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THE COMPARATIVE EXPERIENCE IN MULTISKILLING AMONG U.S. HISPANIC AND NON-HISPANIC CONSTRUCTION CRAFT WORKERS

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Abstract: After the latest economic recession, the U.S. construction industry has faced a shortage of craft workers, mainly among highly skilled trades, such as pipefitters and electricians. Current skilled workers are leaving the industry for other industries, such as manufacturing. As one approach to retain the current workers, multiskilling is one workforce strategy that has been traditionally proposed as a pathway to increase wages and job duration for workers. This study aims to understand the changes in multiskilling and the influence of race on multiskilling patterns through the National Craft Assessment and Certification Program (NCACP) dataset. Previous studies revealed that the Hispanic population has increased sharply in the construction industry but mainly among lower skilled construction trades. Furthermore among single skilled workers, there are significant differences in formal training between Hispanic and non-Hispanic workers. However, the findings show that there was no statistical difference between multi-skilled Hispanic and non-Hispanic construction craft workers in the rate of formal training. Further, there was no difference between Hispanic and non-Hispanic trade patterns among craft workers with dual-skills.

1 INTRODUCTION

The construction industry plays a major role in the United States' economy. Currently, and during economic expansion periods, the U.S construction industry faces a workforce shortage, primarily among highly skilled trades, for two reasons: 1) strong construction demand across multiple industry sectors; and 2) low supply levels of skilled craft workers (Komarnicki 2012; Glavin 2013; Wilder 2013; Shelar 2013). By definition, highly skilled trades are those requiring specialized education or training, which can take years to complete (e.g. carpenters, electricians, and pipefitters), and low skilled trades are those requiring minimal to no training and instruction (e.g. general helpers) (Vereen 2013). The major contributor to the low number of skilled craft workers is a continuance of two factors within the workforce during the last couple of decades. First, increasing numbers of seasoned workers are leaving the construction industry through retirement or industry change. Second, there has been a lack of new workers entering the construction industry (Druker and White 1996; Makhene and Thwala 2009; Belman 2013). The shortage of skilled labor in the construction industry is not a recent issue, but rather a cyclical problem (Dainty et. al. 2004; Castaneda et. al. 2005). The U.S. Bureau of Labor Statistics (BLS) predicted the U.S. construction industry will be the fastest growing industry in the nation over the next decade with an estimated 1.6 million new jobs (Glavin 2013; Gonzales 2013). Because of such rapid growth, 79% of construction companies in the U.S. are having difficulty finding qualified workers to fill job openings (AGC 2015).

There is no single solution to resolve the shortage problem. Multiple approaches are needed to minimize the shortage (Komarnicki 2012; Healy et. al. 2011). Some solutions focus on retaining current craft workers (e.g. increasing workers job satisfaction), attracting new craft workers to the industry (e.g. enhancing vocational program at high schools), and other solutions are based on creating different management approaches (e.g. prefabrication, modularization, and relocation of the craft workers). Because retaining current craft workers is one common strategy for mitigating the labor shortage, this study was conducted to understand how multiskilling contributes to worker retention. A previous study by Albattah et al. (2016) found that recruiting and retention efforts in the construction industry should emphasize extrinsic motivation, primarily in the form of satisfactory wages. Other studies have also found that multiskilling is a strategy that not only increases craft workers' wages, but also affords longer employment times. Further, multiskilling reduces workforce shortages because it increases the number of skills in the labor market pool even if the number of workers remains constant (Burleson 1997; Gomar et al 2002; Carley et al 2003; Ejohwomu et al. 2008; Wang et al. 2009). Burleson et al. (1998) define the multiskilling as "a labor utilization strategy in which workers possess a range of skills that are appropriate for more than one work process and that are used flexibly on a project or within an organization." Multiskilling gives craft workers longer contracts and higher wages that increase job satisfaction (Wang et al. 2009; Carley et al. 2003; Haas et al. 1999a; Gomar et al. 2002). Hispanics are the most rapidly growing population in the U.S. construction industry, while other populations have been shrinking (Goodrum 2004). Further, most of the Hispanic craft workers were in lower skilled trades that did not require unique training (Albattah et al. 2015). Therefore, this study specifically explored the multiskilling rate and the dual-skill patterns among Hispanic craft workers in the U.S. construction industry. Dual-skill individual is the worker who has certification in two different trades. The most valuable contribution of this study was the discovery that the difference between Hispanic and non-Hispanic craft workers almost disappeared when they were multi-skilled, especially when they had formal training background.

1.1 Research Objective

The main objective of this study was to understand the changes in multiskilling and the influence of race (Hispanic versus non-Hispanic) on multiskilling patterns. The Hispanic population has increased sharply in the construction industry in recent decades. Thus, this study examined the types of trades most common among Hispanic craft workers and compared dual-skill trends between Hispanic and non-Hispanic craft workers. Furthermore, the effect of formal training was investigated among both Hispanic and non-Hispanic craft workers.

2 LITERATURE REVIEW

Decades ago, the multiskilling strategy was known and applied in the manufacturing industry (Nonaka 1990; Ettlie and Rezo 1992; Carmichael and McLeod 1993; Burleson 1997). This multiskilling strategy was developed by manufacturing companies for labor cost savings because of technical changes and market demand shifts that decreased worker demand in current jobs and increased demand in other jobs. Therefore, multi-skilled workers were transferred between work groups based on the job demand (Carmichael and McLeod 1993). Burleson (1997) was one of the first researchers to explore multiskilling specifically in the construction industry. Burleson used the Construction Industry Institute (CII) Model Plant, developed in 1985, to create a basis for analyzing a hypothetical petrochemical facility project. In addition, she used a scheduling program (Primavera P3) and applied a cost analysis for a traditional single-skill workforce as a baseline, and then compared it with four multiskilling strategies, **Error! Reference source not found.**. Skill combinations were driven by the phase nature of a construction project, skill complexity, and trade similarities.

According to Burleson, the main motivation for using the multiskilling strategy is to reduce the workforce size in favor of productivity improvements and unit cost savings, achieving both an increase in workers' wages and a decrease in the total project costs. Burleson analyzed the use of multiskilling strategies on a hypothetical petrochemical plant with zero productivity improvement and with 20% productivity improvement. She believed that the 20% productivity improvement using multiskilling was a result of a reduction of supervision and supporting workers, a reduction of absenteeism, a reduction of idle time, and

an increase of output per hour. Among the four multiskilling strategies, Four-Skill Strategy B was the most successful (**Error! Reference source not found.**), in which each worker had all skills under one of the main four groups (Civil/Structure, General Support, Mechanical, and Electrical).

Table 1: The Multiskilling Strategy – the four types (Burleson 1997)

Dual-skill strategy	**Four-skill strategy (A)**	**Four-skill strategy (B)**	**Theoretical optimum strategy**
Welder/General Laborer Electrician/Insulator Rigger/Equipment Operator Carpenter/Pipefitter Surveyor/Instrumentation Worker Iron Worker/Structural Steel Erector Crane Operator/Painter Concrete Finisher/Millwright	**Civil/Structural:** carpenter, iron worker, concrete finisher, structural steel erector. **General Support:** general laborer, equipment operator, truck driver, crane operator, rigger, surveyor, painter. **Mechanical:** insulator, millwright, pipefitter, welder. **Electrical:** electrician, instrumentation worker.	**Civil/Structural:** carpenter, iron worker, concrete finisher, structural steel erector. **General Support:** all helper, general laborer, equipment operator, truck driver, crane operator, rigger, surveyor, painter. **Mechanical:** insulator, millwright, pipefitter, welder. **Electrical:** electrician, instrumentation worker.	**Construction worker:** carpenter, iron worker, concrete finisher, structural steel erector, laborer, equipment operator, truck driver, crane operator, rigger, surveyor, painter, insulator, millwright, pipefitter, welder, electrician, instrumentation worker.

Wang et al. (2009) applied secondary raw data to study the multiskilling strategy in the construction industry. The authors used two data sources: the NCACP dataset from NCCER and previous research data (RT-182) from the Construction Industry Institute (CII 2003). This study shows the results from NCACP data only. The NCACP data included 66,410 participants between 2000 and 2006. Among these participants, 1,579 craft workers were considered multi-skilled. Of 17 different trades in the dataset, the pipefitter, electrician, and boilermaker trades were the three largest trades. For dual-skill results, the authors employed Pearson's analysis to identify the correlation between two skills obtained by workers and ranked the top combination of skills. As shown in Table 2, the most common skill combination involved Electrician and Instrument Technician skills followed by Reinforcement Ironworker and Concrete Finisher, which reflected a natural skill affinity among many of the skill combinations.

Table 2: Top dual skills from the NCACP data (Wang et al. 2009)

Rank	**Craft skill (1)**	**Craft skill (2)**	**Pearson correlation coefficient**
1	Electrician	Instrument technician	0.794
2	Reinforcing ironworker	Concrete finisher	0.475
3	Scaffold builder	Insulation	0.425
4	Scaffold builder	Carpenter	0.329
5	Boilermaker	Pipefitter	0.218
6	Carpenter	Concrete finisher	0.190
7	Electrician	Instrument fitter	0.181
8	Instrument technician	Instrument fitter	0.145
9	Carpenter	Reinforcing ironworker	0.139
10	Crane operator	Structural ironworker	0.100

Wang et al. (2009) found that a higher percentage of non-Hispanic craft workers (83.6%) obtained multiskilling certificates compared to Hispanic craft workers (16.4%). They also found that multi-skilled workers have more years of experience as compared to single skill workers. However, one of the main findings in the Wang et al. (2009) study was that the workers' primary motivation for becoming multi-skilled was to increase functionality rather than length of employment. That finding was based on the fact that the most common combination of skills were those most likely to be performed concurrently rather than consecutively on a jobsite. Concurrent skills may be more functional and consecutive skill combinations increase employment duration.

Other researchers have conducted survey studies on multiskilling strategies in the construction industry (Haas et al. 1999a; Haas et al. 1999b; Carley et al. 2003). Haas et al. (1999a) conducted a survey of about 1,100 craft workers and found that about 70% of the workers were working on trades other than

their main trades, which made them multi-skilled workers. In addition, 57% of workers were interested in learning new skills and cited “higher hourly wages” and “interested in the trade” as the top reasons for doing so. Haas et al. (1999b) conducted 51 personal interviews and 15 telephone interviews in 12 different companies. The interviewees were managers, superintendents, and foremen. The main reason companies implemented the multiskilling strategy was to reduce labor costs, which was most effective when multiskilling was considered during all phases of the project (Haas et al. 1999b).

Carley et al. (2003) surveyed 721 craft workers from 10 construction companies. Most respondents were from Texas and primarily pipefitters/plumbers, followed by electricians. Participants wished to work in trades with higher wages, which were necessarily higher skilled trades such as welders and electricians (Carley et al. 2003). However, other researchers applied a different model to study the multiskilling strategy using a “Multiskilling Optimization Model for Allocation” that was tested and validated by the CII Model Plant data and commercial linear programming software (Gomar et al. 2002). Gomar et al. (2002) addressed the benefits of the multiskilling strategy on the planning and scheduling of the construction projects, and found that multiskilling increases the participation and job employment duration for workers and reduces idle time.

In general, multiskilling has benefits at the project, worker, and industry level. At the project level, the multiskilling strategy significantly reduces total costs (Burleson 1997; Haas et al. 1999b; Gomar et al. 2002). At the worker level, multi-skilled workers have longer employment, higher wages, and higher productivity with fewer construction accidents (Burleson 1997; Haas et al. 1999a; Gomar et al. 2002; Carley et al. 2003; Wang et al. 2009). At the industry level, multiskilling increases worker retention, reducing the demand for new entrants and the number of the workers at the jobsite, and developing career-path opportunities in the construction industry (Burleson 1997).

All previous studies except Wang et al. (2009) that examined the multiskilling strategies used subjective data, while this study in addition to Wang et al. (2009) used objective data. However, none of the previous studies examined the influence of race on the multiskilling strategy, while this study specifically examined the changes in multiskilling and the influence of race (Hispanic versus non-Hispanic) on multiskilling patterns.

3 RESEARCH METHODOLOGY

Data was collected from The National Center for Construction Education and Research (NCCER) to study the Hispanic craft workers in the construction industry and their influence on the multiskilling patterns, focusing on the dual-skill strategy, and compared them to the non-Hispanic craft workers. The National Center for Construction Education and Research (NCCER) developed the NCACP to evaluate journey-level knowledge and skills of experienced craft workers. The worker who achieves a score above a cut-off point is classified as passing their respective written exam for certification, otherwise training is recommended. Besides the workers’ test results (pass/training needed), the NCACP data includes codes identifying each participant’s assessment location, gender, race, training curriculum, training provider, and years of experience in construction. A total of 402,899 cases or exams (number of exams could be taken by a single participant) with 174 different certificates were included in the dataset from 2005 to 2014. This study includes only 14 trades—a total of 134 certificates—related to the construction industry, excluding trades relevant to operation and maintenance and management sectors. Some certificates are related to specific tasks under a certain trade, require more experience (advanced certificates), or are in different language (e.g., Spanish). Only those who took exams in two or more different certificates were included in this study, a total of 20,789 participants.

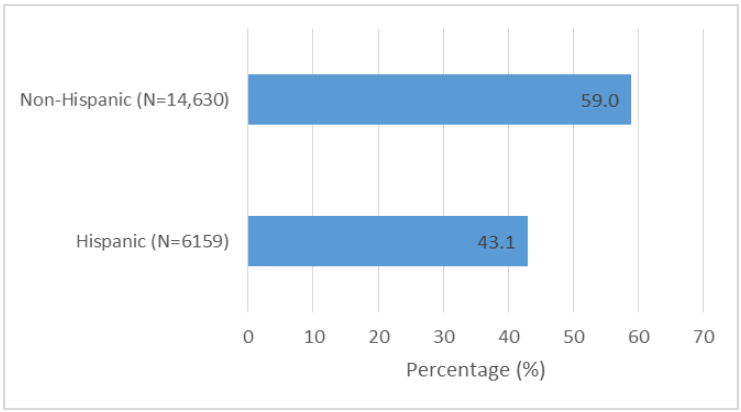
The National Craft Assessment and Certification Program (NCACP) was used to study and compare the rate of multi-skilled craft workers, the formal training effect on the multi-skilled craft workers, and the dual-skill patterns, using a Skill Matrix method, among Hispanic and non-Hispanic craft workers. The Skill Matrix method basically includes the 14 construction trades in the *y*-axis and the same number of trades in the *x*-axis, a total of 91 possible dual-skill combinations. The authors of this study ranked the top dual-skills based on the participants’ rates among all the possible combinations; the higher rate means the higher rank.

4 RESULTS OF ANALYSIS

In this section, comparisons of Hispanic and non-Hispanic multi-skilled craft workers' participation rates and formal training rates are presented. Dual-skill patterns by construction craft trades among Hispanic and non-Hispanic craft workers were also analyzed.

4.1 Multi-Skilled Workers' Rate by Race

The NCACP data was used to compare the multiskilling participation rates of Hispanic and non-Hispanic craft workers. Among all multi-exam takers in the dataset, 29.6% were Hispanic and 70.4% were Non-Hispanic. These percentages include all exam takers—regardless of whether or not they passed the exam—between 2005 and 2014. However, the rate of Hispanic craft workers who passed at least two exams was lower (43.1%) than the rate of non-Hispanics (59%), Figure 1.

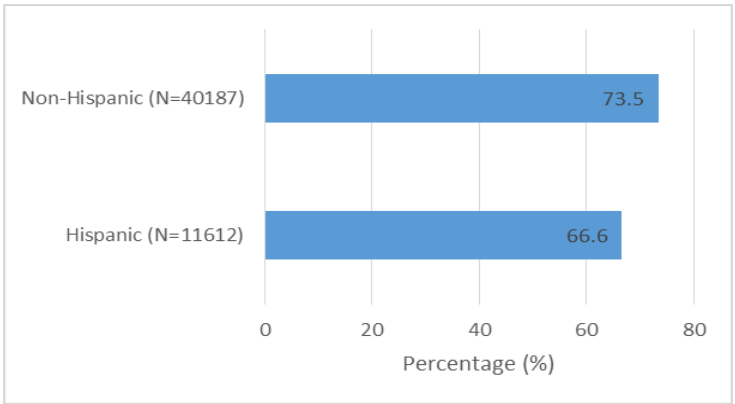


Chi-square test =0.00 was performed to test the difference between the columns.
SOURCE: National Craft Assessment and Certification Program (NCACP).

Figure 1: Multi-skilled Workers' Rate by Race (Hispanic vs. Non-Hispanic)

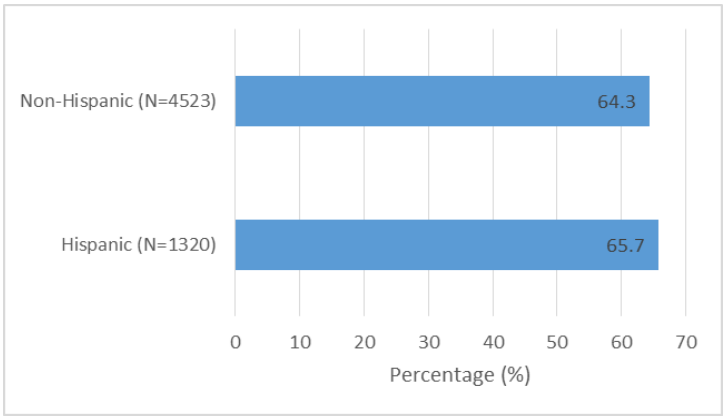
4.2 Formal Training Rate

There was a difference between Hispanic and non-Hispanic craft workers in the formal training rate among all workers in the dataset, including the single-skilled craft workers. Fewer Hispanic craft workers (66.6%) had formal training than non-Hispanic craft workers (73.5%), as shown in Figure . However, there was no statistical difference between multi-skilled Hispanic (65.7%) and non-Hispanic (64.3%) craft workers in the rate of formal training, as demonstrated using chi-square test (p = 0.36), Figure . Therefore, formal training could be a driver for Hispanic craft workers to become multi-skilled.



Chi-square test =0.00 was performed to test the difference between the columns.
SOURCE: National Craft Assessment and Certification Program (NCACP).

Figure 2: Formal Training Rate among All Participants (Hispanic vs. Non-Hispanic)



Chi-square test =0.36 was performed to test the difference between the columns.
SOURCE: National Craft Assessment and Certification Program (NCACP).

Figure 3: Formal Training's Rate among Multi-skilled Workers (Hispanic vs. Non-Hispanic)

4.3 Multiskilling Patterns (Dual-Skill sets)

To define the dual-skill sets, two skill matrices were applied, one for Hispanics (*n* = 6,159) and the other one for non-Hispanics (*n* = 14,630). Fourteen trade skills were included in this study for a total of 91 dual-skill sets. To avoid bias in the ranked results due to a high distribution among some skills, dual-skill sets were normalized, using Equation 1.

Equation 1. Normalized dual-skill sets

$$NDS = \frac{\#BS(x,y)}{[\#S(x) + \#S(y)] - \#BS(x,y)} \times 100$$

NDS = the normalized dual-skill by percentage, *#BS (x, y)* = the number of workers who have the both skills, *#S(x)* = the number of workers who have the skill in the *x*-axis, and *#S(y)* = the number of workers who have the skill in the *y*-axis

The top 10 dual-skill sets were ranked among Hispanics and compared with the top 10 dual-skill sets among non-Hispanic. Carpenter/concrete finisher was the top dual skill-set among all Hispanic multi-skilled craft workers and fourth among non-Hispanics. Reinforcing iron and rebar/concrete finisher was the top dual skill-set among non-Hispanic craft workers and second among Hispanics, Table . Among the 91 dual-skills, nine of the top 10 dual-skills for Hispanic craft workers were in the top 10 dual-skills for non-Hispanic craft workers but with different order. Thus, Hispanic and non-Hispanic construction craft

workers had similar multiskilling patterns,

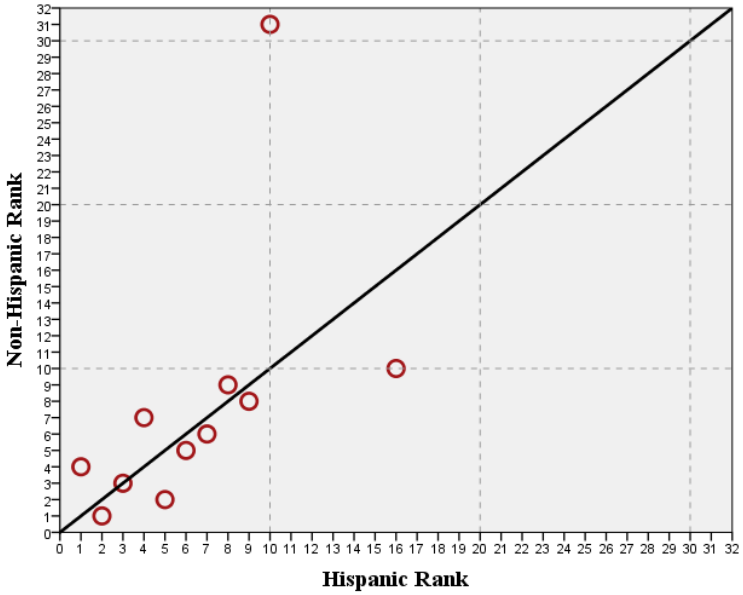


Figure 2.

Table 3: Top 10 Dual-Skills for All Hispanic Multi-Skilled Workers Compared with Non-Hispanics

#	Dual-Skill			Hispanic		Non-Hispanic	
				Rank (#)	%	Rank (#)	%
1	Carpenters	&	Concrete Finisher	1	29.77	4	23.06
2	Reinforcing Iron and Rebar	&	Concrete Finisher	2	28.89	1	32.7
3	Ironworker	&	Riggers	3	27.62	3	26.59
4	Reinforcing Iron and Rebar	&	Carpenters	4	27.19	7	16.61
5	Pipefitter	&	Riggers	5	24.4	2	28.41
6	Boilermaker	&	Riggers	6	20.96	5	20.48
7	Pipefitter	&	Boilermaker	7	20.09	6	18.73
8	Scaffold Builder	&	Insulation	8	19.79	9	15.32
9	Crane Operator	&	Riggers	9	10.09	8	16.29
10	Scaffold Builder	&	Boilermaker	10	9.97	31	2.69
11	Scaffold Builder	&	Carpenters	16	6.04	10	9.95

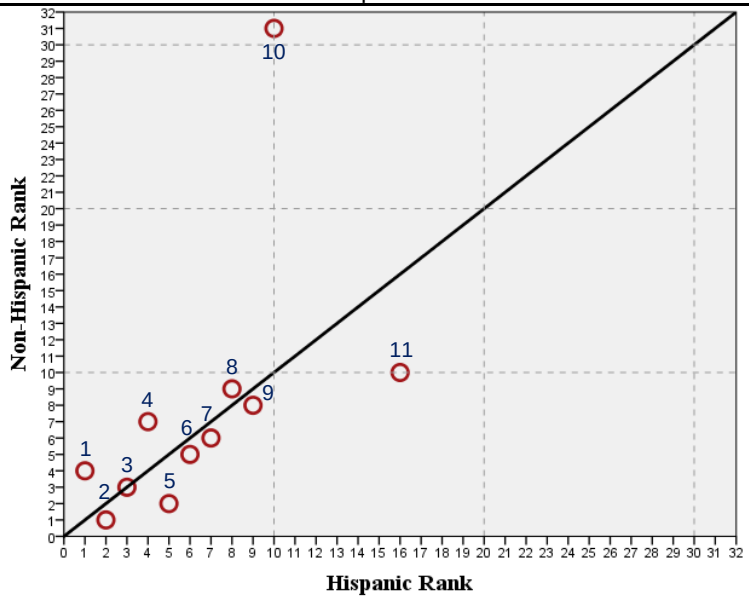


Figure 2: A Scatter Plot Showing the Relationship between Hispanic and non-Hispanic Dual-Skills Ranking (All Workers)

The authors created two additional skill matrices that included only Hispanics (*n* = 1,320) and non-Hispanics (*n* = 4,523) with formal training. Carpenter/concrete finisher was the top dual-skill set among Hispanic craft workers with formal training and fifth among non-Hispanics with formal training. Reinforcing iron and rebar/concrete finisher was also ranked the first among non-Hispanic craft workers with formal training, and seventh among Hispanics with formal training, Table . The top 10 dual-skills for both Hispanics and non-Hispanics were the same as the top 10 dual-skills for all workers when controlling for formal training, but the order of the dual-skills changed. Thus, formally trained Hispanic and non-Hispanic construction craft workers had similar multiskilling patterns, Figure 3.

Table 4: Top 10 Dual-Skills for Hispanic Workers with Formal Training Compared with Non-Hispanics

#	Dual-Skill			Hispanic		Non-Hispanic	
				Rank (#)	%	Rank (#)	%
1	Carpenters	&	Concrete Finisher	1	31.46	5	20.3
2	Ironworker	&	Riggers	2	27.51	3	25.43
3	Pipefitter	&	Riggers	3	23.46	2	27.47
4	Pipefitter	&	Boilermaker	4	23.13	7	18.81
5	Reinforcing Iron and Rebar	&	Carpenters	5	23.08	9	13.17
6	Scaffold Builder	&	Insulation	6	21.92	10	9.77
7	Reinforcing Iron and Rebar	&	Concrete Finisher	7	21.82	1	30.26
8	Boilermaker	&	Riggers	8	21.01	4	23.45
9	Crane Operator	&	Riggers	9	12.96	6	19.48
10	Scaffold Builder	&	Boilermaker	10	9.87	27	3.2
11	Scaffold Builder	&	Carpenters	15	6.38	8	13.33

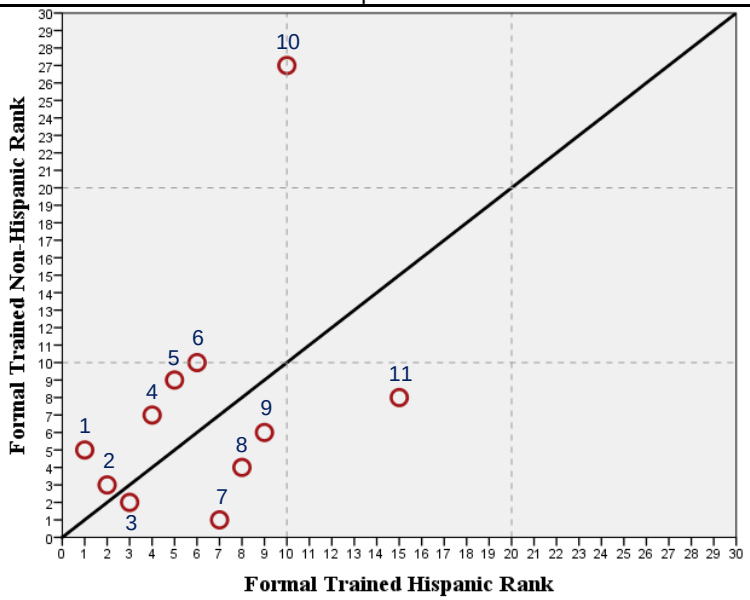


Figure 3: A Scatter Plot Showing the Relationship between Hispanic and non-Hispanic Dual-Skills Ranking (Workers with Formal Training)

5 DISSCUSION

This study examined the influence of race (Hispanic verse Non-Hispanic) on the multiskilling strategy, using objective data, that none of the previous studies did. The authors focused on the Hispanic craft workers since their number in the construction industry is growing quickly (Goodrum 2004). However, most of the Hispanic craft workers are in lower skilled trades that did not require unique training, while

most of the Non-Hispanic craft workers are in highly skilled trades (Albattah et al. 2015). This study proved that the Hispanic multi-skilled craft workers in the construction industry are not different than the Non-Hispanic multi-skilled craft workers.

Nearly 30% of multi-exam takers were Hispanic craft workers, and this percentage was close to the overall percentage of Hispanics in the construction industry. However, the rate of the Hispanic multi-skilled craft workers was 43.1%, far less than the rate among non-Hispanics (59%). To examine the reason for this disparity, formal training among Hispanics and non-Hispanic craft workers was analyzed. When controlling for formal training, no statistical differences were found between the Hispanic and non-Hispanic multi-skilled rate—both populations had a rate of about 65%. These findings may help the construction industry design effective retention strategies for Hispanic craft employees, such as long-term training plans for highly-skilled trades.

Among the 91 dual-skills, nine of the top 10 dual-skills for Hispanic craft workers were in the top 10 dual-skills for non-Hispanic craft workers but with different order. Further, the top 10 dual-skills for both Hispanics and non-Hispanics were the same when controlling for formal training, but the order of the dual-skills changed. Thus, Hispanic and non-Hispanic construction craft workers had similar multiskilling patterns. These findings are similar to Wang et al. (2009) findings, Table 2. Six of the top 10 dual-skills found by Wang et al. (2009) were in the top 10 dual-skills found in the present study. However, three of the top 10 dual-skills found by Wang et al. (2009) were not applicable in this study because they treated electrician, instrument technician, and instrument fitters as different trades, whereas this study combined them as one trade, electricians & instrumentation.

There are some limitations when the NCACP dataset is used. The participants were mainly from the industrial sector and from the Gulf Coast region. In addition, there were no variables for participants' age and education background, which would enrich this study results.

6 CONCLUSION

Using the NCACP data from 2005 to 2014, this study examined and compared the dual-skill strategy among Hispanic and non-Hispanic construction craft workers. The most valuable contribution of this study was the discovery that the difference between Hispanic and non-Hispanic craft workers almost disappeared when they were multi-skilled, especially when they had formal training background. The study also revealed no difference between Hispanic and non-Hispanic craft workers among the dual-skill workers. The study yielded the following findings:

- Among multi-exam takers, only 43% of Hispanic craft workers passed at least two exams in two different skills and were therefore considered multi-skilled. Nearly 60% of non-Hispanic craft workers' multi-exam takers passed exams in two different skills, suggesting that non-Hispanics were better able to pass the exams.
- Both Hispanic and non-Hispanic multi-skilled craft workers with formal training were employed in construction trades at the same rate, about 65%.
- Among dual-skilled workers, Hispanic and non-Hispanic craft workers had similar multiskilling patterns. Nine of the top ten dual-skills for Hispanic craft workers were in the top ten dual-skills for non-Hispanic craft workers but with different order.

The findings of this study will guide the industry's future retention strategies to apply long-term training plans for Hispanic craft workers among highly skilled trades. Also, it will help researchers in the construction industry, or in other industries, to study the multiskilling patterns among craft workers using the same or different dataset, and eventually contribute to the industry's body of knowledge.

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