training completion rate was 56.0%, which indicates that almost half of the workers did not complete their craft training program. Unfortunately, it is outside of the paper's scope to examine why many craft workers do not complete their craft training program, however the study's observed completion rate suggests that future research in this area is warranted.

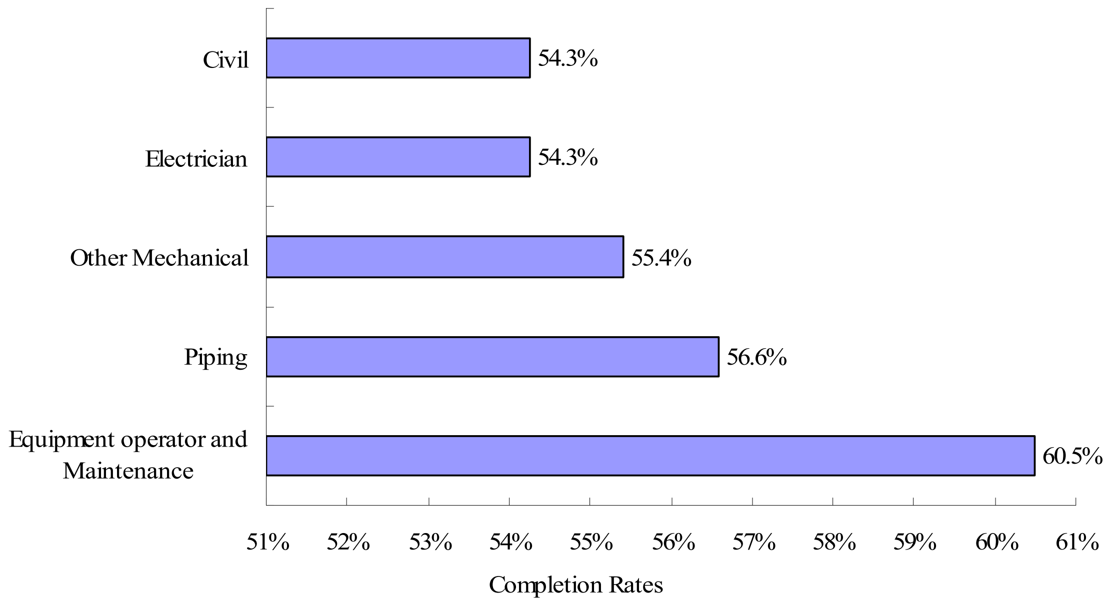


Figure 7. 8: Training Completion Rate by Trades

Next, the study compared the completion rates between union and open shop workers. Figure 7.9 shows that union workers had higher completion rates in all construction trades than open shop workers. The findings of the survey are supported by other studies of construction craft training. Bilginsoy (2005) found that between 1995 and 1999, there were 24, 663 apprentices enrolled in the ABC apprenticeship program, and only 7,154 of these apprentices graduated, with a nationwide graduation rate of only 29%.

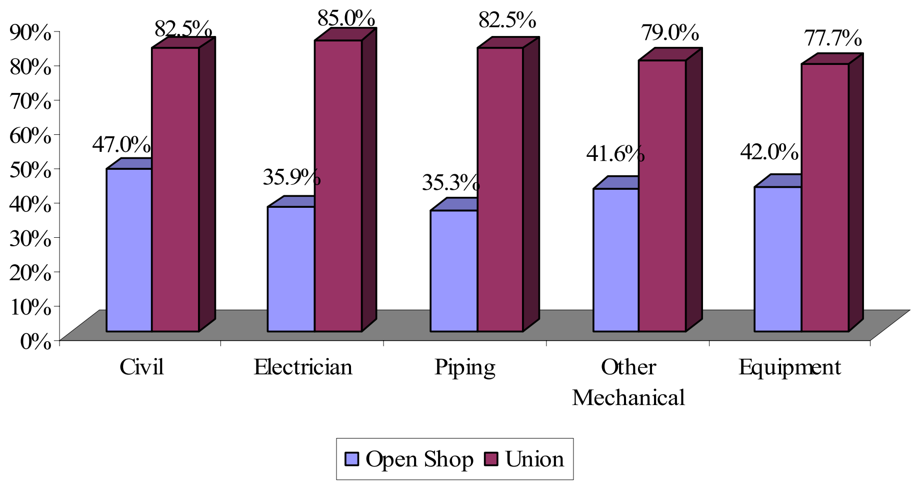


Figure 7. 9: Training Completion Rates in Different Trades by Union Status

For each trade, a t-test was performed to compare the difference between the training completion rates of workers in different trades (Table 7.8). The results showed that the differences in training rates were significant in civil, electrician, pipe and other mechanical trades.

Table 7. 8: Training Completion Rates (Union vs. Open Shop)

	Union	**Open Shop**	**Difference**	**t Value**	**Sig.**
Civil	82.5%	47.0%	35.5%	2.25	**0.03**
Electrician	85.0%	35.9%	49.1%	2.14	**0.05**
Pipe	82.5%	35.3%	47.2%	3.16	**0.01**
Other Mechanical	79.0%	41.6%	37.4%	2.99	**0.01**
Equipment Operator	77.7%	42.0%	35.7%	1.62	0.13

Relationship between Craft Engagement and Formal Training

The RT-231 study also examined which crafts tend to receive more training than others. The survey asked industry experts to choose the crafts which were engaged in training within his/her organization and the crafts in which his/her organization provides formal classroom training. Based on the RT-231 survey data, the researchers analyzed the correlation between the craft engagement and formal training.

Table 7.9 shows the trades of which the correlations between craft engagement and formal training are significant at the level of 0.01. That is to say, if an organization engaged in the trades listed in Table 7.9, there would be a great probability that the organization would provide formal training in the trades. It means that the trades listed in Table 7.9 received more training efforts based on the survey data.

Table 7. 9: Trades Having Significant Correlation between Engagement and Training

Trades Company Engages and Provides Formal Training	Pearson Correlation Coefficient	P Value
Pipefitting	0.51	<0.01**
Electrical Work	0.49	<0.01**
Boilermaking	0.47	<0.01**
Millwright	0.46	<0.01**
Carpentry	0.39	<0.01**
Plumbing	0.34	<0.01**
Painting	0.33	<0.01**
Heavy Equipment Operation	0.33	<0.01**

Table 7.10 shows the trades of which the correlations between craft engagement and formal training were not significant. Companies have a lower probability to provide formal craft training for the trade listed in Table 7.10 than the trades in Table 7.9.

Table 7. 10: Trades Having No Significant Correlation between Engagement and Training

Trades Company Engages and Provides Formal Training	Pearson Correlation Coefficient	P Value
Insulation	0.29	0.01
Structural Steel and Ironwork	0.27	0.01
Concrete Work	0.27	0.01
Reinforcing Steel Work	0.25	0.02
Sheet Metal	0.24	0.02
Construction Craft Laborer	0.23	0.03
Masonry	0.19	0.07

The results of correlation analysis show a very interesting but also an intuitive pattern. Those trades which have significant correlations between engagement and formal training normally require more technical skills, such as pipefitting and electrical work. On the other hand, trades such as masonry and craft labor, which require relatively less technical skills, do not have significant correlations between engagement and formal training.

Barriers of Construction Craft Training

The Survey examined the barriers that companies and organizations experience in conducting a formal training program. Twelve common barriers to advancing formal training programs in construction were included in the survey, and respondents were asked to rate the barriers based on the scale 1 to 5, where 1 means none impact and 5 means very severe impact:

- Lack of financial resources;
- Lack of adequate instructors;
- Lack of adequate instructional material;
- Lack of adequate training facilities;

- Lack of support from job site supervisors;
- Lack of new craft workers interested in training programs;
- Once trained, employees leave our organization;
- Inadequate completion rates of existing training programs;
- Training location is not accessible to employees;
- Training takes too much time to complete;
- Training schedule conflicts with work schedule; and
- Language barriers.

In Figure 7.10, the barriers are listed in order from the greatest to least impact on the formal craft training program. The lack of new craft workers interested in a training program was the most serious barrier which hindered the implementation of craft training in construction.

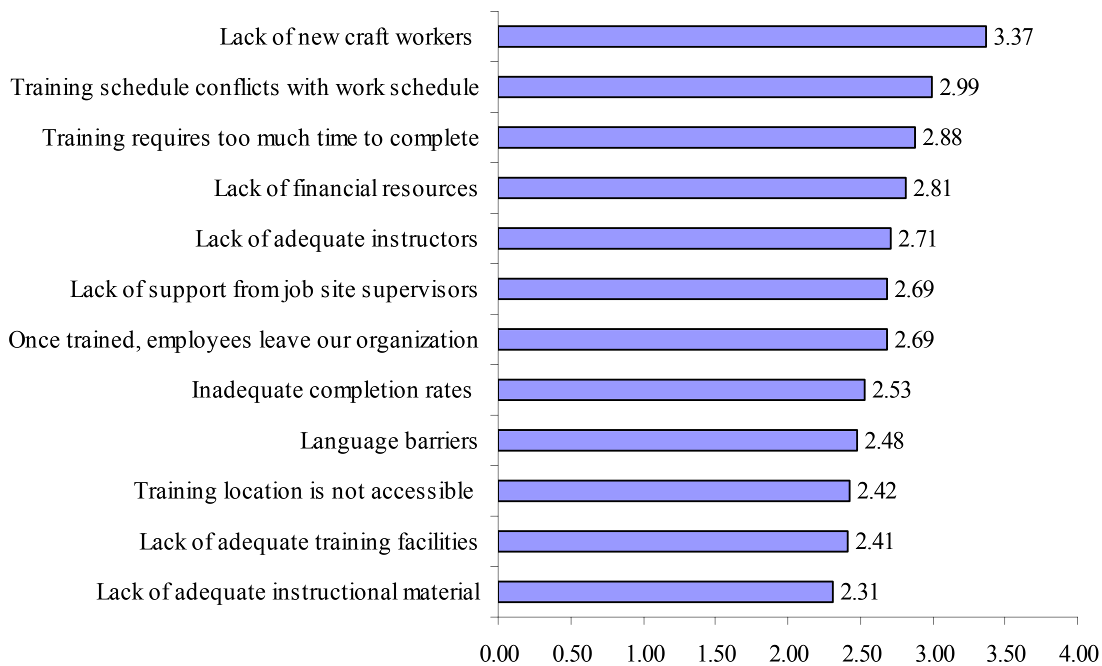


Figure 7. 10: Impact of Common Barriers for Advancing Formal Training in Construction

The study used a paired T-test to identify whether the difference in average rating between any of two barriers was statistically significant. Table 7.11 displays T-test matrix, which shows the average difference and P-value between the ratings of any two barriers and it highlights which differences are statistically significant. Next, the study identified the hierarchy of the importance for common barriers for construction training (Table 7.12). The barriers are listed in descending order according to their rating. The barriers sharing the same letter mean that their ratings of importance do not have a statistically significant difference at a level of 0.05. For example, the lack of new craft workers interested in formal training programs has the same impact as conflicts between training schedules and work schedule at a level of 0.05, but it has a significantly higher impact than any other barrier.

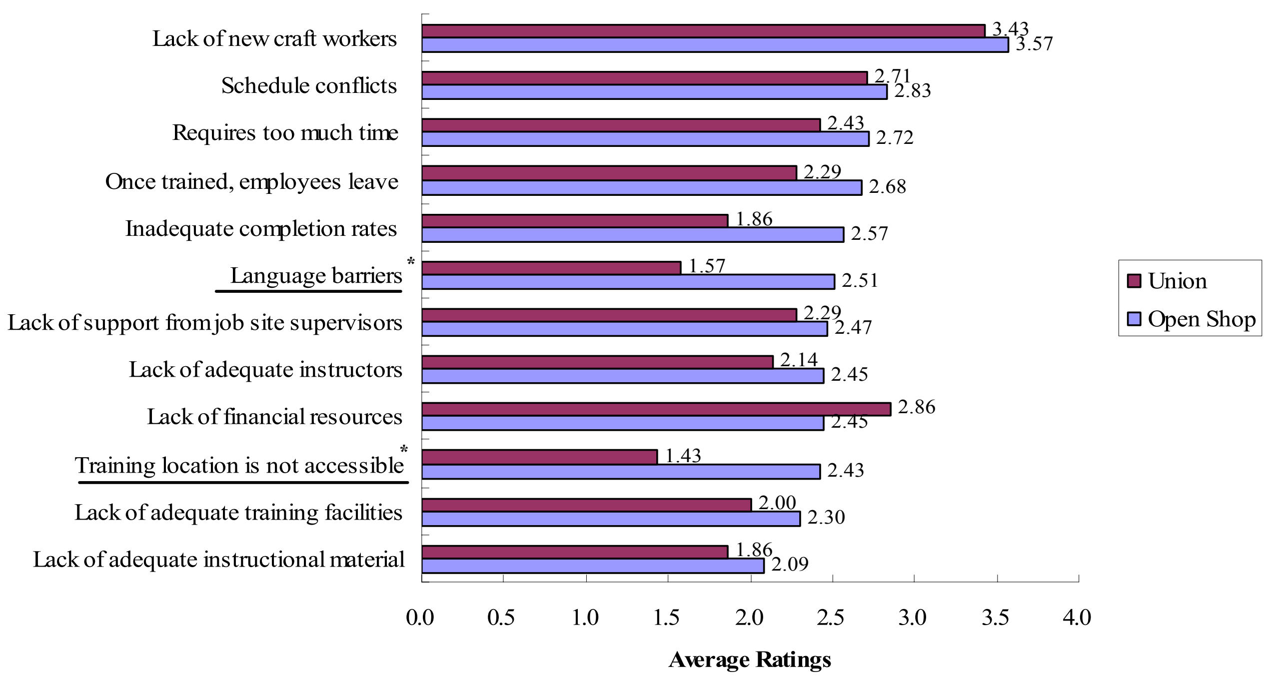
Table 7. 11: Paired T-test Matrix for Craft Training Barriers

	New Craft	Schedule	Too much time	Financial	Instructor	Leave	Supervisor	Completion	Language	Location	Facilities
Training schedule conflicts with work schedule	0.358										
P-Value	0.07										
Training requires too much time to complete	0.481	0.11									
P-Value	**0.007**	0.252									
Lack of financial resources	0.556	0.183	0.073								
P-Value	**0.005**	0.27	0.605								
Lack of adequate instructors	0.667	0.293	0.183	0.11							
P-Value	**0**	0.059	0.136	0.464							
Once trained, employees leave our organization	0.679	0.305	0.195	0.122	0.012						
P-Value	**0**	0.058	0.19	0.474	0.937						
Lack of support from job site supervisors	0.691	0.317	0.207	0.134	0.024	0.012					
P-Value	**0**	**0.025**	0.101	0.417	0.869	0.932					
Inadequate completion rates of existing training programs	0.835	0.45	0.338	0.238	0.163	0.15	0.125				
P-Value	**0**	**0.007**	0.024	0.168	0.302	0.203	0.384				
Language barriers	0.877	0.5	0.39	0.317	0.207	0.195	0.183	0.013			
P-Value	**0**	**0.001**	0.009	0.106	0.193	0.172	0.208	0.921			
Training location is not accessible by our employees	0.938	0.561	0.451	0.378	0.268	0.256	0.244	0.113	0.061		
P-Value	**0**	**0**	**0.001**	**0.037**	0.082	0.062	0.077	0.338	0.632		
Lack of adequate training facilities	0.963	0.585	0.476	0.402	0.293	0.28	0.268	0.15	0.085	0.024	
P-Value	**0**	**0**	**0**	**0.011**	**0.017**	**0.028**	0.053	0.272	0.517	0.84	
Lack of adequate instructional material	1.062	0.683	0.573	0.5	0.39	0.378	0.366	0.225	0.183	0.122	0.098
P-Value	**0**	**0**	**0**	**0.003**	**0**	**0.017**	**0.014**	0.176	0.23	0.408	0.402

Table 7. 12: Hierarchy of the Common Barriers of Craft Training

Common Barriers for Formal Construction Craft Training	**Average Ratings**	
Lack of new craft workers interested in formal training programs	3.37	A
Training schedule conflicts with work schedule	2.99	A
Training requires too much time to complete	2.88	B
Lack of financial resources	2.81	B
Lack of adequate instructors	2.71	B
Once trained, employees leave our organization	2.69	B
Lack of support from job site supervisors	2.69	B
Inadequate completion rates of existing training programs	2.53	C
Language barriers	2.48	C
Training location is not accessible by our employees	2.42	C
Lack of adequate training facilities	2.41	C
Lack of adequate instructional material	2.31	E

Next, the study compared the impact of training barriers between organizations using an open shop work force and those using a union work force. Figure 7.11 shows that the organizations using an open shop work force indicated that the barriers had a higher average impact than those using a union work force, except for the barrier identified as a lack of financial resources.



* The difference is significant at the 0.05 level (2-tailed)

Figure 7.11: Common Training Barriers (Union vs. Open Shop Work force)

A one-way ANOVA was performed to examine whether the difference between union and open shop was statistically significant (Table 7.13). The results show that the difference was significant in the barrier created by the training location not being accessible to employees and in language barriers, which means that the impacts of these two barriers was more significantly severe for open shop organizations than they were for union organizations.

Table 7. 13: Average Importance Rating of the Training Subjects

Common Barriers	Sum of Square	Sum of Squares	df	Mean Square	F	Sig.
Lack of financial resources	Between Groups	1.03	1	1.03	0.55	0.46
	Within Groups	96.47	52	1.86		
	Total	97.50	53			
Lack of Instructors	Between Groups	0.56	1	0.56	0.48	0.49
	Within Groups	60.47	52	1.16		
	Total	61.04	53			
Lack of instructional Material	Between Groups	0.32	1	0.32	0.31	0.58
	Within Groups	52.52	52	1.01		
	Total	52.83	53			
Lack of training facility	Between Groups	0.54	1	0.54	0.49	0.49
	Within Groups	57.83	52	1.11		
	Total	58.37	53			
Lack of support From supervisor	Between Groups	0.20	1	0.20	0.17	0.68
	Within Groups	61.13	52	1.18		
	Total	61.33	53			
Lack of new craft workers Interested in training	Between Groups	0.11	1	0.11	0.07	0.80
	Within Groups	87.02	51	1.71		
	Total	87.13	52			
Once trained, employees Leave our organization	Between Groups	0.95	1	0.95	1.00	0.32
	Within Groups	49.64	52	0.96		
	Total	50.59	53			
Inadequate completion rate Of existing training	Between Groups	3.05	1	3.05	3.23	0.08
	Within Groups	48.16	51	0.94		
	Total	51.21	52			
Training location is not Accessible	Between Groups	6.06	1	6.06	6.97	0.01
	Within Groups	45.20	52	0.87		
	Total	51.26	53			
Training requires too much time to complete	Between Groups	0.53	1	0.53	0.54	0.47
	Within Groups	51.12	52	0.98		
	Total	51.65	53			
Training schedule conflicts with work schedule	Between Groups	0.08	1	0.08	0.07	0.80
	Within Groups	64.07	52	1.23		
	Total	64.15	53			
Language barriers	Between Groups	5.37	1	5.37	4.14	0.05
	Within Groups	67.46	52	1.30		
	Total	72.83	53			

Next, the study compared the impact of training barriers rated by construction site managers and human resource/training managers. Figure 7.12 shows that the site managers indicated a more severe average impact than human resource manager in the barriers created by a lack of financial resources, a lack of instructors, a lack of instructional material, a lack of training facilities, and a lack of support from supervisors, in addition to the barriers created by employees leaving an organization once they are trained, too much time required for training and conflicts between training schedules and work schedules. On the other hand, the human resource/training managers indicated a more severe average impact than site managers in those barriers created by a lack of new craft workers interested in training, inadequate completion rates of existing training, inaccessibility of training locations and language barriers.

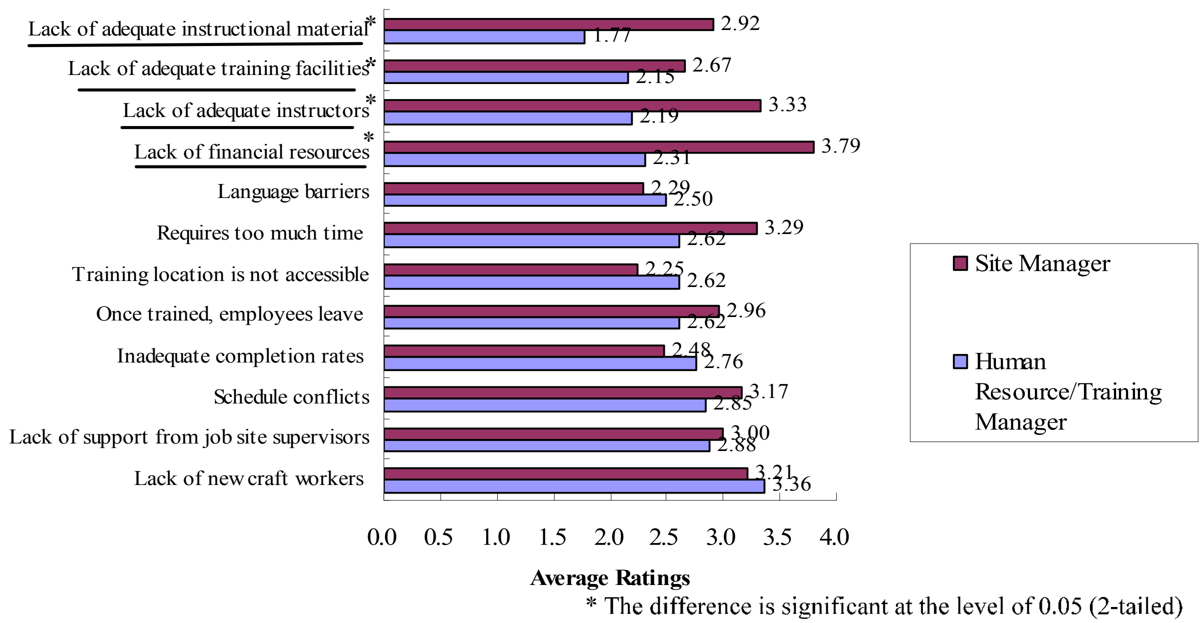


Figure 7. 12: Common Training Barriers (Site Manager vs. Human Resource Manager)

A one-way ANOVA was performed to examine whether the different perceptions between site managers and human resource/training managers were statistically significant (Table 7.14). The results show that the impact of the lack of financial resources, the lack of instructors, the lack of instructional material and the time required for training rated by the site manager were significantly more severe than by human resource/training manager.

Table 7. 14: Average Importance Rating of the Training Subjects

Common Barriers	Sum of Square	Sum of Squares	df	Mean Square	F	Sig.
Lack of financial resources	Between Groups	27.48	1	27.48	19.55	0.00
	Within Groups	67.50	48	1.41		
	Total	94.98	49			
Lack of instructors	Between Groups	16.25	1	16.25	14.61	0.00
	Within Groups	53.37	48	1.11		
	Total	69.62	49			
Lack of instructional Material	Between Groups	16.43	1	16.43	13.97	0.00
	Within Groups	56.45	48	1.18		
	Total	72.88	49			
Lack of training facility	Between Groups	3.28	1	3.28	2.99	0.09
	Within Groups	52.72	48	1.10		
	Total	56.00	49			
Lack of support From supervisor	Between Groups	0.17	1	0.17	0.15	0.70
	Within Groups	54.65	48	1.14		
	Total	54.82	49			
Lack of new craft workers Interested in training	Between Groups	0.28	1	0.28	0.19	0.67
	Within Groups	69.72	47	1.48		
	Total	70.00	48			
Once trained, employees Leave our organization	Between Groups	1.47	1	1.47	1.56	0.22
	Within Groups	45.11	48	0.94		
	Total	46.58	49			
Inadequate completion rate Of existing training	Between Groups	0.95	1	0.95	0.84	0.37
	Within Groups	52.30	46	1.14		
	Total	53.25	47			
Training location is not Accessible	Between Groups	1.67	1	1.67	1.79	0.19
	Within Groups	44.65	48	0.93		
	Total	46.32	49			
Training requires too much time to complete	Between Groups	5.71	1	5.71	6.36	0.02
	Within Groups	43.11	48	0.90		
	Total	48.82	49			
Training schedule conflicts with work schedule	Between Groups	1.28	1	1.28	0.90	0.35
	Within Groups	68.72	48	1.43		
	Total	70.00	49			
Language barriers	Between Groups	0.54	1	0.54	0.53	0.47
	Within Groups	49.46	48	1.03		
	Total	50.00	49			

7.3 Craft Training Benefits

The CII RT-231 survey collected information about training benefits at the employer/project level. The survey asked respondents to estimate the impact of investing 1% of the total project budget for wages/labor on training under two types of scenarios (the average for U.S. corporations in general is 1.25%, (Economist 2006)):

- On a typical 24-month capital project

- On a typical ongoing maintenance/small capital contract

Specifically, requests were for the estimated effects on productivity, and on turnover, absenteeism, injuries and rework. The results of the survey are shown in Table 7.15, based on responses from the 93 completed surveys. The respondents estimated improvements in all categories.

Table 7. 15: Summary of Expected Training Benefits Identified through CII RT-231 Survey

Benefits	Capital Project			Maintenance Project		
	Average	95% Confidence Interval		Average	95% Confidence Interval	
		Lower Bound	Upper Bound		Lower Bound	Upper Bound
Improved Productivity	10.6%	6.8%	14.4%	9.9%	7.7%	12.1%
Reduced Turnover	13.9%	10.3%	17.5%	13.7%	8.0%	19.3%
Reduced Absenteeism	14.5%	10.0%	19.1%	14.6%	8.3%	21.0%
Reduced Injuries	25.5%	18.1%	33.0%	27.5%	17.8%	37.2%
Reduced Rework	23.2%	17.2%	29.1%	26.5%	17.9%	35.1%

Next the study compared the difference between human resource managers and site managers regarding the craft training benefits. The results are shown in Table 7.16, and there is no statistical significance between the human resource managers and site managers regarding their evaluations of craft training benefits.

Table 7. 16: Craft Training Benefits (Human Resource Manager vs. Site Manager)

	Human Resource Manager	Site Manager	Difference	t Value	P Value
Improved Productivity	16.2%	8.7%	7.6%	1.14	0.19
Reduced Turnover	16.1%	10.3%	5.8%	1.28	0.21
Reduced Absenteeism	12.5%	14.0%	-1.5%	-0.31	0.76
Reduced Injuries	31.2%	26.5%	4.7%	0.44	0.66
Reduced Rework	21.6%	25.6%	-4.0%	-0.50	0.62

The study also compared the difference between union and open shop companies regarding the benefits of craft training. The results are shown in Table 7.17, and there is no statistical significance between the union and open shop companies regarding their evaluations of craft training benefits

Table 7. 17: Craft Training Benefits (Union vs. Open Shop)

	Open Shop	Union	Difference	t Value	P Value
Improved Productivity	13.3%	8.7%	4.6%	0.59	0.56
Reduced Turnover	16.0%	11.0%	5.0%	0.86	0.40
Reduced Absenteeism	14.4%	12.5%	1.9%	0.25	0.81
Reduced Injuries	23.9%	33.7%	-9.8%	-0.57	0.59
Reduced Rework	21.4%	27.5%	-6.1%	-0.46	0.66

The RT-231 survey also collected information about the turnover and absenteeism rates among workers with and without craft training. The results are shown in Table 7.18, and workers having training have lower turnover and absenteeism rates than workers without training.

Table 7. 18: Turnover and Absenteeism Rates

	Turnover Rate	Absenteeism Rate
Workers having training	11.7%	12.4%
Workers without training	22.8%	14.7%
Difference	11.1%*	2.4%

*Significant at the level of 0.05

Meanwhile, the CII RT-231 survey also revealed that on average, 47% of the craft workers who received training on one project would be rehired on another project by the same company. Once a company invests in craft workers' skills and capabilities, it is likely to retain them. Currently, hiring costs on many projects approach $2,400 per person (Pappas 2004), so training can increase the craft-rehiring rate and cut hiring costs significantly for construction companies.

7.4 Summary

Based on the study's survey data and industry company case studies, and as corroborated by governmental data sources, the researchers find that the majority of construction craft training is informal training, which varies from 70.5% of total training hours for electrical workers to 77.5% for civil workers. While on-the-job training is not necessarily a bad aspect of training, it is most effective if accompanied by close onsite mentoring of the trainee and deliberate rotation of the trainee among different aspects of the trade (CII 2007). Regardless, informal training cannot replace formal training, which teaches workers crucial skills in basic safety, construction math, blueprinting, and the use of tools. According to the survey results, basic safety is considered the most important subject in a formal training program among the study's survey respondents, followed by introduction to power tools, construction math, basic employability skills and introduction to hand tools. However, the construction industry is facing a serious problem with completion rate of formal training programs, especially in open shop sector. The survey respondents indicated that training completion rates for the open shop organizations averaged only 40.3%; for union sector, the reported training completion rate was.81.3%

The study also identified factors hindering the implementation of formal training in construction. Although conflicts with construction schedules, too much time required for training, and a lack of financial resources were identified by the survey as significant barriers to craft training, the lack of new craft workers interested in entering the formal training program was the most severe barrier, in both the union and open shop sectors.

The study also found that most of the surveyed companies did not measure the craft training benefits. However, they indicated that they anticipated significant benefits of craft training in reduction of absenteeism, turnover, rework and injury as well as improvement of productivity. The study quantitatively identified the expected benefits in these areas and found that the differences in the perceived benefits were not statistically different among site managers and human resource manage or those involved with a union versus an open shop work force. The results show that both site and human resource management believe that benefits of craft training exist, regardless if training is implemented in the open shop or union sector.

CHAPTER 8: BUSINESS CASE FOR CRAFT TRAINING

In contrast to other industries, little research has been devoted to evaluating the returns to training in construction (Glover et al, 1999). CII Research Team 231 found that very few construction firms measure the returns in their craft training efforts. Of the 93 responses to the RT-231 survey, only 13.2% indicated that they measure the costs and benefits of their craft training efforts. The two most frequent reasons given for not measuring the costs and benefits was that respondents did not know what should be measured when it comes to measuring the returns on training and many considered training to be essential regardless of any measured return.

Although difficult, it is possible to measure the benefits of training through a combination of metrics. However, there is one advantage to training that is hard to quantify yet easy to understand: if we do not begin investing in the North American construction work force, we will not be able to build the projects that the economy needs. Fortunately, there are recognized benefits to craft training. Prior research has identified the following benefits of craft training:

- Improved productivity;
- Reduced turnover;
- Improved quality;
- Reduced absenteeism; and
- Improved safety.

Unfortunately, measuring these benefits as a direct result of training on a construction jobsite is difficult for two primary reasons. First, there is a myriad of factors that simultaneously impact a project and its performance in any of these areas. Isolating the discrete effect of one factor, like craft training, is extremely difficult with any degree of certainty. Second, in a classic scientific experiment, there would be two groups to measure the effects of training: a control group and an experiment group. However, assuring that the two groups began the experiment with identical sets of skills and work experiences and that both groups work on identical tasks over prolonged period of time would be unlikely.

Ultimately, a combination of analysis can be assembled that presents a comprehensive argument regarding the benefits of training. RT-231 analyzed the benefits and costs of training based on two sources of data. First, analyses were examined based on expected benefits of training based on data received from industry experts. Second, analyses were examined based on benefits measured using actual project data. Both analyses formulated B/C ratios using the CII

Model Plant.

Previous research has found positive returns to training. Canadian Apprenticeship Forum (2006) established model based on a standard cost-benefit analysis for a single firm that hires apprentices. Benefits or costs were calculated per apprentice per year. The cost included wages and benefits, opportunity cost, disbursements and administration. Benefit components included revenue generated by the apprentice which was determined by total annual chargeable hours of work and charge-out rate. The research found that on average, for each $1 invested in an apprentice, a benefit of $1.38 accrued to the employer, i.e. the B/C ratio was 1.38:1. Brandenburg (2004) performed a benefit cost analysis of training when implementing the Tier I work force strategy on the CII Model Plant. The study estimated the total benefits based on experts' opinions that training would result in 5% increased productivity, 2.5% decreased absenteeism, 10% decreased turnover as well as other savings such as reduced overhead cost due to information technology improvements and administrative cost savings. The training costs include books, instructor cost, material and training aids, and proficiency testing cost. The study identified that the B/C ratio was 2.7:1. Pappas (2004) performed a benefit cost analysis of training when implementing the Tier II work force strategy on the CII Model Plant. The work sampling method and the foreman delay method were used to identify the savings due to increased productivity. Several unpublished case studies were used to identify to savings due to increased safety and decreased absenteeism and turnover. The implementation cost of the Tier II work force strategy included cost of craft training and certification, on-site training coordinator, management skills training, short-interval planning consultant, and information technology. The study identified that the final B/C ratios ranged from 2.8:1 to 3.1:1. Cox and Issa (1999) determined the ROI of craft training during case studies of two construction companies. One company was an electrical contractor, which provided data about 31 electrician trainees from two projects. The company reported 22% increase of productivity and 50% decrease in absenteeism and turnover rate after craft training. Based on the data, the B/C ratio was determined as 7:1. The other company was a fire protection contractor, which provided data involving 103 sprinkler fitter trainees from 94 projects. The company reported 35% decrease in absenteeism rate, 29% decrease in turnover rate and 7% reduction in unit cost, which ended up with a 1.7:1 B/C ratio.

A brief summary of previous research findings are shown in Table 8.1, and the estimated B/C ratio to craft training has ranged from 1.38:1 to 7:1. Therefore, according to previous research the business case for craft training is significantly strong.

Table 8. 1: B/C of Craft Training: What Other Efforts Have Found

Studies	B/C Ratio
"Return on Apprenticeship Training Investment" by the Canadian Apprenticeship Forum, 2006	1.38:1
"An Assessment of Implementation Requirements for the Tier II Construction Work force Strategy" Dissertation by Mike Pappas, University of Texas at Austin, 2003.	2.8:1 – 3.1:1
"Determining the Quantitative Return on Investment (ROI) of Craft Training" by Cox, R.T et. al, University of Florida, 1999.	1.9:1 – 7:1
Brandenburg, S.G, Haas, C.T., and Byrom, K. (2006), "Strategic Management of Human Resources in Construction ",Journal of Management in Engineering, 22(2), 89-96	2.7:1

Although previous research have estimated the benefit to cost ratio of craft training, many of the previous efforts were based on small sample sizes of expert interviews or case studies, and/or the efforts used relatively simple models of a simulated construction project. Our effort examines the case for craft training by a more comprehensive benefit cost analysis, based on the data collected from a nation-wide survey. It does not examine the case from the perspective of craft workers, governments or other stakeholders. However this was done in the original study, since it is critical to the resolution of the current situation in practice.

8.1 Introduction Of The CII Model Plant Project

The CII model plant project is a hypothetical petrochemical processing facility developed by CII member companies in 1985 to provide a standardized physical facility for productivity measurement. The model plant costs $75-85 million dollars (1985 Dollars) to construct. In order to adjust the model plant costs into current dollar value, the study examined several widely used cost/price indexes, such as consumer price index (CPI), GDP (Gross Domestic Product) deflator, ENR (Engineering New Record) Building Cost Index (BCI), ENR Construction Cost Index (CCI), and RS Means Historic Cost Index. Considering that the CII model plant is a heavy industry project, the study used ENR Construction Cost Index (CCI) to convert 1986 dollar values into 2006 dollar values. The costs of the model plant in 2006 dollars range from 134.6 million to 152.5 million (Table 8.2). The construction duration of the CII model plant is estimated as 78 weeks.

Table 8. 2: Construction Cost Index (CCI)

Year	CCI
1986	4295
2006	7704
Inflation Factor	7704/4295=1.794

(Source: Engineering News Record)

The CII Model Plant consists of nine areas, including a tank farm, underground piping, a pipe bridge, a fractionation unit, and other areas. Material takeoffs defining the labor scope of work have been determined from design documents that were supplied by several CII member companies. A code of accounts was established for the various scopes of work at both a detailed and summary level. Contractors and owners, based on actual experience, have estimated the amount of construction labor that would be required to build selected parts of the model plant. First the study estimated the baseline labor cost, turnover, absenteeism, incident and rework costs. Next a hypothetical craft-training program was implemented in CII Model Plant. It is believed that the craft-training program can improve the project performance in productivity, turnover, absenteeism, safety and rework.

Since its development, the CII Model Plant Data has been used to benchmark industry productivity (CII 1988), to analyze the impact of multifunctional equipment (Guo and Tucker 1993), to examine the schedule and manning impacts of utilizing a multiskilled work force (Burleson et al 1998, and Gomar et al 2002), and to examine the impact of alternative training strategies for a project's work force (Castaneda-Maza 2002, Brandenburg 2004, Pappas 2004, and Srour 2005). Since its conception, a number of significant revisions have been made to the plant model. This study uses the latest updated model by Burleson in 1997 (Burleson et al 1998).

8.2 Baseline Cost Of the CII Model Plant

The study first determined the cost of building the CII model plant under baseline condition when no training program was implemented. The craft-training program can have impact on the following costs:

- Labor Cost;
- Turnover Cost;
- Absenteeism Cost;
- Injury Cost; and
- Rework Cost.

The study determined these costs by using the estimation of the CII model plant as well as other construction industry data and previous research findings (Table 8.3). Labor cost was determined according to the *Means Building Construction Const Data* current labor cost and the amount of construction labor man-hours that would be required to build CII model plant. Following their actual experiences in previous projects, five contractors and owners estimated the man-hours (Burleson 1998). The study chose the average values of five contractors' estimation to determine the base line labor cost. For baseline turnover and absenteeism rates, the study used lower bounds of 95% confidence intervals for workers without craft training, which were identified by the survey (Table 8.3). For the rate of injury in construction, the study used the industry average rate 6.4 per 100 full time workers per year, which was published by US BLS (2007). For the cost of each injury, the study used findings by Hinze (1991), who conducted an investigation on 185 projects under construction from more than 100 contractor firms to identify injury costs in construction. For rework cost, the study used the findings of Rogge et al (2001), who surveyed 144 construction projects and identified that the magnitude of field rework ranged from zero percent to 25% with mean value of 4.4% of the labor cost. Section 8.2.1-8.2.5 details how the baseline cost rate for each cost component was derived. Given these rates and unit cost, the estimated total baseline costs for the CII model plant are shown in Table 8.14.

Table 8. 3: CII Model Plant Baseline Cost Rates

Cost Component	Baseline Rate	Source	Unit Cost Rate	Source
Labor	527,457 man-hour	CII Model Plant Research, 1986	Varied by different trade and included fringes and worker's compensation insurance	RS Means, 2006
Turnover	15.53% of total project work force	RT231 Survey	$2,000 per hire	CII member company
Absenteeism	7.20% of daily work force	RT231 Survey	$110 per absence	Pappas, 2004
Injury	6.4 per 100 full time workers per year	US Bureau of Labor Statistics, 2004	Varied by different types of incidents	CII Research "Indirect Cost of Construction Accident"
Rework	-	-	4.4% of Labor Cost	CII Research "An Investigation of Field Rework in Industrial Construction"

8.2.1 Baseline Labor Cost

The study determined the baseline labor cost of the CII model plant based on the amount of construction labor man-hours that would be required to build selected parts of the model plant. The man-hours were estimated by contractors and owners according to their actual experiences.

Five contractors participated in the CII model plant and submitted the labor-hour estimation. The study chose the average values of five contractors' estimation to determine the base line labor cost (Burleson 1998). Table 8.4 shows the baseline man-hours required by each major construction activity.

Table 8. 4: The CII Model Plant Man-hour Estimation

Title	Bidder A	Bidder B	Bidder C	Bidder D	Bidder E	Mean Man-hour
Site Preparation/Improvements	5,461	11,190	13,668	28,132	14,252	14,541
Underground Electrical	9,262	16,853	19,195	21,176	21,924	17,682
Underground Piping	19,426	52,260	26,843	47,929	22,314	33,754
Piling	1,868	2,775	2,753	3,331	3,005	2,746
Concrete and Excavation	56,734	98,505	97,344	76,804	50,110	75,899
Specialized Concrete	916	610	4,231	1,563	3,665	2,197
Structural Steel	26,130	23,310	17,495	23,424	12,275	20,527
Building Construction	1,730	3,833	2,846	2,731	1,818	2,592
Aboveground Racked Piping	50,660	62,797	52,481	45,673	46,749	51,672
Aboveground Nonracked Piping	81,685	88,990	72,290	99,282	104,194	89,288
Aboveground Electrical	48,112	48,920	56,053	67,548	53,773	54,881
Instrumentation	9,259	9,095	8,709	9,921	8,229	9,043
Insulation	28,662	18,370	14,640	21,173	28,907	22,350
Paining	9,779	6,230	38,570	10,959	10,327	15,173
Paving	2,223	9,060	2,396	6,816	6,824	5,464
Major Equipment	94,335	47,792	60,189	80,497	48,720	66,307
Tanks	64,449	33,900	37,960	59,184	21,210	43,341
Total	510,691	534,490	527,663	606,143	458,296	**527,457**

(Source CII Document 23 1986)

In order to determine labor cost, the study reassigned the man-hours needed by each construction activity into different trades abased on the man-loading curves for different trade workers, which were developed by Burleson (1997). The average hourly cost of each trade worker was identified by using *Means Building Construction Cost Data's* (2006). The cost includes the benefit fringes and worker's compensation insurance. Total labor costs under baseline condition were calculated in Table 8.5.

Table 8. 5: The CII Model Plant Baseline Labor Cost Estimation

Trade	Man-hour (hr)	Hourly Cost Fringes included ($/hr)	Worker's Compensation Insurance (%)	Cost Included Compensation ($/hr)	Total Cost ($)
Carpenter	69,543	33.00	18.4	42.09	2,927,156.04
Concrete Finisher	7,675	31.55	10.3	37.94	291,232.11
Crane Operator	22,605	34.80	10.6	42.14	952,530.31
Electrician	48,963	39.40	6.8	44.86	2,196,274.77
Equipment Operator	39,094	32.15	10.6	40.59	1,586,846.20
Labor	37,913	26.00	18.4	32.44	1,229,973.82
Instrumentation	7,549	33.65	6.8	44.86	338,616.01
Insulator	20,032	28.45	9.5	37.34	747,990.39
Iron Worker	26,611	37.10	24.4	49.14	1,307,617.56
Millwright	18,008	34.35	10.4	40.96	737,572.59
Painter	19,189	28.00	13.3	35.92	689,182.88
Pipe Fitter	92,232	39.40	8.2	46.58	4,296,186.34
Rigger	15,182	26.00	18.4	32.44	492,536.79
Structural Steel	8,730	37.10	39.6	55.77	486,862.65
Surveyor	11,766	35.00	6.4	35.12	413,261.80
Truck Driver	11,176	26.45	15.4	32.72	365,627.33
Welder	71,188	39.60	39.6	55.77	3,970,164.98
Total Labor Cost	**527,457**				**23,029,632.58**

8.2.2 Baseline Turnover Cost

The Business Round Table (1982) research "Absenteeism and Turnover" reported that the cost of turnover was equivalent to 24 hours of labor cost per occurrence. The estimation was made more than twenty years ago, and it did not include current requirements for additional safety training or new employee orientation, the administrative costs of hiring and firing, or the additional safety risk posed by new hires (CII 1999).

CII (2000) research "Attracting and Maintaining a Skilled Construction Work force." found that "a 10 percent increase in turnover rate added about a 2.5 percent increase to labor costs, assuming turnover is constant throughout the project." The same study also found that an increasing turnover rate results in a decline in the productivity factor. Pappas (2004) reported in an unpublished case study that one contractor values each turnover case at approximately $2,700, and an article (Winston and Loweis 2004) in the Engineering News Record (ENR) reported that hiring costs alone approach $2,400. In addition, a construction firm involved in the RT-231 research efforts used $2000 per occurrence to estimate the turnover cost in their internal training benefit analysis. Pappas (2004) assumed a 15% turnover rate and the cost of turnover was $2500 per occurrence. The employee turnover rate released by the Bureau of Labor Statistics (2004) showed the voluntarily turnover rate in the construction industry was 25.40%, which is much higher than the rates used by other research.

Finally based on the RT-231 survey, the average turnover rate among the crafts who did not receive training before was 22.68% with 95% confidence interval (15.53%, 29.84%). The RT-231 study used the lower bound of 95% confidence interval (i.e. 15.41% turnover rate) in order to achieve a more conservative estimation. Meanwhile the study assumed that turnover cost was $2000 per occurrence based on RT-231 own experience. Using 15.41% turnover rate and $2000 per occurrence, the study estimated the baseline turnover cost of the CII model plant to be $231,458.20 (Table 8.6).

Table 8. 6: The CII Model Plant Baseline Turnover Cost

Trade	Total number of workers hired
Carpenter	90
Concrete Finisher	20
Crane Operator	25
Electrician	61
Equipment Operator	49
Labor	75
Instrumentation	13
Insulator	29
Iron Worker	39
Millwright	44
Painter	28
Pipe Fitter	129
Rigger	20
Structural Steel	21
Surveyor	18
Truck Driver	21
Welder	69
Total	751
Turnover Number (15.41% turnover rate)	**116**
Turnover Cost ($2,000 per occurrence)	**$231,458.20**

8.2.3 Baseline Absenteeism Cost

The Business Round Table (1983) quantified the effect of absenteeism: “On large projects during periods of high labor demand, absenteeism as high as 20% and annual turnover reaching 200% were reported. If these levels could be cut in half – a reasonable goal – labor-cost savings would range from 5% to 10%." Jack Phillips (1991) estimated that each occurrence of absenteeism cost $80 to $100, which, when updated using the Consumer Price Index, is $110 to $137 in 2004. Pappas (2004) reported three unpublished case studies about construction project absenteeism, in which three contractors recorded the absenteeism rates were 1.2%, 7% and 12% respectively. Pappas (2004) used 8% absenteeism rate and a cost of $110 dollars in his research.

The RT-231 survey study identified that the average absenteeism rate among the crafts who did not receive training was 14.59% with 95% confidence interval (7.10%, 21.99%). The study used the lower bound of the 95% confidence interval (i.e. 7.10% absenteeism rate) in order to achieve a conservative estimation. Meanwhile, the study assumed that the absenteeism cost was $110 per occurrence, which was according to Pappas' estimation. Based on 7.10% absenteeism rate and $110 per occurrence, the study estimated the baseline absenteeism cost of the CII model plant to be $514,929.90 (Table 8.7)

Table 8. 7: The CII Model Plant Baseline Absenteeism Cost

Project Duration (days)	390
Absenteeism Rate	7.10%
Average Worker on Site	169[6]
Absentees per Day	12
Unit Cost of Absenteeism	$110
Cost of Absenteeism per Day ($)	1,320
Total Absenteeism Cost ($)	514,929.90

8.2.4 Baseline Injury Cost

The CII research of Indirect Costs of Construction Accidents (Hinze 1991) conducted an investigation on 185 projects under construction by more than 100 contractor firms. The participants were asked to document all known costs associated with each worker's injury that occurred during a specified period of time. The research categorized the construction project injuries into:

(i) medical cases, which includes minor injuries such that a worker can go back to work after simple medical treatment, and

(ii) restricted activity/lost workday cases, which includes incidences when a worker has to be off work for some days before recovery from an injury.

[6] Calculated as Total Man-hour of the CII Model Plant ÷ Project Duration (weeks) ÷Working Hour (hours per week) = 527,457 ÷ 78 ÷ 40 = 169

The total cost of injury consists of both the direct and indirect costs. The direct cost of an injury is the cost for medical treatment of the injured worker. For the cost of an injury occurred in a construction project, a large portion of the injury cost is the indirect cost, such as lost productivity of the injured work, injured worker's crew, equipment and material damage. Hinze (1991) documented the magnitude of the construction indirect costs (Table 8.8).

Table 8. 8: Indirect Cost of Construction Injury

Cost of Injured Worker	Productive time lost at the time of the injury
	Productive time lost when follow-up treatment is obtained
	Reduced capacity of the worker upon returning to work
Cost of Injured Worker's Crew	Productive time lost at the time of the injury
	Reduced capacity due to being short-handed
Costs Associated with Obtaining Medical Help	Wages of the driver
	Costs associated with transportation
Costs of Other Crews	Productive time lost when watching injury-related activities
	Productive time lost when talking about the injury
Costs of Equipment and Material Damage	Cost of equipment and material damaged by the incident
Costs of Supervisory Staff	Productive time lost investigating the accident
	Productive time lost preparing accident reports
	Productive time lost accompanying regulatory personnel
	Productive time lost addressing media personnel
Other Costs	Damage to company image
	Reduced company competitiveness
	Reduced worker morale
	Pain and suffering of injured worker
	Loss in pay of injured worker
	Adverse impact on family members of injured worker

(Source: Hinze 1991)

Hinze (1991) also identified the average number of each type of injury and indirect/direct cost ratio by project size (Table 8.9). The estimated cost of the CII model plant is $134.6 to $152.5 million in 2006. Based on Hinze's research, 57 medical cases and 29 restricted activity/lost workday injuries would be expected to occur during the construction of the CII model plant.

Table 8. 9: Number of Injuries by Project Size

Range of Project Size	Expected Number of Cases	Cost Ratio
Medical Cases		
Less than $2,000,000	69	2.61
$2,000,000 to $10,000,000	62	4.00
$10,000,000 to $75,000,000	61	4.02
Over 75,000,000	**57**	**4.64**
Restricted Activity/Lost Workday		
Less than $2,000,000	15	5.72
$2,000,000 to $10,000,000	8	3.72
$10,000,000 to $75,000,000	13	9.53
Over $75,000,000	**29**	**9.47**

(Source: CII Source Document 67)

Hinze (1991) grouped the injury cases identified by his survey based on the injury severity level (i.e. the range of direct cost) and gave the ratio of indirect cost versus direct cost for each severity level of injury. The study further identified the percentage of each severity level injury among total injury cases (Table 8.10). Next the expected numbers of medical cases and activity/lost workday injuries during the construction of the CII model plant were proportioned into each injury severity level based on the percentage identified in Table 8.10.

According to the Injuries, Illnesses, and Fatalities program in the Bureau of Labor Statistic, in 2004, the nonfatal injuries and illnesses incidence rate was 6.4 per 100 full-time workers in construction. So the CII model plant was expected to have 75[7] injury cases during 78-week construction. When using Hinze's findings, the CII model plant would expected to have 86 injury cases. The study adjusted Hinze's finding based on current prevailing injury rate in construction and therefore forecasted that 75injuries would occur on the CII model plant. The detailed calculations are shown in Table 8.10.

Typical CII member companies experience injury rates much lower than the average rates of the construction industry. The CII 2005 Safety Report used two incident rates to evaluate the safety in the CII member company.

DART: the days away, restricted, or transfer case incidence rate (DART) is the number of DART cases occurring annually among 100 full-time workers

[7] Calculated by Average Incident Rate × Total Number of Workers Hired × Duration Factor = 6.4% × 751 × (78/50) = 75. The duration of the CII model plant is 78 weeks and 50 week are considered in a year.

(2,000 hours per worker per year).

TRIR: the total recordable incidence rate is the number of recordable injuries occurring annually among 100 full-time workers (2,000 hours per worker per year).

The CII 2005 Safety Report found that for heavy industry, the DART was 0.2 and TRIR was 0.5 in 2004, which are much lower than the average nonfatal injuries and illnesses incidence rate of the whole construction industry, which was 6.4 per 100 full-time workers in 2004. According to CII 2005 Safety Report data, the number of DART cases expected for CII model plant is 3 and the number of TRIR is 7. The DART case is equivalent to restricted activity/lost workday cases in Hinze's research and the medical cases is equal to the difference between TRIR cases and DART cases. So if the contractor of the CII model plant were a CII member company, the number of incident would be expected much lower and the result direct and indirect cost of injuries would be $25,452.99 (Table 8.11). In order to address more prevailing conditions in construction, the study performed the benefit cost analyses based on injury cost of the industry average (listed in Table 8.10) rather than injury cost of CII member companies (listed in Table 8.11).

Table 8. 10: Baseline Injury Cost of CII Model Plant

Ranger of Direct Costs	Median Value of Direct Costs	Empirical Percent of Each Injury Level	Number of Cases for CII Model Project	Direct Cost ($)	Indirect Cost/Direct Cost	Indirect Cost	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
				(2) × (4)		(5) × (6)	(5) + (7)
Medical Cases							
0 to 50	$25	7.80%	4	$100.00	8.19	$819.00	$919.00
51 to 100	$75	19.50%	10	$750.00	4.4	$3,300.00	$4,050.00
101 to 150	$125	20.89%	10	$1,305.63	3.24	$4,230.23	$5,535.85
151 to 200	$175	15.32%	10	$1,750.00	2.86	$5,005.00	$6,755.00
201 to 300	$250	18.11%	9	$2,250.00	2.62	$5,895.00	$8,145.00
301 to 1000	$650	16.43%	8	$5,200.00	2.04	$10,608.00	$15,808.00
Over 1000	$1,000	1.95%	1	$1,000.00	1.18	$1,180.00	$2,180.00
		Subtotal	50			**Subtotal**	$43,392.85
Restricted Activity/Lost Workday							
0 to 300	150	26.26%	7	$1,050	11.07	$11,623.50	$12,673.50
301 to 1000	650	24.24%	6	$3,900	8.15	$31,785.00	$35,685.00
Over 1000	1000	49.49%	12	$12,000	7.25	$87,000.00	$99,000.00
		Subtotal	25			**Subtotal**	$147,358.50
						Total(1991$)	**$190,751.35**
						Total (2006$)	**$262,099.60**

Table 8. 11: Baseline Injury Cost of CII Model Plant (CII Member Company)

Ranger of Direct Costs	Median Value of Direct Costs	Empirical Percent of Each Injury Level	Number of Cases for CII Model Project	Direct Cost ($)	Indirect Cost/Direct Cost	Indirect Cost	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
				(2) × (4)		(5) × (6)	(5) + (7)
Medical Cases							
0 to 50	$25	7.80%		0	8.19	0	0
51 to 100	$75	19.50%	1	75	4.4	330	405
101 to 150	$125	20.89%	1	125	3.24	405	530
151 to 200	$175	15.32%	1	175	2.86	500.5	675.5
201 to 300	$250	18.11%	1	250	2.62	655	905
301 to 1000	$650	16.43%		0	2.04	0	0
Over 1000	$1,000	1.95%		0	1.18	0	0
		Subtotal	4			**Subtotal**	$2,515.50
Restricted Activity/Lost Workday							
0 to 300	150	26.26%	1	150	11.07	1660.5	1810.5
301 to 1000	650	24.24%	1	650	8.15	5297.5	5947.5
Over 1000	1000	49.49%	1	1000	7.25	7250	8250
		Subtotal	3			**Subtotal**	$16,008.00
						Total (1991$)	**$18,523.50**
						Total (2006$)	**$25,451.99**

8.2.5 Baseline Rework Cost

Previous research by Rogge et al (2001) surveyed 144 construction projects and identified the magnitude of field rework ranged from zero to 25%, with a mean value of 4.4%. Smith and Jikik (CII 2006) reported a 0.33 rework rate based on a survey of 23 industrial projects. These percentages were computed from the ratio of field rework cost to total construction phase cost as shown in Equation 8.1.

$$\text{Rework Rate} = \frac{\text{Total Direct Cost Field Rework}}{\text{Actual Construction Labor Cost}} \quad \ldots\ldots\ldots\ldots(8.1)$$

Table 8.12 summarizes the rework rates identified by several CII research.

Table 8. 12: Literature Summary of Rework Rates

Research	Field Rework Percentage	Project Data
Research Summary 10-1 (1989)	2.5%	9 industrial projects
Benchmarking & Metrics Data Report (1997)	3.4%	19 industrial project
Investigation of Field Rework in Industrial Construction (2001)	4.4%	144 industrial projects
Making Zero Rework a Reality (2005)	0.33%	23 industrial projects

Previous research only measured the direct cost of rework; however, it is believed that indirect costs account for a large portion of total rework costs (Smith and Jirik 2005). Currently, the actual indirect cost of rework has not been measured and was not included in the total cost of rework. In order to remedy the effect of neglecting indirect rework cost in the estimation, the study decided to choose the conservative rework rate from previous research findings (Rogge et al 2001), which also had the largest sample size. It was estimated that rework cost of the CII model plant is equal to 4.4% of construction labor cost. The rework cost of the CII Model Plant is calculated in Table 8.13.

Table 8. 13: Rework Cost of CII Model Plant (2006$)

Total Construction Labor Cost	$18,341,584.42
Rework Cost (4.4%)	$807,029.71

8.2.6 Summary of the CII Model Plant Baseline Cost

Finally, based on the calculations in previous sections, the study determined the total cost of CII model plant under the condition that no craft training was implemented. The costs included in the total cost were those items that would be affected by craft training program. Therefore, the material, equipment, and other associated management costs are not included.

Table 8. 14: Baseline Cost Summary (2006$)

Cost	Amount ($)	Percent
Labor Cost	22,020,933.64	92.35%
Turnover Cost	233,260.60	0.98%
Absenteeism Cost	522,182.43	2.19%
Injury Cost	262,099.60	1.10%
Rework Cost	807,029.71	3.38%
Total	23,845,505.99	

8.3 Benefit/Cost Estimated Using Construction Craft Training Survey Data

The study assumes craft workers hired by the CII model plant have no training experience before they start in the CII Model Plant Project. It was assumed that the longer a worker stays in the project, the more performance improvement he/she can achieve. Based on this assumption, the study first established a linear learning curve function to model the relationship between performance improvement and time. Next the study determined the labor usage strategies for the CII model plant. Finally,, the study identified the cost savings after craft training was implemented and the resulting benefit cost ratio.

8.3.1 Craft Worker Learning Curve Function

The learning curve effect states that the more times a task has been performed, the less time will be required on each subsequent iteration. The craft workers' learning curve was considered by the research when determining the benefits of craft training. The workers can only increase productivity and decrease rework gradually after the craft training is implemented. In the RT-231 survey, the respondents were asked on average the time needed to achieve half of the improvement in productivity after a craft-training program was implemented. To model the time effect on the workers' performance improvement, the research assumes time and workers' performance improvement in productivity and rework, followed a simple linear relationship after receiving craft training:

$$Y_i = a \times X \text{..................}(8.1)$$

Where:

Y_i: performance improvement in i^{th} week, such as productivity increase and rework reduction;

X: weeks, based on worker's average duration in the CII Model Plant, X is from 1 to the last week a worker in the project; and

a: linear learning curve coefficient.

Based on the RT-231 survey, the study found an average of 35-week was needed to achieve half of the benefits from a training program, such as productivity improvement and rework reduction. Therefore, the coefficient, a, can be determined by:

$$a = \frac{\textbf{Half of the Performance Improvement in Productivity and Rework(\%)}}{\textbf{35 (week)}}$$

The linear learning curve function was applied to improvements in productivity and rework. For the reductions in turnover, absenteeism and injury of workers after training, the research adopted the opinions from the industrial experts that these specific improvement happened very quickly after workers completed the training. Under this assumption, the learning curve effect does not apply to turnover, absenteeism and injury reduction.

8.3.2 Determination of the Labor Usage of the CII Model Plant

When considering the effect of learning curve on improvement of worker's performance caused by craft training, the worker spending shorter time in a project may not achieve the same performance improvement as the worker spending longer time in a project due to the learning curve effect. In order to address this problem, the study has to determine the average duration for workers in each individual trade. The study used the man-loading curves developed by Burleson (1997) to identify the average duration. Figure 8.1 shows the man-loading curve of *carpenter*. The number of hired or fired workers in each week can be calculated by counting the incremental increases and decreases along the Y-axis of the man-loading curve. Hires and fires were independently counted and the total hires should be equal to total fires. Table 8.16 shows the number of weekly hired/fired carpenters in the CII model plant. The total number of hired/fired carpenters for the CII model plant was 90.

When calculating the average duration of carpenter in the CII model plant, the study used a "*first-in, last out*" approach. This approach assumes that contractors hire the most desirable workers in each skill level first, and then attempt to retain these workers until no additional work in their trade is needed. Using this assumption, the employment duration of workers in each trade was estimated by measuring the number of hired workers and their employment duration for each week including the change in the number of hired workers. The employment duration of trade workers was read from the X-axis of the man loading curve, and the number of trade workers employed during that duration was read from the Y-axis of the man loading curve. The average duration of workers in a trade can be calculated as follows:

$$D_{average} = \frac{\sum d_i \times n_i}{\sum n_i} \qquad (8.2)$$

Where: d_i is employment duration of a group of worker, and n_i is the number of workers employed for the length of d_i.

Based on Figure 8.1, Tables 8.16 and 8.17 and Equation 8.2, the average duration for the Carpenters, for example, was calculated as:

Average Duration of Carpenter

$$= \frac{(1)8 + (2)1 + (3)3 + (4)4 + (5)11 + (6)1 + (7)4 + (10)1 + ... + (63)3 + (64)1 + (65)1 + (66)1 + (70)1 + (71)1}{90} = 18$$

Similar man-loading curves were utilized for 17 trades including carpenter, concrete finisher, crane operator, electrician, equipment operator, labor, instrumentation, insulator, iron worker, millwright, painter, pipe fitter, rigger, structure steel worker, surveyor, truck driver and welder. The study determined the average employment duration of a carpenter is 18-week in CII model plant project based on Equation 8.2. The study calculated the average employment duration for all major trades in the CII Model Plant. Table 8.15 shows the number of workers hired in each trade and the average employment duration.

Table 8. 15: Baseline Labor Utilization of the CII Model Plant

Trade	Total number of workers hired	Average Duration (week)
Carpenter	90	18
Concrete Finisher	20	9
Crane Operator	25	21
Electrician	61	19
Equipment Operator	49	19
Labor	75	13
Instrumentation	13	14
Insulator	29	16
Iron Worker	39	16
Millwright	44	10
Painter	28	16
Pipe Fitter	129	17
Rigger	20	18
Structural Steel	21	15
Surveyor	18	6
Truck Driver	21	13
Welder	69	22
Overall	751	18

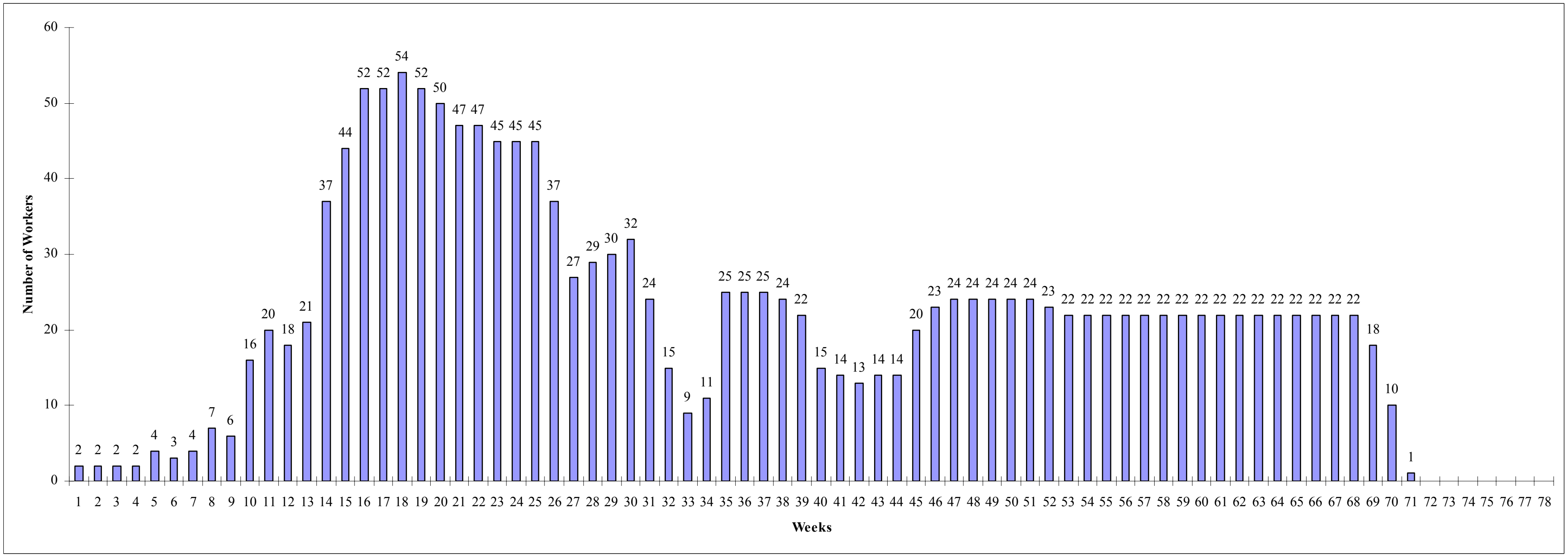


Figure 8. 1: Man Loading Curve: Carpenter

Table 8. 16: Labor Utilization Strategy Analysis Sheet: Carpenter

Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Number of Hires	2				2		1	3		10	4		3	16	7	8		2							
Number of Fires						1			1			2							2	2	3	2			

Week	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
Number of Hires			2	1	2				2	14								1		6	3	1			
Number of Fires	8	10				8	9	6					1	2	7	1	1								

Week	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75
Number of Hires																									
Number of Fires		1	1																4	8	9	1			

Week	76	77	78
Number of Hires			
Number of Fires			

Total Number of Hires	90
Total Number of Fires	90

Table 8. 17: Labor Utilization Duration Analysis Sheet: Carpenter (First-in, Last-out)

Duration of Employment	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**
Number of Employees	8	1	3	4	11	1	4			1	7		10				3	3	3		2	1	8	2	4

Duration of Employment	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**
Number of Employees		1								2	1	1													

Duration of Employment	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**	**60**	**61**	**62**	**63**	**64**	**65**	**66**	**67**	**68**	**69**	**70**	**71**	**72**	**73**	**74**	**75**
Number of Employees										3			2	1		1				1	1				

Duration of Employment	**76**	**77**	**78**
Number of Employees			

Average Duration (weeks)	18[8]

---

[8] Based on Figure 8.1 and Equation 8.2, the Average Duration of Carpenter can be determined as: Average Duration of Carpenter Average

$$\text{Duration} = \frac{\sum d_i \times n_i}{\sum n_i} = \frac{1 \times 8 + 2 \times 1 + 3 \times 3 + 4 \times 4 + 5 \times 11 + 6 \times 1 + 7 \times 4 + 10 \times 1 + ... + 63 \times 3 + 64 \times 1 + 64 \times 1 + 66 \times 1 + 70 \times 1 + 71 \times 1}{90} = 18$$

8.3.3 Determination of the Cost Savings from Craft Training Program

Next the study identified the cost savings from a craft-training program for the CII model plant. As said in the previous sections, the craft-training program can save the following costs:

- Labor Cost;
- Turnover Cost;
- Absenteeism Cost;
- Injury Cost; and
- Rework Cost.

The study applied the finding from the CII RT231 survey, which collected the information about expectations in improved productivity, turnover, absenteeism, injury and rework for a 24-month capital project after investing 1% of total project budget for wages/labor in craft training. Based on 93 complete surveys, the study identified the training benefits, which are shown in Table 8.18. 95% confidence intervals for the training benefits were identified and were used in the latter benefit cost analysis to generate more reliable analysis results.

Table 8. 18: Summary of Expected Training Benefits (Construction Craft Training Survey)

	Capital Project		
	Average	95% Confidence Interval	
		Lower Bound	Upper Bound
Productivity Improvement	**10.6%**	6.8%	14.4%
Turnover Decrease	**13.9%**	10.3%	17.5%
Absenteeism Decrease	**14.5%**	10.0%	19.1%
Injury Decrease	**25.5%**	18.1%	33.0%
Rework Decrease	**23.2%**	17.2%	29.1%

(1) Labor Cost Savings

Based on current 93 complete surveys, the study found that there was an average 10.6% productivity improvement with a 95% confidence interval (6.8%, 14.4%). The study calculated the labor cost savings from productivity improvement by the using average, lower bound and upper bound of 95% confidence interval respectively. Considering the learning curve effect, the productivity improvement has to be achieved on a weekly basis. Because each trade has a different average duration in the project, the real productivity improvement rate is varied among each trade. The longer a trade is involved in the project, the higher improvement rate the trade can achieve. The study used average weekly productivity improvement rate to determine the labor cost saving from productivity improvement. The average weekly productivity rate was calculated based on Equation 8.3:

Average Improvement Rate for craft working in the project for i^{th} week = $\frac{\sum_{1}^{i} Y_i}{i}$ ……….(8.3)

Where Y_i: the productivity improvement made in i^{th} week, which is calculated by Equation 8.1.

For example, the average improvement in productivity for a six-week employment duration (linear learning curve coefficient a = 0.151) was calculated as follows:

$$\frac{0.151 \times (1+2+3+4+5+6)}{6} = 0.530$$

Table 8.19 shows the average weekly productivity improvement rates calculated based on average, lower bound and upper bound of 95% confidence interval of the productivity improvement rate. According to Table 8.15, the average duration of each trade ranged from 6 to 22 weeks. To determine the productivity improvement rate for a trade, the study first identified the average duration of the trade engaging in the project from Table 8.15 and then the productivity improvement rate from Table 8.19 according to the average duration. For example, welders, whose average duration in the CII model plant is 22 weeks, are expected to achieve an average 1.7% improvement in productivity with a 95% confidence interval (1.1%, 2.4%).

Table 8.20 shows the details of the calculation of labor cost savings for the CII model plant. The Labor cost saving is determined by:

Labor Cost Savings = Baseline Cost × Productivity Improvement Rate Achieved within the Duration in the Project

Table 8.19: Productivity Improvement

	Average Improvement	Lower Bound Improvement	Upper Bound Improvement
Expected Improvement	10.6%	6.8%	14.4%
Week Needed to Achieved Half of Improvement	35	35	35
Learning Speed Function	Y = a × X Where: a=0.151	Y = a × X Where: a=0.097	Y = a × X Where: a=0.205
Productivity Improvement	$\sum_{1}^{i} Y_i / i$		
Week	**Productivity Imp. Rate (%)**	**Productivity Imp. Rate (%)**	**Productivity Imp. Rate (%)**
1	0.151	0.097	0.205
2	0.227	0.146	0.308
3	0.303	0.195	0.410
4	0.378	0.244	0.513
5	0.454	0.292	0.615
6	0.530	0.341	0.718
7	0.605	0.390	0.821
8	0.681	0.438	0.923
9	0.756	0.487	1.026
10	0.832	0.536	1.128
11	0.908	0.585	1.231
12	0.983	0.633	1.333
13	1.059	0.682	1.436
14	1.135	0.731	1.538
15	1.210	0.780	1.641
16	1.286	0.828	1.744
17	1.362	0.877	1.846
18	1.437	0.926	1.949
19	1.513	0.974	2.051
20	1.589	1.023	2.154
21	1.664	1.072	2.256
22	1.740	1.121	2.359

Table 8. 20: Cost Saving from Improvement of Productivity

Trade	Average Duration	Productivity Imp. (%)			Baseline Cost ($)	Cost Saving ($)		
		Avg.	Lower	Upper		Avg.	Lower	Upper
Carpenter	18	1.437	0.926	1.949	2,927,156	42,070	27,097	57,042
Concrete Finisher	9	0.756	0.487	1.026	291,232	2,203	1,419	2,987
Crane Operator	21	1.664	1.072	2.256	952,530	15,851	10,210	21,493
Electrician	19	1.513	0.974	2.051	2,196,275	33,227	21,401	45,052
Equipment Operator	19	1.513	0.974	2.051	1,586,846	24,007	15,463	32,551
Labor	13	1.059	0.682	1.436	1,229,974	13,025	8,390	17,661
Instrumentation	14	1.135	0.731	1.538	338,616	3,842	2,475	5,210
Insulator	16	1.286	0.828	1.744	747,990	9,619	6,195	13,042
Iron Worker	16	1.286	0.828	1.744	1,307,618	16,815	10,830	22,800
Millwright	10	0.832	0.536	1.128	737,573	6,137	3,953	8,321
Painter	16	1.286	0.828	1.744	689,183	8,862	5,708	12,017
Pipe Fitter	17	1.362	0.877	1.846	4,296,186	58,496	37,677	79,315
Rigger	18	1.437	0.926	1.949	492,537	7,079	4,559	9,598
Steel Erect	15	1.210	0.780	1.641	486,863	5,892	3,795	7,990
Surveyor	6	0.530	0.341	0.718	413,262	2,188	1,409	2,967
Truck Driver	13	1.059	0.682	1.436	365,627	3,872	2,494	5,250
Welder	22	**1.740**	**1.121**	**2.359**	3,970,165	69,072	44,489	93,656
				Total	23,029,633	**322,257**	**207,564**	**436,951**

(2) Turnover Cost Savings

The study found that there was an average 13.9% turnover cost decrease with a 95% confidence interval (10.3%, 17.6%). The study believes that the turnover rate deduction would be achieved immediately after workers complete training program. The turnover cost savings for the CII model plant cost is shown in Table 8.21.

Turnover Cost Savings = Baseline Cost × Turnover Cost Reduction Rate (8.4)

Table 8. 21: Turnover Cost Savings of the CII Model Plant

Baseline Turnover Cost	$231,458.20
Turnover Cost Saving (Average Reduction 13.9%)	$32,149.54
Turnover Cost Saving (Lower Bound Reduction 10.3%)	$23,789.76
Turnover Cost Saving (Upper Bound Reduction 17.6%)	$40,509.33

(3) Absenteeism Cost Savings

The study found that there was an average 14.5% absenteeism cost decrease with a 95% confidence interval (10.0%, 19.1%). The study calculated the absenteeism cost, by the using average, lower bound and upper bound results respectively. The study believes that the absenteeism rate deduction is achieved immediately after workers complete training program. The absenteeism cost savings for the CII model plant cost is showed in Table 8.22.

The absenteeism cost saving is determined by:

Absenteeism Cost Savings = Baseline Cost × Absenteeism Cost Reduction Rate (8.5)

Table 8. 22: Absenteeism Cost Savings of the CII Model Plant

Baseline Absenteeism Cost	$514,929.90
Absenteeism Cost Saving (Average Reduction 14.5%)	$74,870.81
Absenteeism Cost Saving (Lower Bound Reduction 10.0%)	$51,591.95
Absenteeism Cost Saving (Upper Bound Reduction 19.1%)	$98,149.66

(4) Injury Cost Savings

The study found that there was an average 25.5% injury cost decrease with a 95% confidence interval (18.1%, 33.0%). The study calculated the injury cost saving, by the using average, lower bound and upper bound results respectively. The study believes that the injury cost deduction will happen immediately after workers complete training program. Table 8.23 shows the details about the calculation of injury cost savings for the CII model plant. The injury cost saving is determined by:

Injury Cost Savings = Baseline Cost × Injury Cost Reduction Rate (8.6)

Table 8. 23: Injury Cost Savings of the CII Model Plant

Baseline Injury Cost (2006$)	$262,099.60
Injury Cost Saving (Average Reduction 25.5%)	$66,940.24
Injury Cost Saving (Lower Bound Reduction 18.1%)	$47,452.50
Injury Cost Saving (Upper Bound Reduction 33.0%)	$86,427.98

(5) Rework Cost Savings

The study found that there was an average 23.2% rework cost decrease with a 95% confidence interval (17.2%, 29.1%). The study calculated the rework cost saving, by the using average, lower bound and upper bound results respectively. Considering the learning curve effect, the rework cost decrease has to be achieved on a week-by-week basis. The overall average duration for a worker on site was 18 weeks for the CII model plant. The study used Equation 7.3 to calculate that the rework cost decrease rate in 18 weeks was 3.0% with 95% confidence interval (2.2%, 3.8%). Table 8.24 shows the average weekly rework cost decrease rates.

Table 8. 24: Average Weekly Decrease of Rework Cost Rate

	Average Improvement	Lower Bound Improvement	Upper Bound Improvement
Expected Improvement (Average)	23.2%	17.2%	29.1%
Week Needed to Achieved Half of Improvement	35	35	35
Learning Speed Function	Y = a × X Where: a=0.331	Y = a × X Where: a=0.246	Y = a × X Where: a=0.416
Productivity Improvement	$\sum_{1}^{i} Y_i / i$		
Week	**Average Rework Decrease (%)**	**Average Rework Decrease (%)**	**Average Rework Decrease (%)**
1	0.331	0.246	0.416
2	0.497	0.369	0.624
3	0.662	0.492	0.832
4	0.828	0.615	1.040
5	0.993	0.738	1.248
6	1.159	0.861	1.456
7	1.324	0.984	1.664
8	1.490	1.107	1.872
9	1.655	1.230	2.080
10	1.821	1.353	2.288
11	1.986	1.476	2.496
12	2.152	1.599	2.704
13	2.317	1.721	2.913
14	2.483	1.844	3.121
15	2.648	1.967	3.329
16	2.814	2.090	3.537
17	2.979	2.213	3.745
18	3.145	2.336	3.953

Table 8.25 shows the details of the calculation of rework cost savings for the CII model plant. The rework cost saving is determined by:

Rework Cost Savings = Baseline Cost × Injury Cost Reduction Rate within the Duration in the Project (8.7)

Table 8. 25: Rework Cost Savings of the CII Model Plant

Baseline Rework Cost	$807,029.71
Rework Cost Saving (Average Reduction 3.1%)	$25,377.05
Rework Cost Saving (Lower Bound Reduction 2.3%)	$18,854.52
Rework Cost Saving (Upper Bound Reduction 4.0%)	$31,899.58

8.3.4 Determination of the Benefit Cost Ratio for Craft Training

Based on the previous analysis, the total savings after implementing a training program are calculated in Table 8.26. The total cost of training is 1% of the labor cost, which is $230,296.33. Therefore, the benefit cost ratio for the CII Model Plant Project can be determined as follows:

$$\text{B/C Ratio} = \frac{Benefits}{Costs}$$

Table 8. 26: Summary of Cost Savings Based on Average Improvement

	Savings ($)	Savings ($)	Savings ($)
	Average Improvement	Lower Bound Improvement	Upper Bound Improvement
Productivity Improvement	322,257.30	207,563.62	436,950.97
Decrease of Turnover	32,149.54	23,789.76	40,509.33
Decrease of Absenteeism	74,870.81	51,591.95	98,149.66
Decrease of Injury	66,940.24	47,452.50	86,427.98
Decrease of Rework	25,377.05	18,854.52	31,899.58
Total Benefits	521,594.93	349,252.36	693,937.51
Training Cost	230,296.33	230,296.33	230,296.33
Benefit Cost Ratio	2.26	1.52	3.01

The findings show what even under the lower bound of improvement, the craft training has a benefit-cost ratio as high as 1.52, which means if the company invests 1 dollar in craft training, 1.52 dollars benefit will be generated.

8.4 Development of a Benefit/Cost Model Using Data From Individual Companies

Quantifiable results were found within two CII companies, referred to as Company A and B. Company A is a North American heavy industrial construction firm that utilized an internal craft-training program. Company B is also a North American heavy industrial construction firm that engaged in both capital facility and construction maintenance projects.

8.4.1 Determination of the Training Benefits in Turnover and Absenteeism

Company A monitored the absenteeism and turnover rates on four projects over a 15 month period among three groups of craft workers: (1) craft workers with certification who had completed their respective training program (ACE), (2) craft workers engaged in training but who had not yet achieved certification, and (3) craft workers who had not engaged in craft training.

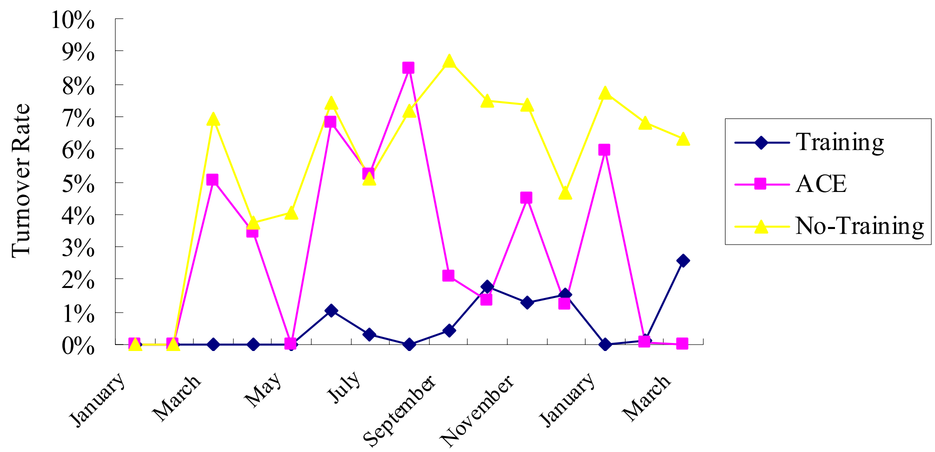


Figure 8.2: Monthly Turnover Rates

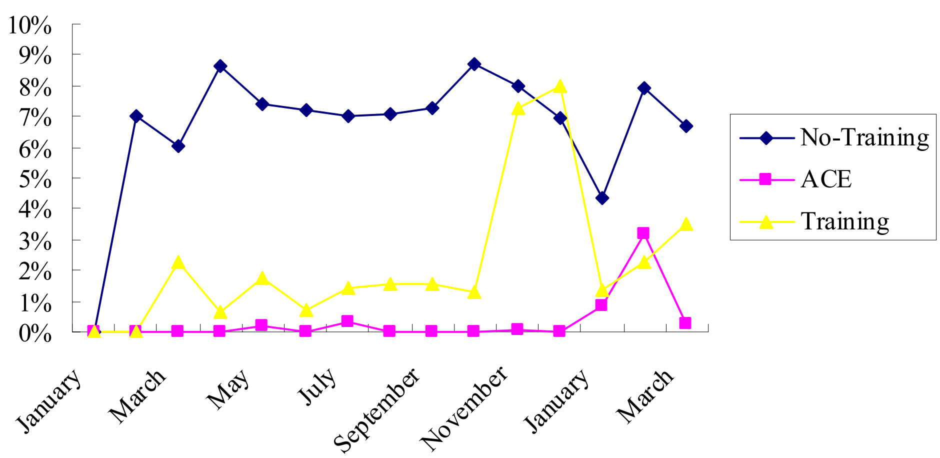


Figure 8.3: Monthly Absenteeism Rates

The study combined the four projects together and determined the average turnover and absenteeism rates of workers receiving training and workers without training (Figure 8.2 and 8.3). The study found that workers receiving training had a lower turnover and absenteeism rates than workers without training. Table 8.27 summarizes this company's experiences.

Table 8.27: Turnover and Absenteeism Rates for Company a Craft Workers

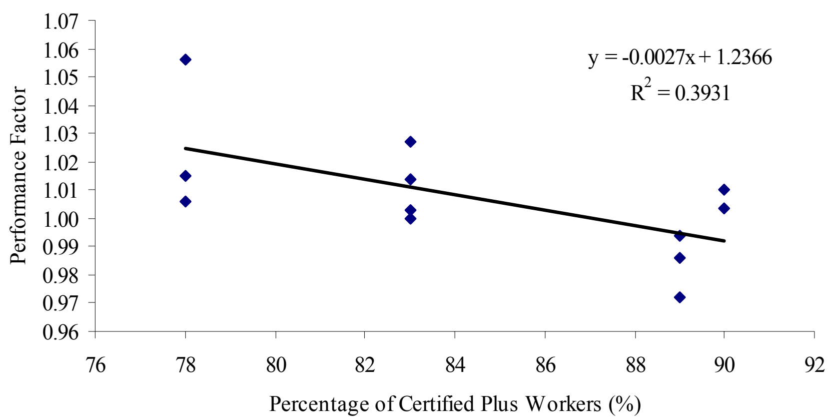
	Workers with no Training	Worker Receiving Training	Difference	Z-Value
Voluntary Turnover Rate	6.5%	0.6%	5.9%	19.12*
Absenteeism Rate	7.3%	2.5%	4.8%	9.73*

* Significant at the level of 0.05

Next, the study compared the difference between workers receiving training and workers without training. Based on Table 7.26, the training can decrease turnover rate by 5.9% and absenteeism rate by 4.8%.

8.4.2 Determination of the Training Benefits in Improving Productivity

On one construction maintenance project Company B engaged, the owner actively promoted certification of all crafts employed on the project. In this instance, craft workers were certified in accordance to the NCCER certifications up to certified plus, which included both written and performance certifications. As a result, the construction company began a two year effort to certify a large percentage of its overall project work force to certified plus. Over time, Company B measured the percentage of its project work force that had achieved certified plus and the corresponding productivity performance factor. In this instance, a productivity performance factor less than one indicates better than expected productivity performance. Although the case study involved a limited sample size, a statistically significant relationship was found as shown in Figure 8.4. As the percentage of certified plus of the project's work force increased, the project's productivity performance factor decreased.



Independent Variable			Model Summary		
Constant	Percentage of Certified Plus Workers		F	R^2	Adj. R^2
1.2366 (13.703*)	-0.0027 (-2.545*)		6.478*	0.391	0.332

Dependent Variable: productivity performance factor
t-values shown in parenthesis
* Significant at the level of 0.05

Figure 8. 4: Relation between Percent of Certified Plus Workers and Performance Factor

A linear regression model was established and the relationship between percent of certified plus workers and performance factor can be shown by the following equation:

$$\text{Performance Factor} = -0.0027 \times \text{Percent of Certified Plus works} + 1.2366$$

Therefore, when there are no certified plus workers in the work force, the baseline Performance Factor is equal to 1.237. The improvement of productivity can be defined by the following equation:

$$\text{Productivity Improvement Rate} = \frac{\textbf{Performance Factor B - Performance Factor A}}{\textbf{Performance Factor A}} \times 100\% \quad \text{......(8.8)}$$

Based on the equation above, the productivity improvement rate at different percents of certified plus workers among work force were calculated in Table 8.28.

Table 8. 28: Productivity Improvement Rates under Different Percent of Certified Plus Workers

Performance Factor	Percent of workers Certified (%)	Productivity Improvement Rate (%)
1.2366	0	-
0.9667	100	21.8
1.0207	80	17.5
1.1017	50	10.9
1.1557	30	6.6

8.4.3 Determination of the Training Costs

When dealing with real industry company data, the study continued using the CII Model Plant Project in order to keep the analysis consistent and comparable with analysis using RT231 survey data. The study estimated that the training cost includes \$0.10 per worker hour for basic on-site training, which is based on the rates of funding used by companies A and B and covered costs such as safety training. Since total man-hour of CII model plant project is 527,457 hours, the basic training cost is 527,457×0.1=\$52,745.7.

The study also chose NCCER training curriculum as the advanced training for workers who want to get certified. The cost of NCCER advanced off-site certification training includes:

- Employer costs: \$0.15 per hour per worker, and
- Individual Worker tuition cost \$75 per quarter (10 weeks): for CII model plan, the average duration of a worker in the project is 18 week, so the tuition cost is \$75×1.8=\$135 per worker.

The study assumed that the CII model plant project paid all employer cost and that the CII model plant project paid certain percentages (100%, 80%, 50% or 30%) of individual worker's tuition based on the percent of certified plus workers, which the project decided to reach (Table 8.29).

Table 8. 29: Training Cost under Different Percent of Certified Plus Worker

Certified Percent	100%	80%	50%	30%
Total Workers Hired	751	751	751	751
Total Workers Trained to Be Certified	751	601	376	225
Total Hours	527,457	527,457	527,457	527,457
Basic Training Cost (10 cents per hour)	52,745.70	52,745.70	52,745.70	52,745.70
Advanced Cost 1(15 cents per worker during contract)	81,108	81,108	81,108	81,108
Advanced Cost 2 ($75 per worker for a 10-week session)	101,385.00	81,108.00	50,692.50	30,415.50
Total Training Cost ($)	235,238.70	214,961.70	184,546.20	164,269.20

8.4.4 Determination of the Cost Savings from Craft Training

Based on already presented company data (Table 8.26 and 8.27), the benefits were restricted to improved turnover, absenteeism, and productivity, since these improvements could be statistically verified based on the case study data. The study still assumed it took 35 weeks to achieve half of the improvement when considering the learning curve effects. The B/C ratios were estimated based on different percentages of craft workers completing training to certified plus levels. As the percent of certified plus workers varies, the expected productivity improvement rate varies. Table 8.30 shows the average productivity improvement rates at different percent of certified plus workers among the total work force.

Table 8. 30: Productivity Improvement Rates under Different Percent of Certified Plus Workers

Percent of Certified Plus Workers	100%	80%	50%	30%
Expected Improvement in Productivity	21.8%	17.5%	10.9%	6.6%
Week Needed to Achieved Half of Improvement	35	35	35	35
Learning Speed Function	Y = a × X Where: a=0.312	Y = a × X Where: a=0.250	Y = a × X Where: a=0.156	Y = a × X Where: a=0.094
Productivity Improvement	$\sum_{1}^{i} Y_i / i$			
Week	**Productivity Imp. Rate (%)**	**Productivity Imp. Rate (%)**	**Productivity Imp. Rate (%)**	**Productivity Imp. Rate (%)**
1	0.312	0.250	0.156	0.094
2	0.468	0.374	0.234	0.140
3	0.624	0.499	0.312	0.187
4	0.780	0.624	0.390	0.234
5	0.936	0.749	0.468	0.281
6	1.092	0.873	0.546	0.327
7	1.248	0.998	0.624	0.374
8	1.404	1.123	0.702	0.421
9	1.559	1.248	0.780	0.468
10	1.715	1.372	0.858	0.515
11	1.871	1.497	0.936	0.561
12	2.027	1.622	1.014	0.608
13	2.183	1.747	1.092	0.655
14	2.339	1.871	1.170	0.702
15	2.495	1.996	1.248	0.749
16	2.651	2.121	1.326	0.795
17	2.807	2.246	1.404	0.842
18	2.963	2.370	1.481	0.889
19	3.119	2.495	1.559	0.936
20	3.275	2.620	1.637	0.982
21	3.431	2.745	1.715	1.029
22	3.587	2.869	1.793	1.076

Next, the study calculated the labor cost savings based on the productivity improvement rates under different percent of certified plus workers in the work force.

Labor Cost Savings = Baseline Cost × Productivity Improvement Rate Achieved within the Duration in the Project (8.9)

The detailed calculations are shown in Table 8.31.

Table 8. 31: Labor Cost Savings under Different Percents of Certified Plus Workers

	Base Line Labor Cost	Average Duration	100% Certified Plus		80% Certified Plus		50% Certified Plus		30% Certified Plus	
			Productivity Improvement Rate (%)	Labor Cost Savings	Productivity Improvement Rate	Labor Cost Savings	Productivity Improvement Rate (%)	Labor Cost Savings	Productivity Improvement Rate (%)	Labor Cost Savings
Carpenter	2,927,156	18	2.963	86,730	2.3703635	69,384	1.4814772	43,365	0.8888863	26,019
Concrete Finisher	291,232	9	1.559	4,542	1.2475598	3,633	0.7797248	2,271	0.4678349	1,362
Crane Operator	952,530	21	3.431	32,679	2.7446315	26,143	1.7153947	16,340	1.0292368	9,804
Electrician	2,196,275	19	3.119	68,500	2.4951195	54,800	1.5594497	34,250	0.9356698	20,550
Equipment Operator	1,586,846	19	3.119	49,492	2.4951195	39,594	1.5594497	24,746	0.9356698	14,848
Labor	1,229,974	13	2.183	26,853	1.7465837	21,483	1.0916148	13,427	0.6549689	8,056
Instrument	338,616	14	2.339	7,921	1.8713396	6,337	1.1695873	3,960	0.7017524	2,376
Insulator	747,990	16	2.651	19,830	2.1208516	15,864	1.3255322	9,915	0.7953193	5,949
Iron Worker	1,307,618	16	2.651	34,666	2.1208516	27,733	1.3255322	17,333	0.7953193	10,400
Millwright	737,573	10	1.715	12,652	1.3723157	10,122	0.8576973	6,326	0.5146184	3,796
Painter	689,183	16	2.651	18,271	2.1208516	14,617	1.3255322	9,135	0.7953193	5,481
Pipe Fitter	4,296,186	17	2.807	120,594	2.2456076	96,475	1.4035047	60,297	0.8421028	36,178
Rigger	492,537	18	2.963	14,594	2.3703635	11,675	1.4814772	7,297	3.2748443	16,130
Steel Erect	486,863	15	2.495	12,148	1.9960956	9,718	1.2475598	6,074	0.7485359	3,644
Surveyor	413,262	6	1.092	4,511	0.8732918	3,609	0.5458074	2,256	0.3274844	1,353
Truck Driver	365,627	13	2.183	7,982	1.7465837	6,386	1.0916148	3,991	0.6549689	2,395
Welder	3,970,165	22	3.587	142,399	2.8693874	113,919	1.7933671	71,200	1.0760203	42,720
Total ($)	23,029,633			**664,364**		**531,491**		**332,182**		**211,061**

(b) Savings in Turnover and Absenteeism Cost

For CII Model Plant Project, the number of total hired workers is 751. Based on Company A data, the turnover rate for workers without training is 6.5%, and there will be 5.88% turnover cost reduction after 100% workers are trained. The detailed calculations of baseline cost and cost savings are shown in Table 8.32.

Table 8. 32: Baseline Turnover Cost and Cost Saving from Craft Training

	Number of Workers Hired	Turnover Rate	Total Number of Workers Lost	Unit Cost of Turnover Per Occurrence	Total Cost
Baseline Cost	751	6.5%	49	2000	97,780
Turnover Cost Savings (5.88%)					$5,749

The absenteeism rate for workers without training is 7.3%, and there will be 4.77% absenteeism cost reduction after 100% workers are training. The detailed calculations of baseline absenteeism cost and cost savings from craft training are shown in Table 8.33.

Table 8. 33: Baseline Absenteeism Cost and Cost Saving from Craft Training

	Total Man-hour	Average Worker on Site	Rate	Cost per Occurrence($)	Cost per Day	Total
Baseline Cost	527,457	169[9]	7.3%	110	1353.8063	527,984[10]
Absenteeism Cost Savings (4.77%)						$25,185

Assuming the training program is implemented in the CII mode plant project, the expected cost savings and benefit-cost ratios are listed in the Table 8.34.

Table 8. 34: B/C Ratios Using Consolidated Data from Companies A & B for the CII Model Plant Estimate (2006$)

	100% Certified Plus	80% Certified Plus	50% Certified Plus	30% Certified Plus
Estimated Productivity Improvement	$664,364	$531,491	$332,182	$211,061
Estimated Turnover Reduction	$5,749	$4,600	$2,875	$1,725
Estimated Absenteeism Reduction	$25,185	$20,148	$12,592	$7,555
Total Benefits ($)	$695,299	$556,239	$347,649	$220,341
Training Cost ($)	$235,239	$214,962	$184,546	$164,269
Benefit-Cost Ratio	**2.96**	**2.59**	**1.88**	**1.34**

[9] Calculated as Total Man-hour of the CII Model Plant ÷ Project Duration (weeks) ÷Working Hour (hours per week) = 527,457 ÷ 78 ÷ 40 = 169

[10] Duration 78 weeks and 5 days per week

8.5 The Effect of Workers' Project Employment Duration on the Benefit Cost Ratio

The craft workers' duration on the project is a critical element of the B/C estimates, and this was examined in further estimates.

The increases in the craft workers' duration significantly improve the estimated productivity savings. Figure 8.5 shows that the relation between average duration in the project and the productivity improvement rate workers would achieve.

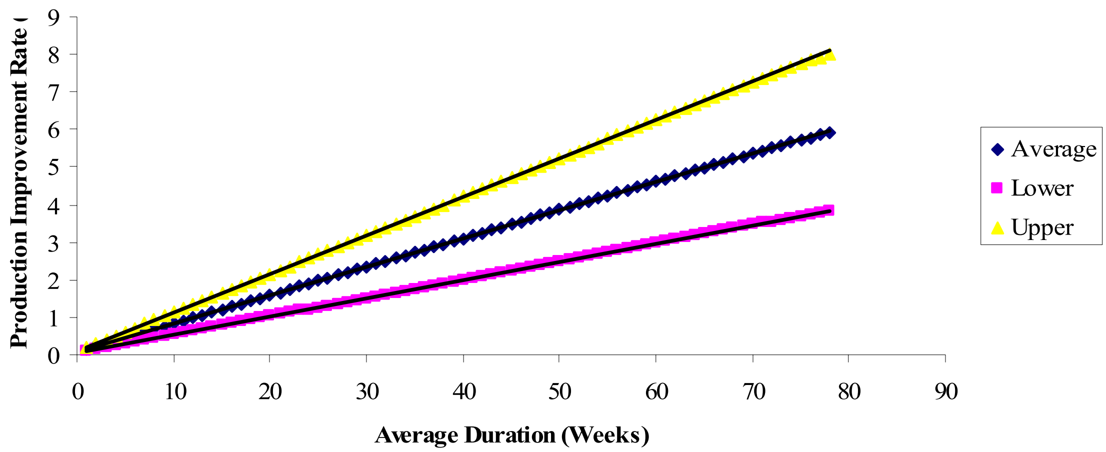


Figure 8. 5: Relation between Average Duration and Productivity Improvement Rate

The relation between average duration workers engaged in the project and productivity improvement rate can be quantitatively shown by the following equations:

Average Productivity Improvement Rate (%) = 0.0754×Average Duration+0.0813

Lower Bound Improvement Rate (%) = 0.0486×Average Duration+0.0524

Upper Level Improvement Rate (%) = 0.1023×Average Duration+0.1103

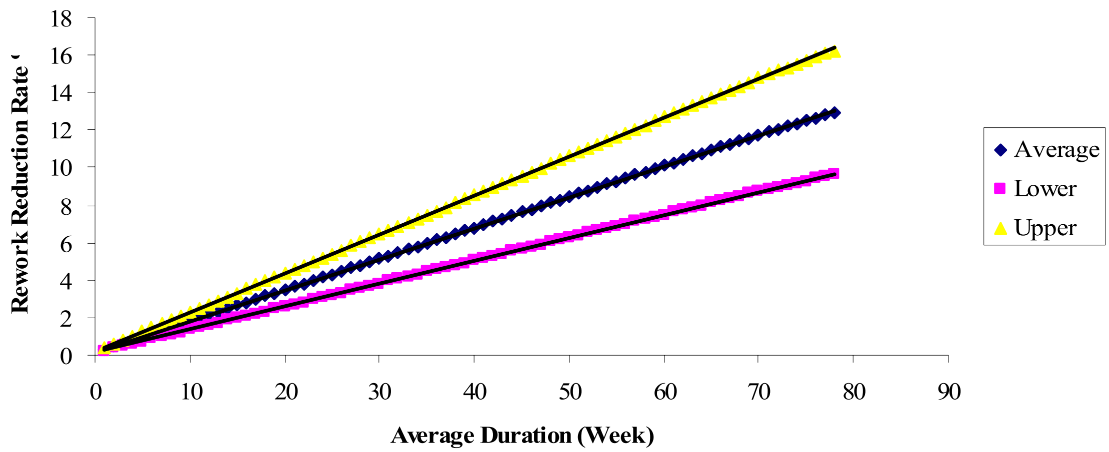


Figure 8. 6: Relation between Average Duration and Rework Deduction Rate

The relation between average duration worker engaged in the project and rework reduction rate (Figure 8.6) can be quantitative show by the following equations:

Average Rework Reduction Rate (%) = 0.165×Average Duration+0.1779

Lower Bound Rework Reduction Rate (%) = 0.1226×Average Duration+0.1322

Upper Level Rework Reduction Rate (%) = 0.2074×Average Duration+0.2237

The research assumes that a change in the craft workers' duration on the project will result in a change in the total number of workers hired by the project. The total number of workers hired is equal to the total number of man-hours needed to complete the project, divided by the hours worked per week and the average duration of workers on the project. For CII Model Plant project, the total man-hours needed was a fixed value, estimated by previous research, and the study assumed that the project maintained a 40- hour week of work. Therefore, as shown in Equation 8.4, increasing the craft workers' duration would decrease the total number of workers hired by the project.

Total Number of Workers Hired =

$$\frac{\text{Total Man - hour Needed (527,457hr)}}{\text{Weekly Working Hours (40hr/week)} \times \text{Average Duration of Workers}} \quad (8.10)$$

As a result, the estimated turnover and injury baseline costs decreased, and consequently the cost savings from reduction in turnover and absenteeism declined (shown in Figure 8.7).

Therefore, as the average duration of workers engaged in the project increased, the estimated benefits from turnover and injury cost savings decreased, but the estimated productivity improvement and reduction in rework increased linearly with the increased craft workers' duration.

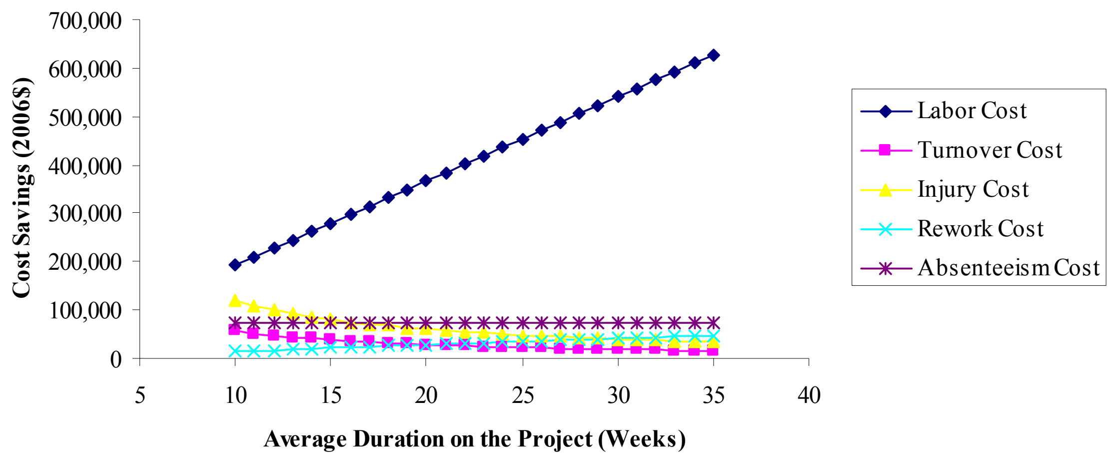


Figure 8. 7: Relation between Changes of Values of Benefit Components and Average Duration

As a result, the B/C ratio of craft training increases when the study extended the average duration of craft workers on the model project (Show in Figure 8.8).

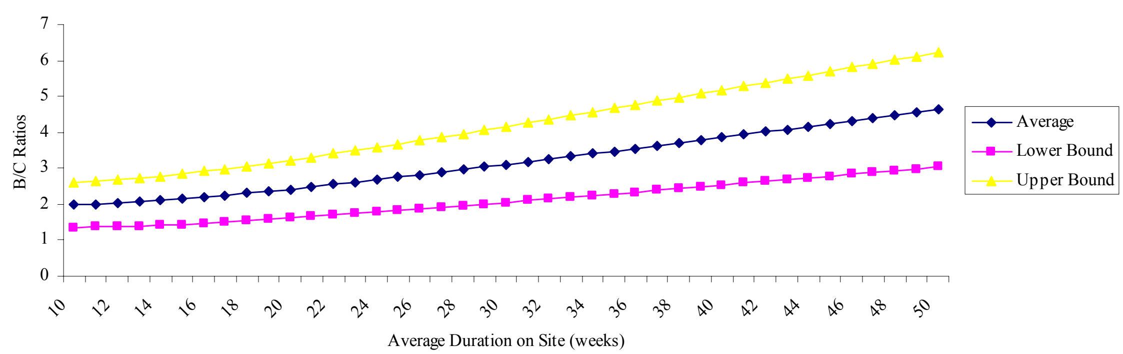


Figure 8. 8: Changes of B/C Ratios with Average Duration on Site

Figure 8.8 shows that the longer the project can keep the trained worker the rate of benefits accrued due their training increases due to the learning curve, and it also implies that craft workers employed in a "community" where craft training is prevalent and continuous from project to project will significantly improve their performance, compared to craft workers engaged in a single project training effort. Under this scenario, craft workers may receive training from their former employers or from a community training organization. Since the craft workers are assumed to work and receive training continuously in a "community", they can achieve their maximum performance improvement and maximize training benefits in the community of projects. This scenario would be typical of a union training environment. However it might also be achieved in an open shop environment.

8.6 Limitation of Benefit Cost Analysis

The study completed the benefit-cost analysis based on several assumptions, which simplified the analysis and made it feasible to perform. However, these simplifications and assumptions did impose limitations and need to be considered carefully when examining the results:

- The B/C analysis largely depends on estimated craft training benefits using 93 complete surveys, therefore the accuracy of the estimated benefits relies on the collective wisdom and expertise of the respondents. Although the respondents were training directors or project managers with an average of 23.4 years experience in construction, the estimation of craft training benefits is still a complicated task. To compensate for measurement errors on behalf of the survey respondents, the study used both the 95% confidence interval lower and upper bound estimates along with the averages during the B/C analyses in order to provide more reliable results;

- The B/C analyses are based on the CII model plant. The accurate portrayal of the plant as a typical petrochemical facility is partially determined by the quality of the cost and work hour estimates used to develop the CII model plant;

- The study used a "first-in, last-out" strategy to determine the average duration of workers on the job. This strategy assumes that contractors hire the most desirable workers in each skill level first and then attempt to retain them until no additional work is available in their trade. This strategy only approximates the real situation in determining the average duration that actual workers are typically employed on a project.

- It was assumed that the survey respondents implicitly considered a linear learning curve function when estimating the average time required for achieving improvement in productivity and rework. When determining the cost savings in turnover, absenteeism and injury, the study assumed the performance improvement in these areas were achieved instantly after receiving training. This assumption was made after consulting industry experts and examination of the case study data, as presented herein.

- When determining the baseline cost of the plant, the study identified the incident rate and unit cost of turnover, absenteeism, injury and rework by reviewing previous research efforts and current industry data. The incident rate and unit cost used by the study were based on industry averages. For an individual project, the actual incident rate and unit cost may vary significantly.
- While estimated B/C ratios provide an attractive business case for craft training, they only provide a partial perspective on the economics required to make construction craft training successful. Craft training must also be attractive to the individual craft worker in terms of wage increases, extended employment, and improved career satisfaction. As examined by the authors elsewhere (CII 2007), there are significant concerns that many craft workers do not sufficiently benefit from increased training, particularly in terms of increased wages in the open shop sector. Worker incentives need to be addressed to make craft training successful on a macro scale.

8.7 Summary

The study found that appropriate metrics for evaluating craft training include improvements in absenteeism, turnover, productivity, safety, and rework. A nation wide survey was administered to 93 construction experts to collect information on the expected benefits to training, which was partially validated using actual data from two major construction companies. A B/C estimate of craft training was calculated based on a model plant project and updated worker utilization plans. The study considered the learning curve effect on workers in order to generate a more accurate estimate of craft training effects. The analysis estimated a positive B/C ratio for craft training ranging from 1.5:1 to 3.0:1. This estimate reinforces the findings of previous research. The analysis also revealed that the B/C ratio increases with the craft workers' duration in a training program. Training durations are likely to be longer under a "community training" model in which firms collaborate to sponsor training and workers have greater opportunities to continue in their training program as they move from firm to firm. Thus, the community training model should be promoted in the construction industry in order to increase the effectiveness of craft training programs and benefits to employers. Meanwhile, as another way to increase the benefits of craft training, incentives such as wage increases and extended employment need to be available in order to attract craft workers to enroll and stay engaged in craft training.

CHAPTER 9: BUSINESS CASE FOR THE CRAFT WORKER

9.1 Why Should Craft Workers Seek Training

Every generation of workers has a different set of values. While pay manages to rise to the top of that set for most generations, its importance and the rank of the remaining values fluctuate. What we do know is that workers are getting older, less geographically mobile, more skilled in IT, and more concerned about work-life balance. A business case that encourages such a worker to enter into the construction industry and seek training must present a complete employment value proposition. Its elements must include:

- Pay;
- Benefits;
- Career path;
- Social status; and
- Work environment.

In a formal craft apprenticeship program, the benefits of training in terms of pay are obvious. The craft worker moves from a typical rate of 50% of a journeyman's wage in the first year of training to 100% after final certification. Studies show that in locations where union wage rates prevail, this can provide a craft worker with an annual income approaching or exceeding that of the average college graduate. However, where open shop wages prevail, the pay argument for craft training is more difficult. Statistically, one hundred formal craft training hours might result in an average of a $0.08 per hour wage increase for some trades to as much as an average $1.00 per hour wage increase for the electrical trades. Depending on the cost to the craft worker, the payback period in the first case might be 10 to 30 years and the rate of return might be only a couple of percent, whereas in the second case the payback period might be less than a year and the rate of return as much as 50%. (It is likely that the average young individual's planning horizon for making economic decisions is no more than a few years.) In areas where the craft worker may become "certified plus", and he receives a $2.00 per hour wage increase, the incentive is extremely convincing, if honored by subsequent employers. Even if not, it may still be worth the effort to the craft worker to get upgrade training, but the case to the craft worker is less convincing. Again, it is clear that a coordinated approach on the part of the employers results in a win-win situation for all. When employers break ranks, incentives decline for them and for the craft workers.

Evidence exists that benefits do not play a strong role in attracting young craft workers, and even as construction craft workers age, they tend to rely on permanently employed spouses to provide health insurance, pension benefits, etc. A high per diem will attract construction craft workers, however.

Most craft workers sense that lack of training will negatively impact their career growth, and they are attracted to training because it provides hope for a **career path** and progression. Survey results from CII RT 182 as well as common sense support this assertion. Human resource managers know that craft workers gravitate to companies that train.

Most people aspire to a higher **social status** and most currently do not see construction as a path to higher status among their peers, however there is a relationship in America between pay and social status. Status may become an attractor again if craft workers begin to be paid more and lives on the same street as the university educated professional, and if young people translate the current fad for home improvement shows on TV to a personal vision of a career path. Until then however, there is not a strong business case to be made for construction craft training based on social status.

Construction is a negative and hostile **work environment** for women and to some extent minorities. This is a major stumbling block to making a business case for training to over half of the potential work force. The issue must be addressed. It is also still a relatively unsafe environment compared to other industries. Ironically, this helps the business case for safety and other types of training. We can also focus on the opportunity in construction for training to transform a worker's job from one focused on brute physical labor to one focused on skilled and challenging work.

9.2 Return on Investment from the Worker's Perspective

As noted in the previous section, from the perspective of wages alone, survey and case study results indicate that workers may receive a very wide range of returns on investment in their own training. They may receive nothing but may keep their jobs. They may receive as little as 10 cents an hour for a hundred hours of training, or as inferred from the statistical data, if they are electricians they may receive as much as two dollars per hour additional wages for every hundred hours of training in which they invest. A union apprentice may count on a well defined wage progression, though like all construction workers, his annual income will likely fluctuate significantly. It may be argued hypothetically that any organized body of workers should be able to negotiate wage increases above cost of living even for journeymen and independent of market fluctuations, if they have added value to their collective skill set through training.

Given this very wide range of potential outcomes, it is instructive to examine a set of typical lifetime income streams for an archtypical set of workers, in order to compare potential ROI or equivalently NPW outcomes for a range of career choices. The following graphs (Figures 9.1-9.5) present typical constant dollar wage progressions for:

- a service industry fast food worker
- a construction helper (someone who does not progress through training)
- a journeyman construction worker
- a typical college graduate in a white collar career
- a college professor

Living expenses are not subtracted from these income streams, since they vary wildly depending on life style and values. Potential pension plans are also not included for the same reason. Extending the earning life would change the results slightly, but due to the discounting factor, less than what one might expect. Two discount factors were used to represent conservative and aggressive ends of the wealth building spectrum.

The results are interesting though certainly not conclusive. They indicate that it is quite possible for a young person to enter the trades after high school, work their way through an apprenticeship, and on a lifetime income basis alone end up in a better position than any given individual having chosen one of the other paths. Given the potential career paths for a well trained journeyman craft worker, an even better outcome is possible (Figure 9.6).

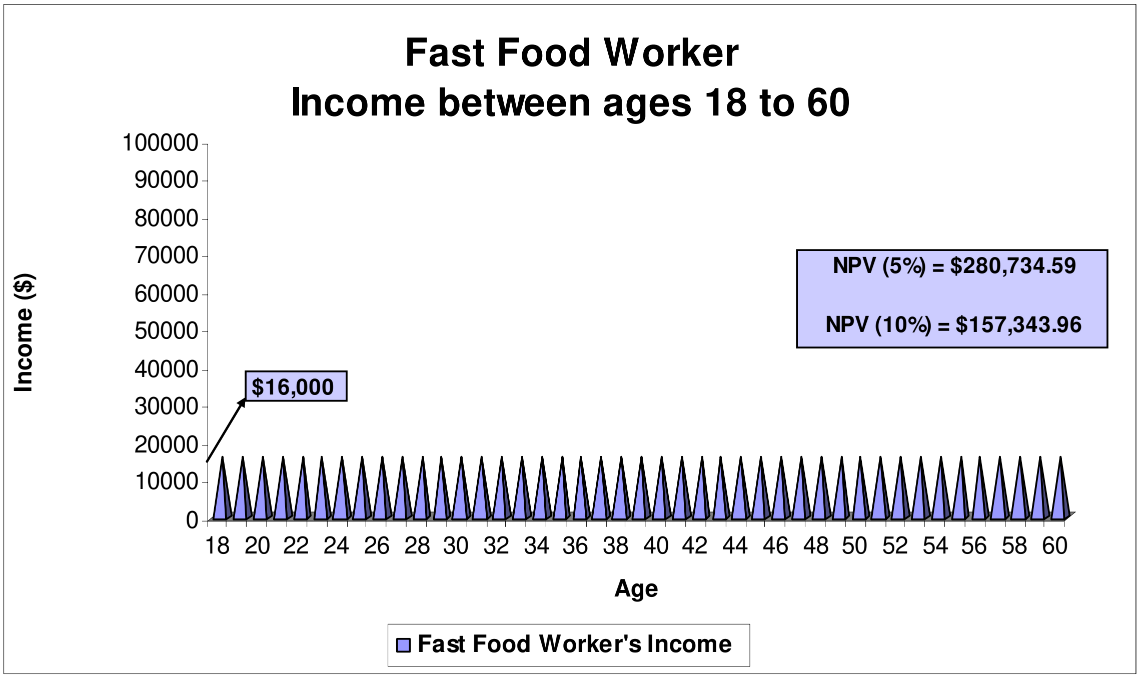


Figure 9. 1:A Fast Food worker, $8/hr, 2000 hrs per year

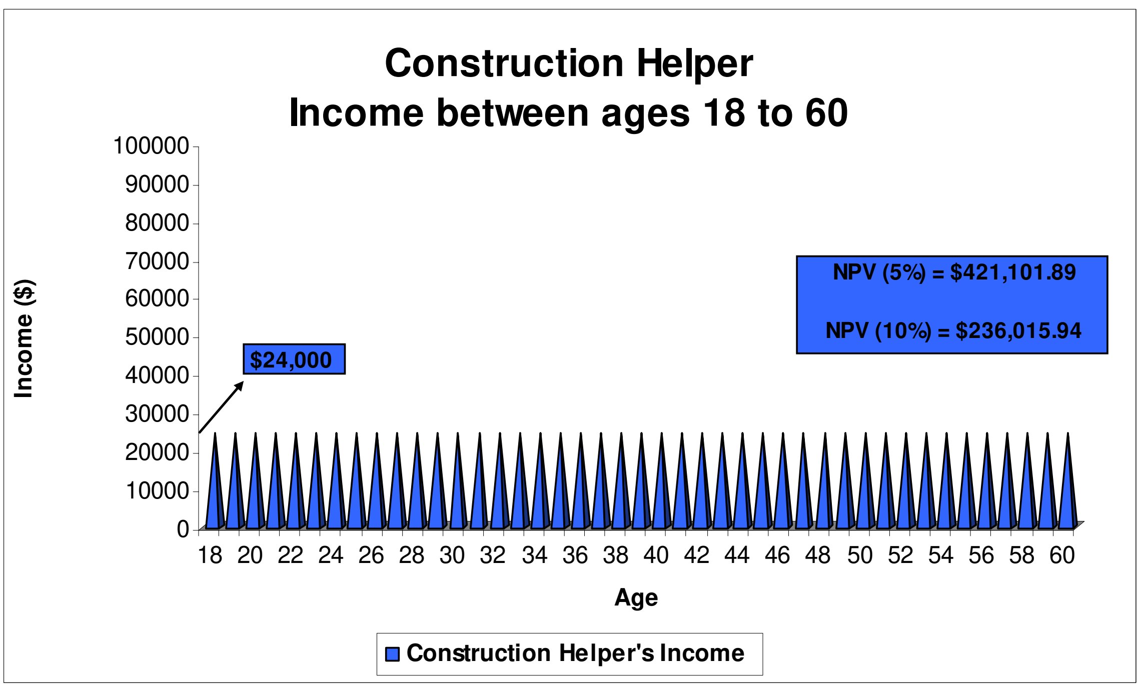


Figure 9. 2: Construction Helper, $12/hr, 2000 hrs per year

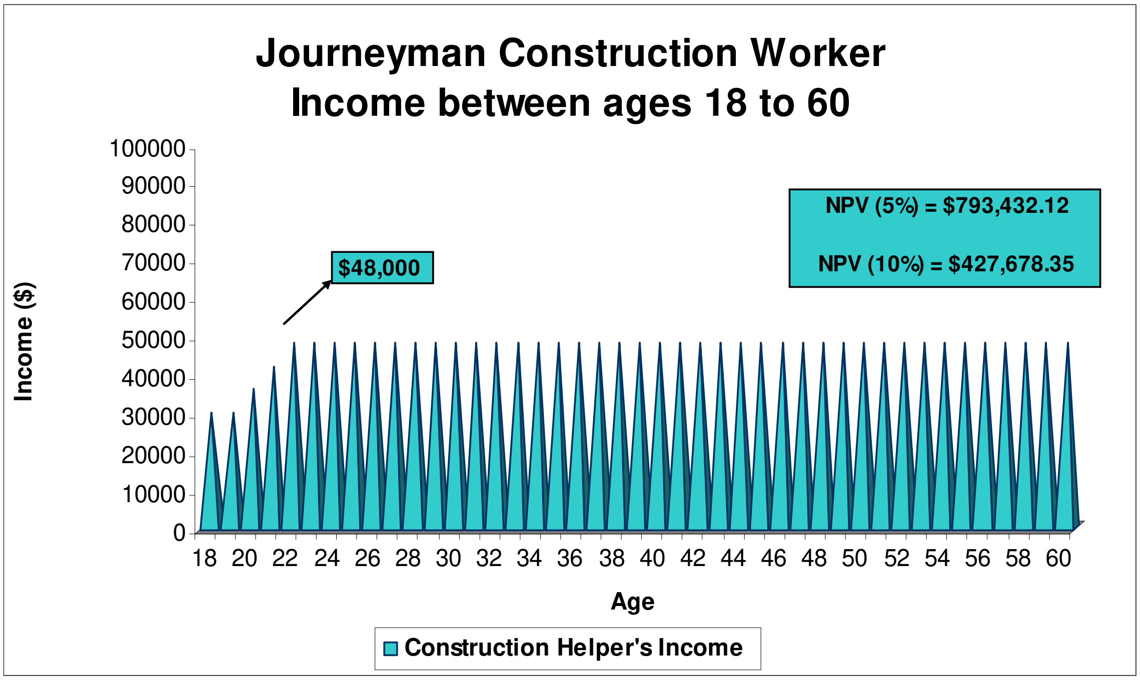


Figure 9. 3: A Journeyman Construction worker, $24/h after the fourth year, 2000 hrs per year

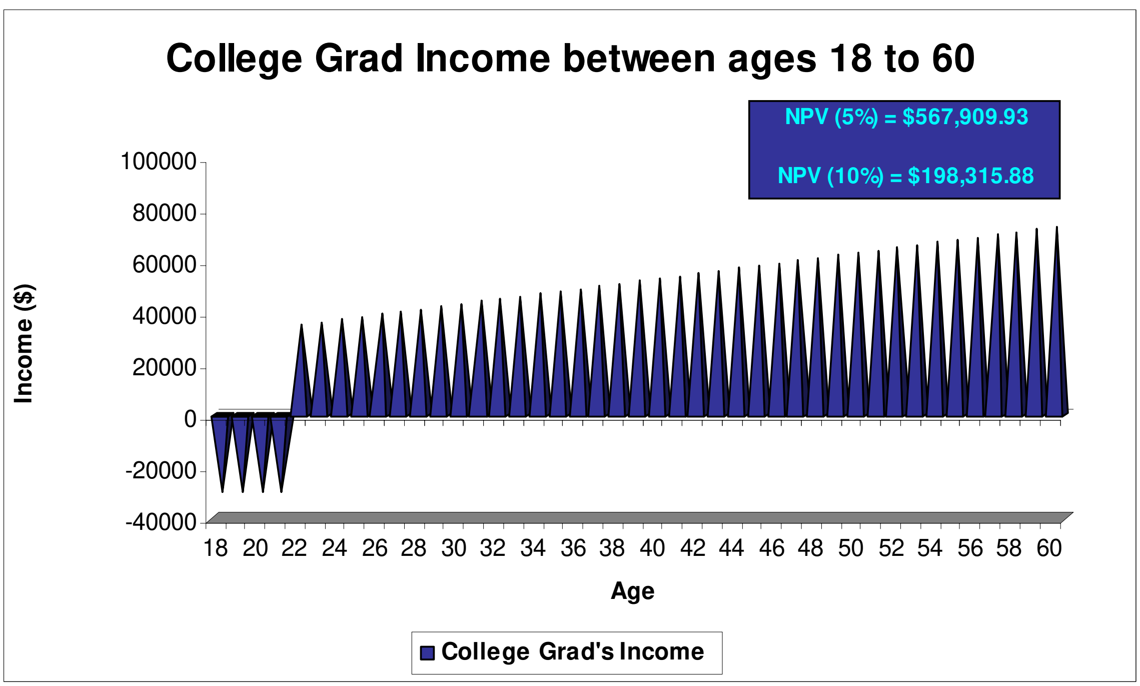


Figure 9. 4: A College Grad, first income $35,000 after the forth year with an increment of $1000 per year, 2000 hrs per year

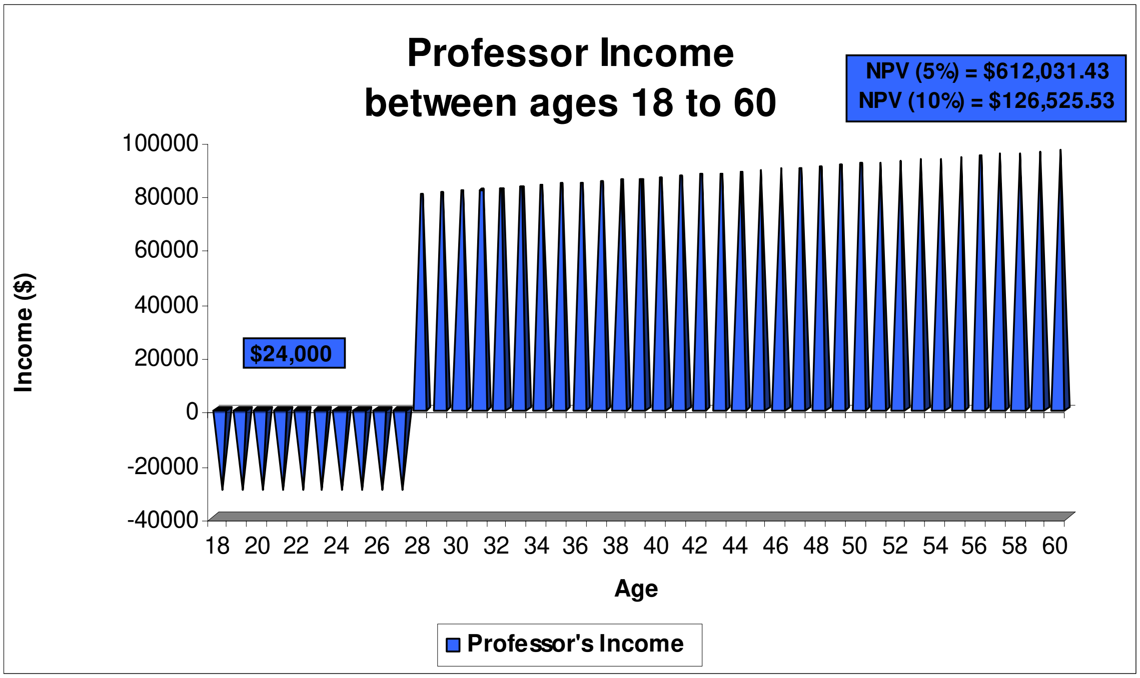


Figure 9. 5: A Professor, first income $80,000 after the tenth year with an increment of $500 per year, 2000 hrs per year

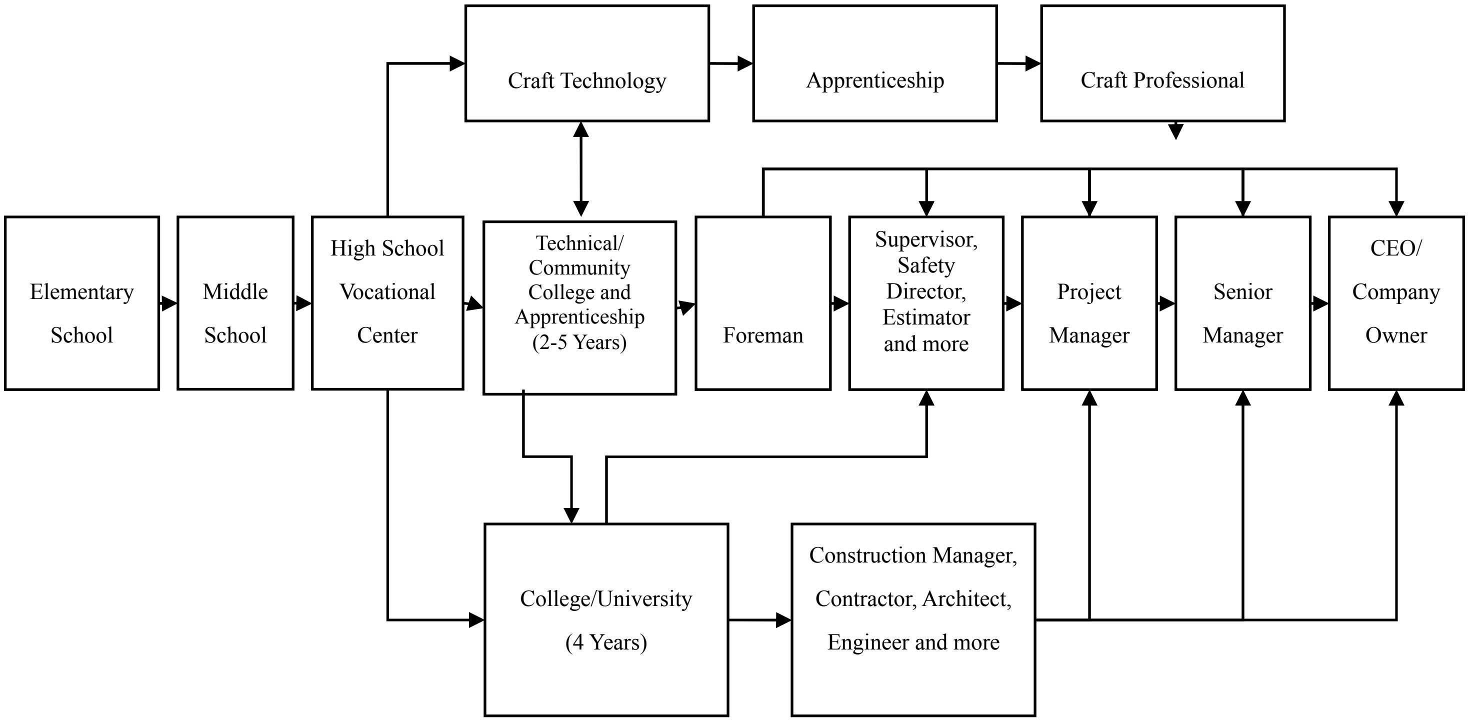


Figure 9. 6: Construction Career Paths

CHAPTER 10: CRAFT TRAINING TOOLKITS

Construction Industry Institute Research Team 231 (RT-231) was chartered to explain and quantify the business case for craft training in construction. This toolkit is for all those involved or responsible in some way for craft training. It provides information, tools, points of contact and references that will help the reader implement and improve a craft training program.

Accompanying this toolkit is an Excel spreadsheet, which provides a simple tool for calculating an expected return on investment in training for your company's projects. It uses default values based on a survey of nearly 100 industry experts. You may also want to replace the default value with those that more closely reflect the experience of your company.

This toolkit also provides suggested best practices checklists. These checklists are based on thorough research and the combined experiences of our team of experts. We also reference other well-developed checklists.

Other useful topics include background information on human resource management practices as well as sources and means of delivering craft training today. We also describe approaches for forecasting regional craft labour demands and for analyzing craft labour supply in future project locations.

U.S. businesses spend on average 1.25% of their payroll on maintaining training for their work forces. Construction typically falls well under this average. Yet CII research proves that training pays off. This guide will help you achieve that payoff.

10.1 Training Investment Analysis (TIA) Tool

The CII Training Investment Analysis Tool (TIA Tool) performs a benefit-cost ratio estimate for craft training from a project and company perspective. The benefit-cost (B/C) ratio is defined as the ratio of benefits to cost. By definition, the B/C ratio is greater than or equal to one when an investment is economically acceptable and less than one when an investment is not economically acceptable.

The TIA Tool uses a hypothetical petrochemical project based on characteristics of the CII model plant to perform a B/C ratio analysis on construction craft training. The model plant includes detailed work-hour and cost demands for activities required to construct a generic petrochemical facility. The model addresses a full range of construction activities from civil, structural, electrical, mechanical, and architectural finishes. The estimated 2006 costs for the

CII model plant range from $134.6 to 152.5 million with construction duration of 78 weeks and 527,457 total man-hours. TIA Tool assumes a hypothetical craft training program is implemented on the CII model plant project. By applying the training benefits estimated by a user, TIA Tool determines the benefit cost-ratio for craft training.

10.1.1 The Structure of the TIA Tool System

(a) Baseline and Training Cost

TIA Tool incorporates a baseline cost of the hypothetical petrochemical plant assuming no training program is implemented. The baseline cost is determined by estimating costs attributed to:

- Labor
- Turnover
- Absenteeism
- Injuries
- Rework

These costs were determined using estimates incorporated in existing industry data and previous research findings. The baseline cost for the hypothetical project based on the above factors is shown in Table 1.

Table 10. 1: Baseline Cost Summary (2006$)

Cost	Amount ($)	Percent of Total
Labor Cost	$23,029,633	92.7%
Turnover Cost	$231,458	0.9%
Absenteeism Cost	$514,930	2.0%
Injury Cost	$262,100	1.1%
Rework Cost	$807,030	3.3%
Total	$24,845,150	

The default training cost used by the TIA Tool is 1% of the total labor cost of the project, or approximately $248,452. Users can estimate their own training costs based on their expertise or use the default value when performing a B/C ratio analysis.

(b) Determine the Training Benefits

The TIA Tool requires its users to estimate the improvement rates in the following areas after a craft training program is implemented:

- Productivity
- Turnover
- Absenteeism

- Safety
- Re-work

If possible, the above benefits should be based on an individual firm's experience and historical data.

(c) Effects of the Shape of Learning Curves

Because experience can be accumulated, the more often a task is performed the lower will be the cost of doing it. The learning curve effect states that the more times a task has been performed, the less time will be required on each subsequent iteration. The TIA Tool assumes that improved safety, reduced absenteeism, and reduced turnover, occur immediately. Experience dictates and the research literature supports the TIA Tool assumption that other benefits, such as increased productivity and reduced rework, require more time to accrue allowing for the crafts' skills to improve. Thus, a linear learning curve function was used to model the crafts' improvement in productivity and rework. The development of the learning curves was based on data from the CII RT-231 survey as well as other industry data sources. The details of learning curves used by the TIA Tool can be found in the CII RT-231 Research Report.

A worker employed for a short time on a project may not achieve the same performance improvements as a worker spending a longer duration on a project due to the learning curve effect. In order to address this issue, the TIA Tool allows users to adjust the average duration that a craft worker is assumed to work on the CII model plant. The default average duration is 18 weeks.

10.1.2 Using the TIA Tool

TIA Tool was developed in Microsoft Excel™ (Figure 1). Four steps are needed for users to estimate the B/C ratio for construction craft training.

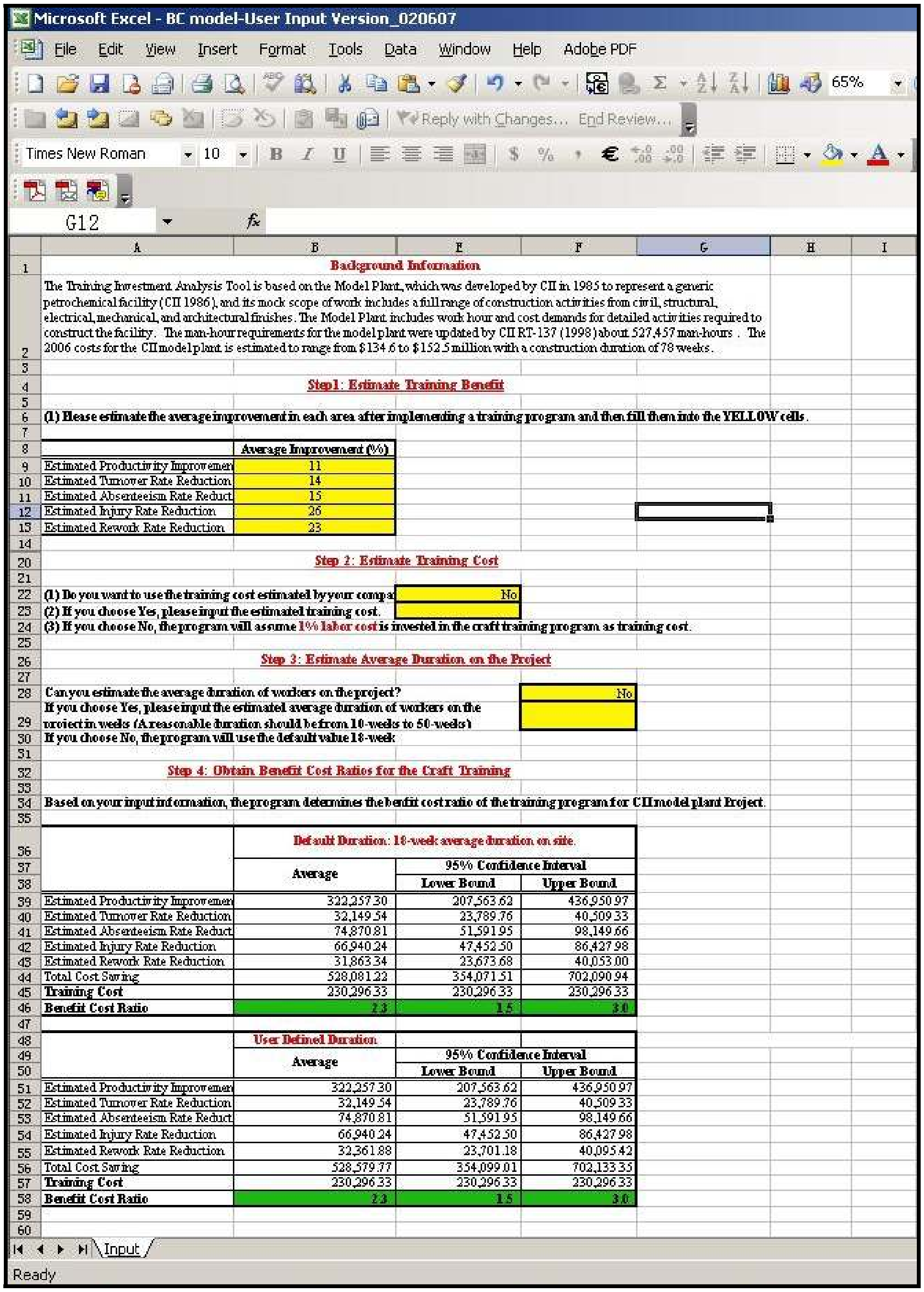


Figure 10. 1: Interface of TIA Tool

Step 1: Input the Estimated Percentages of Improvement from a Craft Training Program.

Users are required to input their expected improvement rates or use the systems default values in productivity, turnover rate, absenteeism, injury and rework into TIA Tool (Figure 2).

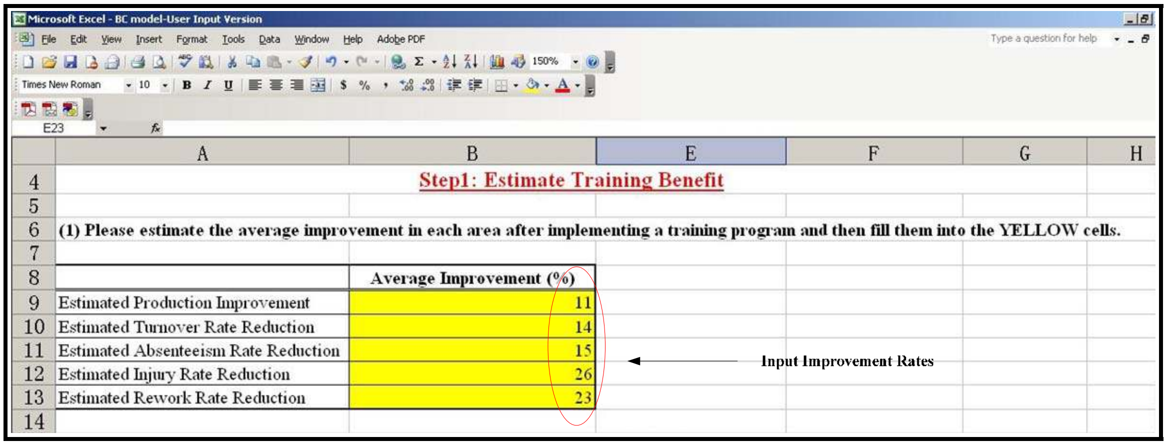


Figure 10. 2: Input Improvement Rates into the TIA Tool

Step 2: Determine the Craft Training Cost

Users can either choose to use their own estimated training cost (Figure 3) or the default value of training cost (Figure 4), which is 1% of the total labor cost of the CII hypothetical project ($248,452). If a user company decides to use its own training cost data on a project, the size of the project should be similar to the TIA tool's hypothetical project.

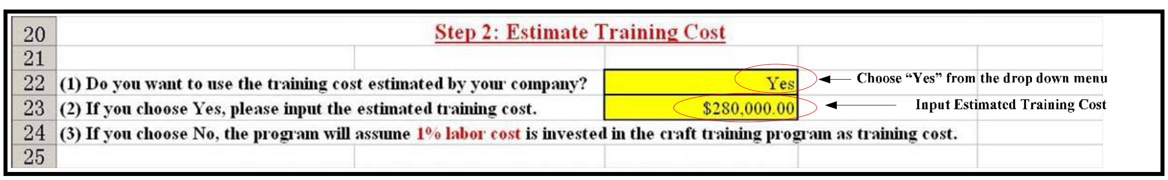


Figure 10. 3: Input Estimated Training Cost into TIA Tool

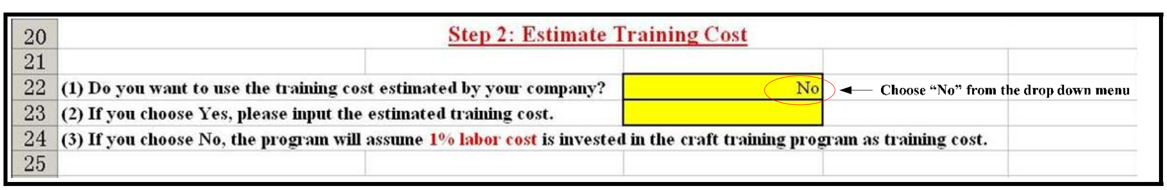


Figure 10. 4: Use Default Training Cost

Step 3: Estimate the Average Craft Worker Duration on the Project

By default, the TIA Tool uses 18 weeks for the craft workers' average duration on the project, which is based on the man-loading curves developed for the CII model plant. The user has the option to either decrease or increase this duration (Figure 5 and 6) in order to examine the effect that craft workers' duration has on the estimated B/C ratios.

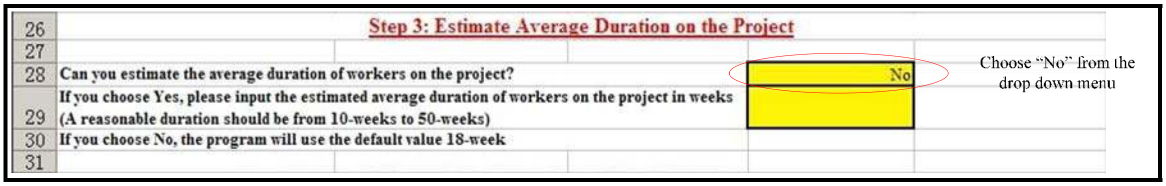


Figure 10. 5: Use Default Worker's Average Duration on the Project

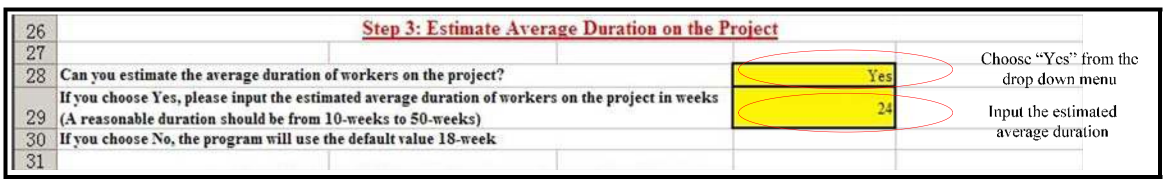


Figure 10. 6: Input User Estimated Worker's Average Duration on the Project

Step 4: Obtain and Interpret B/C Ratios

The TIA Tool estimates the cost savings after implementing craft training by applying the estimated benefits of craft training on productivity, turnover, absenteeism, injury and rework supplied by users in Step 1. The TIA Tool estimates the B/C ratio on the average expected benefits from training. It also shows a range of B/C ratios, which represent the 95% confidence interval of the estimates.

Furthermore, the TIA Tool determines the B/C ratios of craft training for the default average craft worker duration (18 weeks) on the project and the user selected duration (Figure 7).

Step 4: Obtain Benefit Cost Ratios for the Craft Training

Based on your input information, the program determines the benfit cost ratio of the training program for CII model plant Project.

	Default Duration: 18-week average duration on site.		
	Average	95% Confidence Interval	
		Lower Bound	Upper Bound
Estimated Productivity Improvement	322,257.30	207,563.62	436,950.97
Estimated Turnover Rate Reduction	32,149.54	23,789.76	40,509.33
Estimated Absenteeism Rate Reduction	74,870.81	51,591.95	98,149.66
Estimated Injury Rate Reduction	66,940.24	47,452.50	86,427.98
Estimated Rework Rate Reduction	31,863.34	23,673.68	40,053.00
Total Cost Saving	528,081.22	354,071.51	702,090.94
Training Cost	230,296.33	230,296.33	230,296.33
Benefit Cost Ratio	2.3	1.5	3.0

	User Defined Duration	24	
	Average	95% Confidence Interval	
		Lower Bound	Upper Bound
Estimated Productivity Improvement	423,605.37	272,834.36	574,369.89
Estimated Turnover Rate Reduction	24,112.16	17,842.32	30,382.00
Estimated Absenteeism Rate Reduction	74,870.81	51,591.95	98,149.66
Estimated Injury Rate Reduction	66,940.24	47,452.50	86,427.98
Estimated Rework Rate Reduction	42,393.59	31,155.04	52,704.97
Total Cost Saving	631,922.16	420,876.17	842,034.49
Training Cost	230,296.33	230,296.33	230,296.33
Benefit Cost Ratio	2.7	1.8	3.7

Figure 10.7: B/C Ratios under Different Average Durations

10.1.3 Limitations of the TIA Tool

The TIA Tool uses several assumptions which simplify the analysis and make it feasible. It is important that these assumptions be carefully considered when reviewing B/C analyses:

- The TIA Tool uses described parameters of the typical petrochemical project. As a result, the B/C ratios estimated by the TIA Tool are based on specific labor resource loading over the schedule estimated for the hypothetical plant.
- When determining the baseline cost of hypothetical plant, the TIA Tool uses industry average values for incidence rate and unit cost of turnover, absenteeism, injury and rework from sources that are referenced in the source document for RT 231. For an individual company or project, the incidence rate and unit costs may vary significantly.
- The TIA Tool uses a “first-in, last-out” strategy to determine the average duration of workers on the project, which assumes that contractors hire the most desirable workers in each skill level first, and then attempt to retain them until no work is available in their trade. This strategy is an approximation of reality on most projects.

- Improvements in productivity and rework generally require more time to be achieved by a worker. The study used linear learning curve functions to address the learning curve effect on the productivity improvement and rework reduction of workers after receiving craft training. A linear learning curve is the simplest function to use to model this behavior, and it was assumed that the CII RT-231 survey respondents intuitively considered a linear learning curve function when estimating the average time required to achieve improvements in productivity and rework.

- The TIA Tool estimates the B/C ratio under the assumption that the CII model plant starts with a work force with little to no prior training experience. The estimates assume that no outside funding sources are used to pay for the cost of training. Governmental scholarships and grants can help offset some of the costs and the B/C estimates may increase.

10.2 Training Best Practices Checklists

Training best practices checklists serve several purposes, including for use as a:

- Basis for awards encouraging work force development (HBRT)
- Basis for pre-qualification and/or contract award (CURT)
- Basis for benchmarking and metrics programs for self-improvement (Tier I and Tier II metrics from UT Austin)
- Starting point for implementation of a program

This toolkit provides four checklists. The checklists outline the responsibilities of each stakeholder to help achieve an optimal learning environment for improved project performance. The practices they recommend are based on the research conducted as part of CII Research Team 231 and on other well documented research and experience. The *Owner's Checklist* may be used as a basis for prequalification of contractors, for contractor work force development awards, or as a checklist for building or improving training efforts. The *Employer's Checklist* provides a list of practices that should help a contractor implement the most effective training program possible. The *Trainee's Checklist* provides pointers to help apprentices and other trainees make the most of their training experiences. The *Journeyman's Checklist* provides journeymen guidance in their mentoring and training role toward trainees and apprentices. If you have not checked 80% of these boxes in your own list, you might want to re-evaluate your craft training.

Owner's Checklist

This is a basis for pre-qualification of contractors, as criteria for contractor work force development awards, or as a checklist of issues to cover if directly engaged in construction or improving training efforts.

Do you?

- Provide support on all construction and maintenance projects
- Use craft training checklists to pre-qualify contractors
- Ensure that entry-level workers or apprentices are encouraged on your sites in order to offer access for new recruits to the industry
- Support image enhancement of craft workers and the construction industry
- Support recruiting from high school, community college, and technical institutes
- Advocate for government support of training
- Incorporate language in your contracts requiring training
- Require more than 80% craft skill certification on your projects

Employer's Checklist

This will help a contractor implement the most effective training program possible.

- o Do you participate in work force training? If yes, elaborate on cents-per-hour contribution, percent of work force covered, and specific training programs.

  ____

- o Do you have a written craft work force-management program? If yes, elaborate on roles and responsibilities of those involved, and the procedures for evaluating how well the program works.____

- o Do you have formal classroom training? If yes, elaborate on facilities, hours, and percent of time per year spent in classroom training for apprentices and percent spent for upgrade training, etc.

  ____

- o Do you provide or help facilitate financial support for craft workers for the hours they spend in formal classroom training?

- o Do you have a written mentoring program for OJT, with training and incentives for mentors?

- o Do you have a written structured jobsite (OJT) training program?

- o Do you use training material developed by the industry in the union sector or by NCCER?

- o Are elements of your training program approved by a professional organization or vendor? If yes, elaborate on the organizations and/or vendors.

- Do you assess new hires? If yes, elaborate on the methods and types of assessment.

- Do you utilize pay or bonus incentives for formally certified craft progression? If yes, elaborate on dollars per hour, or percent of journeyman level wages, or other schemes.

- Do you participate in record keeping for certifications of craft persons at a regional or national level beyond the boundaries or hiring databases of your own firm? If yes, in which programs do you participate?

- Do you offer access to craft supervisors for training in leadership, administrative, and site management skills? If yes, elaborate on your program.

- Do you publish and communicate to your craftworkers a clear career progression program? Do your workers have a good understanding of the career progression program?
- Do you have formal hiring and retention preferences for employees in craft training? If yes, how are they implemented?

- Is continued craft training required and supported for certified journeymen?
- Do you measure the benefits of your training? If so, what metrics do you use?
- Do you share your work force development policies with your employees? If so, how?

Trainee's Checklist

This will help apprentices make the most of their learning experiences and define the responsibilities of the trainee in the training process. In some cases, the elements of this checklist can be used by employers to assess workers and to provide feedback to them. It may also be included in your employee handbook.

- Do I attend all formal training sessions?
- Do I follow the recommended training and certification schedule?
- Do I ask questions of journeymen I work with, especially when I don't understand something?
- Have I connected with my assigned mentor(s)?
- Do I listen to those who are trying to teach me?
- Do I handle failure in a constructive way?
- Am I a team player?
- Do I provide the best product and work in return for my wages?
- Do I keep my apprenticeship records up to date?
- Am I seeking opportunities to learn new things?
- Do I work safely?
- Am I satisfied with the work I am doing and do I keep a positive attitude?
- Am I creative and do I demonstrate initiative on my job site?
- Do I demonstrate respect for my co-workers?

Journeyman’s Checklist

This will help journeymen make the most of the training and apprenticeship experiences and define the responsibilities of the journeyman as a mentor in the training process. In some cases, the checklist can be used by employers to assess journeymen and to provide feedback to them. It may also be included in the employee handbook.

- Do I work safely?
- Am I a positive role model for my apprentices?
- Do I share my knowledge and experience with apprentices?
- Do I demonstrate respect for my co-workers and site supervisory people?
- Do I provide constructive feedback to my apprentices?
- Am I patient with the apprentice when he/she makes mistakes?
- Do I show pride and passion for my trade?
- Do I encourage my apprentice to follow the recommended craft progression?
- Do I show the apprentice how to do a task, then allow the apprentice to do it while I watch carefully, and then do I provide constructive feedback?

CHAPTER 11: CONCLUSIONS AND RECOMMENDATIONS

With the support of CII, NCCER, and CURT, the research study's primary objective was to quantify the business case for craft training. In support of this objective, the study compiled and analyzed an unprecedented amount of data characterizing craft training efforts throughout the United States and Canada. Although craft training exists, more is needed. Undoubtedly, what prevents many companies from investing in training is the lack of a clear, well-defined business case to justify their effort. As described in this report, most of the surveyed companies conducting training are not measuring the effectiveness of their training efforts. Other conclusions can be made about current construction craft training efforts in the United States and Canada:

- **Significant benefits to craft training can be achieved through a sufficient sole project effort.** Survey and industry data indicates that a positive B/C ratio can range from 1.3:1 to 3.0:1. The benefits will increase with the craftworkers' duration in a training program.
- **Offering meaningful training can help attract and retain craft workers to one's company and to the industry**. In addition to the tangible benefits of increasing a craftworker's salary, training also improves a craftworker's job satisfaction.
- **Craft training is where safety was years ago**. Decades ago, owners became more involved in construction safety, and the industrial construction sector witnessed significant improvement. Likewise, there is evidence that shows similar improvement in craft training is possible when the owner becomes involved and mandates that craft training and certification be provided.
- **Most companies do not measure the effectiveness of craft training, but it can be done**. Suggested metrics for training results include improvements in absenteeism, turnover, productivity, safety, and rework.
- **Owners are paying for training on union projects, but rarely pay for training on open-shop projects.** On union projects, it is an accepted requirement that training/apprenticeship cents per hour contributions are paid by owners and contractors. Although there are instances where formal training programs are funded through cents per hour contributions in the open shop sector, this is a relatively rare occurrence. Unfortunately, on many open shop projects where training/apprenticeship contributions are an option, owners question why they should be funding the training and why it should not simply be considered the contractor's responsibility to provide a qualified work force.

- **The benefits to training do not occur at once.** Some of the training payoffs occur immediately, such as improved safety, reduced absenteeism and reduced turnover. Others will take more time to allow an increase in craft skill, such as increased productivity and reduced rework. While these benefits produce tangible results, perhaps the most important benefit is the development of skilled craftworkers to meet future demands.

The craft training implementation toolkit developed through this project can provide effective tools for company management to justify the business case for craft training to company stakeholders. Once the decision is made to invest in craft training, the toolkit provides information, checklists, and references that will help the reader implement and improve a craft training program and measure its benefits in comparison with its costs.

Craft training does exist in the United States and Canadian construction industry, but more is needed. Understanding the business case behind craft training should motivate industry leaders, business managers, plant managers, policy makers, and other decision makers to invest in craft training, not only for the sake of their company's profit margins but also for the viability of the industry. To help increase craft training efforts throughout both countries, CII RT 231 developed the following recommendations:

- Owners should require craft training and certification on larger projects
- Owners who have plants in areas where industry is concentrated should require training on all construction and on-going maintenance projects (e.g., U.S Gulf Coast)
- Contractors should provide comprehensive employment packages that include competitive wage, training, and benefits
- Contractors need to participate in an established, confidential database on training certifications (e.g., NCCER)
- Measuring the benefits of training should be common
- Owners should mandate craft certification under common training standards

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