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AIC

Accelerating Constructor Excellence

The Professional Constructor

Journal of the American Institute of Constructors

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The Professional Constructor

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ABOUT THE AIC

Founded in 1971, the American Institute of Constructors mission is to promote individual professionalism and excellence throughout the related fields of construction. AIC supports the individual Constructor throughout their careers by helping to develop the skills, knowledge, professionalism and ethics that further the standing of the construction industry. AIC Members participate in developing, and commit to, the highest standards of practice in managing the projects and relationships that contribute to the successful competition of the construction process. In addition to membership, the AIC certifies individuals through the Constructor Certification Commission. The Associate Constructor (AC) and Certified Professional Constructor (CPC) are internationally recognized certifications in the construction industry. These two certifications give formal recognition of the education and experience that defines a Professional Constructor. For more information about the AIC please visit their website at **www.aic-builds.org**.

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- A qualifying body to serve the individual in construction, the Constructor, who has achieved a recognized level of professional competence;
- Opportunities for the individual constructor to participate in the process of developing quality standards of practice and to exchange ideas;
- Leadership in establishing and maintaining high ethical standards;
- Support for construction education and research;
- Encouragement of equitable and professional relationships between the professional constructor and other entities in the construction process; and
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American Institute of Constructors Education Foundation Announces the Creation of the

Dr. Dennis C. Bausman National Construction Education Program Award Endowment

With a generous gift of $100,000 from his family, the American Institute of Constructors Education Foundation is excited to announce that it has established the Dr. Dennis C. Bausman National Construction Education Program Certification Award Endowment in memory of Dr. Bausman and his passion and contribution to the enhancement of professionalism in both construction education programs and among practicing professionals through professional certification. The annual interest generated from the endowment will be used as a monetary stipend to be given as part of the annual Dr. Dennis C. Bausman National Construction Education Program Certification Award.

Dr. Bausman was born on June 8, 1949 in Hampton, Iowa. He graduated from Ackley High School in Ackley, Iowa and on June 5, 1971 married his wife. He received his Baccalaureate Degree in Construction Engineering from Iowa State University, his Master Degree in Construction Science and Management from Clemson University and his Ph.D. in Construction Management from Heriot-Watt University in Edinburgh, Scotland. After a 28-year career as a construction management executive with two major commercial construction companies, he and Jennifer moved to Seneca, SC where he began a 24-year career in the Department of Construction Science and Management at Clemson University, Clemson, SC as a construction management educator. Dennis passed away at home on November 29, 2022.

During his 24 years at Clemson University, Dr. Bausman (known to all as Dr. B) moved from being a Lecturer to a tenured Professor and CSM Faculty Endowed Chair. He was a very effective teacher and researcher evidenced by the many national, regional and local industry and academic awards he received including the 2002 Clemson University Alumni Teaching Award. Dr. Bausman dedicated himself to improve the image of the construction industry and especially that of the role of the manager of the construction process (*Constructor*) among his students and those with which he engaged both within and outside of the construction industry. He was a Fellow in the American Institute of Constructors (AIC) and served in various leadership roles on the AIC's Constructor Certification Commission as a Certified Professional Constructor (CPC) including serving as Chair of the Commission for many years. Finally, he was the faculty advisor for the Clemson student chapter of Habitat for Humanity for over 25 years and participated in the chapter's Homecoming Build each year. In addition, he loved Clemson football, boating, traveling, and bicycling.

In his role as Commission Chair he focused his efforts on encouraging students in Clemson's CSM Department and in similar departments throughout the United States to achieve their Certified Associate Constructor (CAC) certification by studying for and passing the CAC certification examination. At the same time he worked to increase the visibility of both the CAC and CPC certifications throughout the construction industry to enhance its professional credibility as one equivalent to architecture and engineering. It was his hope that all of his efforts within and outside academia would lead to his students and peers becoming certified in recognition of their professional status in the construction industry.

Dr. Bausman credits his highly impactful relationship with Dr. Roger Liska, Chair Emeritus of the Construction Management Program at Clemson University. Roger's influence on coaching Dennis' conversion from industry to the academic world of building tomorrow's constructors was highly influential on Dennis' career and style. Dennis was very grateful for the friendship and example of continuous leadership well past Roger's retirement. This award grew from the seed of their collaboration and friendship."

The Dr. Dennis C. Bausman National Construction Education Program Certification Award will recognize and reward construction education programs and their faculty and students who demonstrate support for the high ethical standards expected of construction professionals through participation in constructor certification-related activities including serving as certification examination sites, preparing their students to take the CAC examination and other faculty and student initiatives that promote constructor ethics and certification such as participating in the AIC National Ethics Competition. The AIC Education Foundation will soon announce the application and selection criteria for the National Award.

The AIC Education Foundation is now accepting donations in memory of Dr. Bausman to increase the value of the endowment for future use to enhance the Award. Any amount would be sincerely appreciated. Please send your tax-deductible contribution to the:

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For more information about the Endowment and/or AIC's national two-level constructor certification process, please contact Dr. Roger Liska, Foundation Trustee, at riggor@clemson.edu.

Insights from Roofers on Heat Safety

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Abstract

Understanding current awareness and mitigation strategies is crucial to protect vulnerable workers from the impacts of working in the heat. This study examines roofers' awareness and strategies for handling heat exposure. Data was collected from 102 roofers through closed and open-ended survey questions. Thematic analysis revealed eleven critical themes related to heat stress awareness. Standard practices for handling heat stress were frequently part of roofing employees' heat safety strategies. Additionally, thematic analysis identified best practices for mitigating heat exposure, such as acclimatization, communication, and work schedule adjustments. The findings highlight key observations of awareness and practices based on age, experience, and job role. This paper underscores the need for comprehensive heat safety programs. It also adds additional best practices for working in the heat to the body of knowledge.

Keywords: Heat Safety, Heat Stress, Roofers, Construction, Best Practices

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INTRODUCTION

The construction industry is integral to the U.S. economy, contributing 5.1% of all nonfarm payroll employment and 4% of the GDP in 2022 (USBLS 2024a). The nature of construction work, which involves operating heavy machinery, powered tools, and continuous physical exertion, significantly increases the risk of heat-related illnesses and injuries (Xiang et al. 2014). Direct exposure to sunlight compounds these risks that many construction workers face.

Heat-related illnesses and injuries can have severe consequences for construction workers, affecting their cognitive and physical abilities. Symptoms such as dizziness, muscle fatigue, impaired judgment, and heat cramps can lead to accidents and injuries on the job site (Echt et al. 2024; Calkins et al. 2019; CDC 2018). Gubernot et al. (2015) found that the rate of heat-related deaths among construction workers was 1.13 per million, significantly higher than the 0.22 per million rate for all workers. This highlights the disproportionate danger faced by construction workers in hot environments. Furthermore, a study by Dong et al. (2019) revealed a growing trend of heat-related deaths in the construction industry, with such fatalities accounting for 37.4% of all heat-related deaths across various industries between 2011 and 2016.

Specific subsets of construction workers are at even higher risk. Dong et al. (2019) identified that cement masons, roofers, and construction helpers face significantly higher risks of heat-related deaths when compared to other construction workers. These trades, often performed by subcontractors who complete 80-90% of the work on many projects (Olbina et al. 2011), require special attention due to their specific work conditions and tasks. For instance, roofers, who represent approximately 13% of the labor force in the category of foundations, structures, and building exterior contractors (USBLS 2024b), experience high rates of injuries and fatalities. Their work, characterized by climbing, kneeling, and heavy lifting, combined with prolonged exposure to high temperatures, places them at a significant risk of heat-related illnesses (USBLS 2024c).

By taking an active approach, the industry can mitigate the risks of working in hot environments. This paper explores heat safety awareness and mitigation knowledge by providing insights and recommendations from roofers, a vulnerable group, to enhance heat safety in construction.

LITERATURE REVIEW

Construction Worker Awareness of the Impact of Working in Hot Environments

Several studies have indicated that construction workers' awareness of the risks of working in hot environments is generally low. For instance, a study focusing on Nigerian construction workers highlighted that over 76% of the workers had never considered the need for adaptive strategies to manage extreme heat, and 40% reported having no information sources on heat risks (Moda et al. 2024).

Similarly, research by Song and Zhang (2022) found that the current awareness of heat-related illnesses among construction workers was suboptimal. Workers with roles directly related to safety demonstrated a better understanding of heat-related symptoms and prevention strategies than their peers. This study underscores the importance of targeted training for all workers to enhance their knowledge and preparedness for heat-related risks.

Dutta et al. (2015) revealed that while some construction workers were aware of heat-related health risks, they lacked adequate resources to address these issues effectively. This gap between awareness and resource availability indicates a need for better support systems and infrastructure to protect workers from heat stress.

Fatima (2023) noted that existing heat-related policies at construction companies primarily focus on administrative control measures such as changing work schedules to cooler parts of the day, providing more breaks, or reducing employee workload. Comprehensive policies that include worker consultation, risk assessment, training, and evaluation of control measures are necessary to enhance heat safety awareness and effectiveness.

Strategies for Mitigating and Preventing the Impact of Working in Hot Environments

Practical strategies to mitigate and prevent the impact of working in hot environments have been identified across various studies. Examples are hydration, acclimatization, work scheduling, and environmental modifications.

Ensuring adequate hydration is a fundamental strategy. Various studies emphasize the importance of providing workers with access to potable water. For instance, Oko (2022) highlighted that providing water regularly and ensuring availability on construction sites are among the best practices adopted by contractors to reduce heat-related injuries.

Acclimatization protocols are essential to help workers gradually adapt to working in hot conditions. Edirisinghe and Fernando (2018) and Morris et al. (2020) recommend acclimatization and improving workers' aerobic fitness to reduce heat stress. Additionally, training programs focused on heat illness prevention, first-aid, and symptom identification are critical. Song and Zhang (2022) emphasize that workers receiving heat-related training better understand prevention strategies and symptom recognition, demonstrating the importance of regular and comprehensive training sessions.

Adjusting work schedules to avoid peak heat times and implementing mandatory rest breaks are effective strategies to prevent heat stress. Rowlinson et al. (2014) and Moda et al. (2024) advocate for controlling continuous work time with mandatory work-rest regimens and enabling self-paced working conditions. These measures help reduce the duration of heat exposure and allow workers to recover during cooler periods.

Modifying the work environment to reduce heat exposure can also be effective. This includes providing shaded rest areas, using ventilation systems, and considering the design and material of work clothing to enhance cooling (Baizhan & Andrew 2018; Morris et al. 2020). Specific clothing design and fabric considerations, as recommended by Chan et al. (2018), can significantly mitigate heat stress for workers in hot, humid conditions.

Developing comprehensive heat safety plans that encompass all these strategies is crucial. Morrissey et al. (2021) outlined 40 occupational heat safety recommendations through a consensus process involving experts. These recommendations cover various aspects of heat safety, including hydration, acclimatization, scheduling, environmental controls, and training. Implementing such comprehensive plans can significantly reduce the incidence and severity of heat-related illnesses among construction workers.

Research has provided some insight into awareness and mitigating strategies; however, the research team wanted to know if there was more insight from a subgroup that tends to be more vulnerable to heat-related safety issues: roofers. Therefore, the research team would like to know:

RQ1: What do roofers understand about the impact of working in hot environments?

RQ2: What strategies are employed by roofers for heat safety?

METHODOLOGY

Instrumentation, Administration & Responses

The study was conducted with the Roofing Alliance, the foundation of the National Roofing Contractors Association (NRCA). The research team collected data from a sample of roofing professionals using a set of primarily open-ended survey questions. The Roofing Alliance distributed the survey electronically via Qualtrics (Qualtrics 2024) to its members. Each member company was asked to distribute the survey within their organizations. Data was collected over three months. The survey included demographic questions and inquiries about heat stress awareness and mitigation strategies (see Table 1). A total of 153 responses were initially received. After data cleaning and filtering to include only those who sufficiently completed the survey and acknowledged awareness of the impact of working in hot environments, 102 responses were deemed suitable for analysis. Calculating a precise response rate was challenging due to the distribution and recruitment methods; approximately 99% of the completed surveys were responses to an anonymous link shared by the Roofing Alliance.

Table 1. Summary of Survey Items

#	Question Asked	Item Type & Description
Q1	What is your age?	Open-ended and grouped, open-ended and grouped, and multiple-choice, respectively.
Q2	What is your experience?	Open-ended and grouped
Q3	What is your job role?	Multiple choice
Q4	Can you describe what you know about issues related to working in hot environments/heat stress/heat stress conditions concerning roofing?	Open-ended, thematically coded for data analysis
Q5	What do you do to handle heat exposure?	Multiple choice with multiple answers allowed, includes an ‘other’ option for additional information.
Q6	Are there any ‘best practices’, advice, and/or resources you and/or your company employs regarding working in hot environments that you wish to share?	Open-ended, thematically coded for data analysis

FINDINGS

Demographics

Responses were received from roofers of different ages, levels of experience, and job roles. There were 87 responses to the question of age, with the mean age being 59 and the range of ages being as low as 24 and as high as 75. There were 102 responses to the question about experience, with the average years of experience being 22 and the range of experience being from 0 to 55 years. There were a variety of roofing job roles represented, with Executives (*n=49*) being the most representative group. Additionally, responses were received from HR professionals (*n=2*), Health and Safety personnel (*n=17*), Project Management personnel (*n=14*), Roofing Technicians (*n=3*), Site Supervisors (*n=9*), and a group of "Others" (*n=8*).

Thematic Analysis

Qualitative responses from each participant were thematically analyzed, resulting in eleven confirmed and emergent themes from the Q4 data (see Table 2). An example response corresponding to each theme is also provided. After generating the themes, each respondent's statement was visually coded and quantified in MS Excel. Frequency tables were created and charted using MS Excel.

Table 2. Schedule of Themes for Q4 Data

#	Theme	Example of Statement in Response to Q4
A1	General Awareness	"I know it is dangerous unless properly dealt with"
A2	Education & Training	"Proper training not given to employees"
A3	Environmental Conditions	"A 90-degree day can be 120 in this environment"
A4	Physiological Impact	"The heat wears coworkers down much faster"
A5	Mental Impact	"Heat impacts the decision-making process"
A6	Symptom Recognition	"which could lead to heat stress [or] heat stroke"
A7	Monitoring	"constantly monitoring the heat/heat index/dew point…"
A8	Recognition & Treatment	"how to recognize the signs of heat-related illness and first aid for them"
A9	Productivity	"Heat also slows down production"
A10	Policy	"We have a policy that we review with our employees regularly"
A11	Prevention & Mitigation	"Very dangerous and we have put preventative measures in place"

Qualitative responses from each participant were thematically analyzed, resulting in the emergence of themes from the Q6 data (see Table 3). Examples of responses corresponding to each theme are also provided. After generating the themes, each respondent's statement was visually coded and quantified in MS Excel.

Understanding of Issues Related to Working in Hot Environments (Q4)

When asked the open-ended question, "Can you describe what you know about issues related to working in hot environments/heat stress/heat stress conditions as it pertains to roofing?" roofers responded in various ways. Figure 1 highlights the frequency of various issues identified by roofers related to their work environment and personal safety. The most frequently observed themes were *prevention and mitigation* and *symptom recognition*, each cited 38 times, underscoring the recognition that proactive safety measures and recognizing symptoms are critical aspects of their work. This focus on prevention and awareness suggests that roofers prioritize understanding and managing potential risks before they escalate into serious health problems.

Table 3. Schedule of Themes for Q6 Data

#	Theme	Example of Statement in Response to Q6
M1	Acclimatization	"We do our best to acclimate new hires"
M2	Agency to Speak Up	"Encourage workers to speak up if feeling sick"
M3	Agency to Stop Work	"Superintendents have full authority to pull off a project due to hot weather conditions"
M4	Taking Breaks/Rest	"Siesta or 2-hour break for lunch during peak heat hours"
M5	Communication	"Continuous communication of the importance of heat illness prevention tips through foreman"
M6	Supplement Use	"Sugar free electrolyte replacement drinks"
M7	Engineering Controls	"use engineering and administrative practices to combat heat"
M8	Hydration	"Purchased BANA for the guys to rehydrate them"
M9	Job Site Audits	"Job site visits by top management in the summer"
M10	Peer Mentoring	"Watching over co-workers for signs of heat stress"
M11	Proper PPE/Attire	"provide cooling towels and neck gaiters"
M12	Self-Monitoring	"don't ignore the symptoms"
M13	Symptom Recognition & Response	"knowing your body and how it reacts to heat is important"
M14	Tech/App Usage	"OSHA heat index app"
M15	Threshold Setting	"cancel work over 100 heat index"
M16	Training	"Training on recognizing heat-related illness on the roof"
M17	Urinalysis	"Posting a urine analysis diagram to show levels of hydration bases on color of urine in porta jons"
M18	Work Schedule Shifts	"Wake up early. Rotate the harder jobs."

Other notable frequencies include *environmental conditions (n=24),* which indicate a significant concern for the hot environments roofers work in, *and general awareness* (*n=13*). *Education and training, mental impact, monitoring,* and *general physiological impact* were mentioned less frequently, suggesting that while these areas are recognized, they may not be what roofers think of immediately compared to direct prevention strategies. This pattern reflects a practical focus on immediate, actionable strategies to maintain safety and productivity in challenging work conditions.

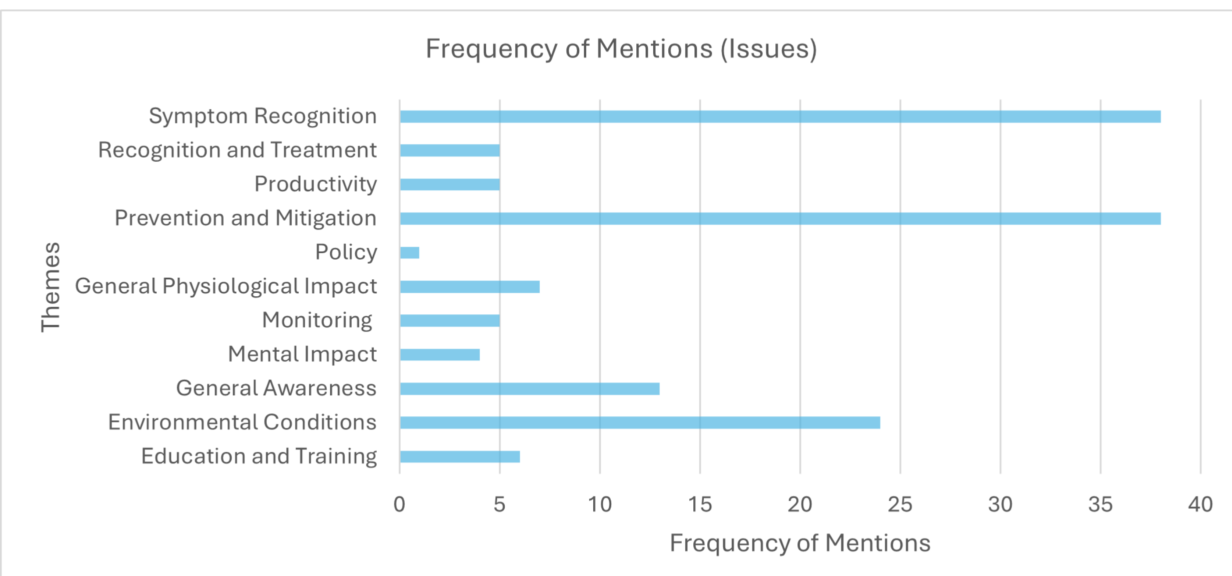

Figure 1. Bar chart of the frequency of issue recognition

How Roofers Handle Heat Exposure (Q5)

When roofers were asked how they manage heat exposure, the survey allowed them to select multiple strategies. The results indicate that roofers frequently use various methods to cope with heat, and the responses were consistently high across the different options provided (see Figure 2). The data from the figure indicates that roofers employ various mitigation strategies to manage heat exposure, with some methods being more prevalent than others. The most frequently reported strategy was drinking lots of water, which was selected 93 times, emphasizing the importance of staying hydrated as a primary response to heat exposure. Other strategies selected included increasing breaks ($n=89$) and seeking shade ($n=85$), highlighting that frequent rest periods and access to shaded areas are critical components of roofers' approach to managing extreme temperatures. These strategies directly respond to the physical demands of working in high-heat environments.

On the other hand, strategies like wearing suitable/light clothing ($n=73$), working earlier in the morning ($n=79$), and work/rest cycling ($n=55$) were slightly less common but still significant, indicating an awareness of adjusting work practices and attire to reduce heat impact. Notably, "nothing" was not selected by any participant, suggesting that roofers are generally proactive in managing heat risks. The overall distribution of responses underscores the importance of immediate, accessible actions, such as hydration and breaks, while also integrating work patterns and clothing adjustments to enhance comfort and safety under heat-stress conditions.

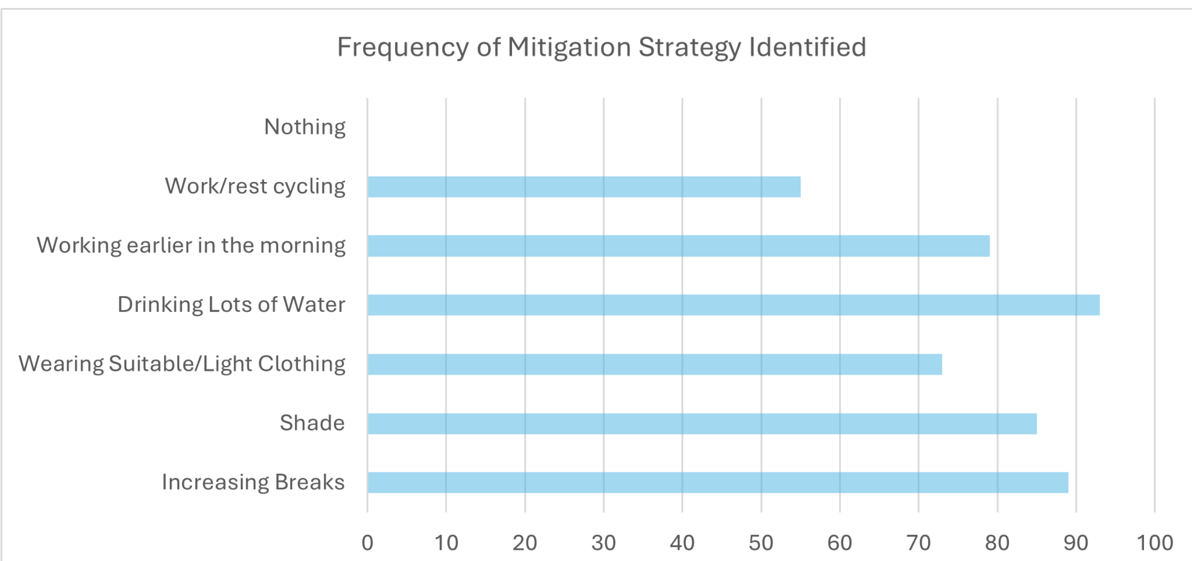

Figure 2. Bar chart of the frequency of recognized mitigation strategies

Expanding on Mitigation Strategies (Q6)

As a follow-up question to Q5, roofers were asked to share any additional best practices (that may not have already been shared). There were 86 observed responses categorized into 18 themes, and the frequencies were charted (see Figure 3). The data reveals that roofers utilize diverse strategies to manage heat exposure, with a relatively balanced distribution across various mitigation techniques. The most frequently reported method was hydration, which was mentioned 15 times, indicating that staying hydrated is the primary approach adopted by roofers to combat heat stress. Other commonly cited strategies include communication, electrolyte intake, and symptom recognition and response, each mentioned 6 times, highlighting the importance of maintaining open dialogue, replenishing essential minerals, and staying vigilant about heat-related symptoms. Techniques like work-rest cycles, engineering controls, and peer monitoring were also noted with similar frequency, suggesting a holistic approach where roofers combine physical, behavioral, and environmental modifications to manage heat exposure effectively.

Notably, less frequently mentioned strategies such as agency to speak up, job site audits, and work schedule shifts were reported only once, which could indicate either lower perceived effectiveness or less emphasis on these methods in routine practices. This distribution suggests that while roofers are aware of multiple strategies, some methods, particularly hydration, are prioritized due to their immediate and direct impact on mitigating heat stress. The overall pattern of responses underscores the adaptability and awareness among roofers, reflecting a multifaceted approach to heat management that combines preventive measures, immediate responses, and long-term strategies to safeguard their health on the job.

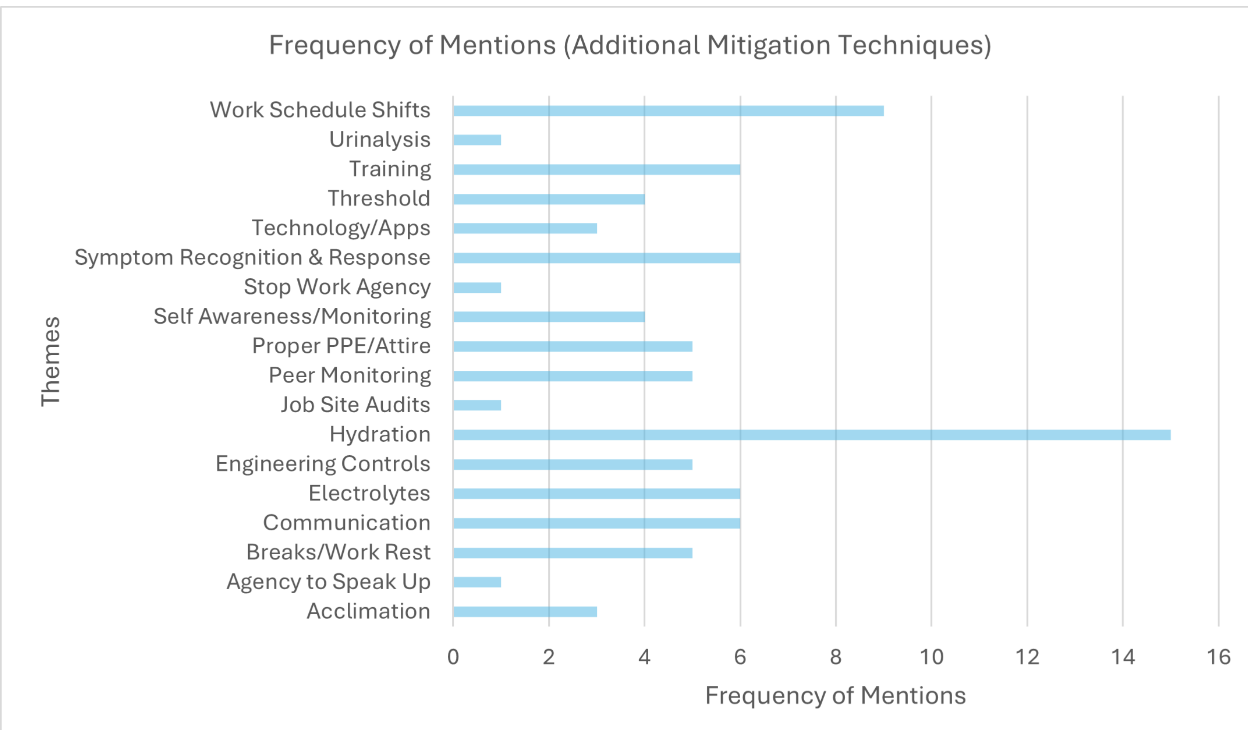

Figure 3. Bar chart of the frequency of additional heat stress mitigation measures

Key Findings on Issue Identification Among Groups (Q4)

The data on what comes to mind regarding issues related to working in hot environments across different job roles reveals notable trends. Executives show moderate recognition of prevention and mitigation (37%) but lower general awareness levels (12%). In contrast, Health & Safety professionals demonstrate higher recognition in both prevention (53%) and symptom recognition

(47%), reflecting their role's focus on safety protocols. Despite a small sample size, HR Management shows significant general awareness of issues related to working in hot environments (50%), though their participation in other categories is minimal. Project Management balances the identification of general awareness (14%) and prevention efforts (36%), indicating a moderate understanding and application of heat stress measures.

A single respondent in the 21-25 age range mentioned education and training (100%) being tied to the issue or working in the heat. However, their awareness in other areas remains low. The 56-60 age group shows the highest general awareness (38%), suggesting increased recognition of heat stress issues with age, although their prevention efforts are not as pronounced. The 46-50 group stands out for its focus on symptom recognition (54%), highlighting an understanding of identifying heat stress symptoms, which is crucial for timely intervention.

In terms of years of experience, those with 6-10 years show balanced identifications across categories, including environmental conditions (40%) and prevention measures (40%). This suggests that mid-career professionals may have developed a comprehensive approach to managing heat stress. However, individuals with over 40 years of experience display high involvement in prevention strategies (42%) but lower general awareness (25%), indicating potential gaps in updated knowledge or training.

Key Findings on Mitigation Techniques Among Analyzing Groups (Q5)

The data highlights key patterns in how those in different roles employ various workplace safety measures. Executives report high adoption of measures such as increasing breaks (96%), drinking lots of water (96%), and using shade (90%), reflecting a strong focus on maintaining comfort and hydration. Similarly, those in Health & Safety roles show notable adherence to these measures, with 88% emphasizing increasing breaks and drinking lots of water alongside other personal protective practices. Roles of Project Management and Site Supervision display slightly lower recognition of adoption, particularly in work/rest cycling and shade use, indicating potential areas for enhanced safety protocols. Notably, HR Management roles reported 100% engagement across all measures, albeit from a very small sample size, suggesting an ideal scenario for adopting best practices.

Age groups also reveal distinct safety priorities, particularly among younger and older cohorts. A single respondent aged 21-25 and those aged 41-45 (*n=9*) exhibit 100% adoption of all recommended practices, including working earlier in the morning and wearing suitable clothing, suggesting a strong awareness and implementation of safety measures at these life stages. In contrast, this decreases among other groups, such as 46-50 (*n=13*) and 51-55 (*n=12*), where adherence to wearing suitable clothing is notably lower (77% and 67%, respectively). This pattern indicates that although overall awareness remains high across age groups, certain practices may require reinforcement, particularly in groups that balance work demands and physiological changes.

Experience levels also significantly influence recognition of the adoption of safety strategies, with a new professional (<1 year) and those with extensive experience (40+ years; *n=12*) showing high adoption of all safety measures. This adherence reflects a commitment to best practices at the beginning and later stages of careers. However, middle-experience groups, such as those with 16-20 years (*n=11*), show variability, particularly in using protective measures like shade (91%) and work/rest cycling (64%). Even with low sampling among certain groups, this data suggests that continuous education on safety practices is crucial across all stages of professional development to maintain high standards and reduce risks.

Additional Qualitative Insight

Several responses elaborate on important themes. For instance, one executive states, "*Start work as early as possible, don't work in the hottest time of the day, cut daily work hours down, if possible, work early shirt and evening shift,"* another states, *"4-day work weeks, reduced work hours, provide cooling towels and neck gaiters, mandatory tents, coolers, water, electrolytes on each job site and job truck*." Another executive states, "*Safety measures are very important. Have a heat temperature threshold, if the temperature increases beyond the threshold, you shut down the job for the day.*"

One health and safety professional added, "*Continuous communication of the importance of heat illness prevention tips through foreman in the morning meetings. Posting heat related illness OSHA posters in common work/break areas. Posting a urine analysis diagram to show levels of hydration based on color of urine in porta jons.*" Another reiterates the importance of acclimatization and hydration, "*Acclimatization to the trade and to the heat. Hydration is key and hydration starts the day before work. Share the information on drinks like coffee, Energy Drinks dehydrate a person. Provide electrolytes to crews.*" Site supervisors also provide interesting insight as one stated, "*Give employees a goal of production to reach between breaks. Know your body and say something if you don't feel right.*"

DISCUSSION AND CONCLUSION

Discussion

The insights from roofers in this study provide a clear picture of their knowledge and practices related to heat mitigation on job sites. Roofers repeatedly identified hydration as a crucial component of their heat management strategies, emphasizing that drinking lots of water throughout the day is the most straightforward and effective way to combat heat stress. Many roofers highlighted that ensuring continuous access to potable water is a basic yet vital step, with some mentioning electrolyte replacement drinks to maintain hydration and replenish essential minerals lost through sweating. This focus on hydration aligns with previous studies, such as Oko (2022), highlighting the importance of hydration. This focus on hydration underscores a fundamental understanding among roofers that maintaining body fluids is essential for preventing heat-related illnesses.

Roofers also frequently mentioned the importance of taking breaks and seeking shade to manage heat exposure. They reported that increasing the frequency of breaks, particularly during peak heat hours, allows them to recover and reduces the risk of overheating. This finding is consistent with the work of Rowlinson et al. (2014), which advocated for mandatory work-rest regimens to help workers manage continuous heat exposure effectively. Roofers stressed the need for shaded rest areas where they can cool down, reflecting a practical approach to environmental control that is easily implementable on most job sites; this supports Baizhan and Andrew's (2018) recommendation. This awareness of environmental adjustments, such as using tents, canopies, or shaded zones, shows that roofers recognize the importance of adapting their surroundings to minimize heat impact, even if such measures often depend on job site conditions and resources provided by employers.

In addition to hydration and environmental controls, roofers identified wearing suitable, light clothing as another key strategy to reduce heat stress. They noted that choosing breathable fabrics and lighter-colored clothing can significantly help manage body temperature, especially during prolonged exposure to direct sunlight. This aligns with the findings of Chan et al. (2016), who emphasized that specific clothing design and fabric considerations can significantly mitigate heat stress for workers in hot, humid conditions. This knowledge reflects an understanding of how personal protective measures can complement other heat mitigation strategies. Roofers also mentioned working earlier in the morning as an effective approach, scheduling tasks to avoid the hottest parts of the day and aligning work hours with cooler temperatures. This strategy is consistent with the literature, as Rowlinson et al. (2014) and Moda et al. (2024) advocate for work schedule adjustments to avoid peak heat times and prevent heat stress. This strategy demonstrates an awareness of the benefits of adjusting work patterns to reduce heat exposure, particularly during extreme weather conditions.

However, while roofers are generally well-versed in these basic mitigation strategies, the study highlighted areas where their knowledge and practices may not have been apparent from their responses. For instance, while many roofers are familiar with taking breaks and adjusting their schedules, fewer mentioned structured approaches like work/rest cycling or specific acclimatization protocols. This may suggest that while roofers understand the value of rest and recovery, there may be opportunities to formalize these practices into more consistent, scheduled routines that could further reduce heat stress. Similarly, few roofers discussed using advanced cooling technologies or personal protective equipment (PPE), such as cooling towels or vests, which could provide additional relief in high-heat environments.

Roofers also noted the importance of symptom recognition and self-monitoring, though this was mentioned less frequently than other strategies. Some roofers expressed that they monitor their signs of heat stress, such as dizziness or fatigue, but overall, this practice appears less recognized than hydration and shade use. This indicates a potential area for improvement, where more education and training on recognizing early symptoms of heat-related illnesses could empower roofers to take timely action before symptoms escalate. This aligns with Song and Zhang (2022), who emphasize that workers who receive regular heat-related training are better equipped to recognize symptoms and implement prevention strategies. Expanding knowledge in this area could help roofers better protect themselves and their colleagues, enhancing overall job site safety.

Overall, the perspectives shared by roofers in this study reflect a strong foundation of practical knowledge about managing heat on job sites, emphasizing readily implementable actions like hydration, rest, and environmental adjustments. However, there are also clear opportunities to enhance their heat safety practices through more structured training, increased access to cooling technologies, and greater emphasis on symptom recognition and formalized rest cycles. By addressing these gaps and building on the insights provided by roofers, the construction industry can develop more comprehensive heat safety programs that directly respond to the needs and experiences of those most affected by heat stress on the job.

Implications for Practice

The insights roofers provide in this study offer practical implications for improving heat safety measures on job sites. One of the key takeaways is the importance of reinforcing hydration practices. While roofers already recognize drinking water as a primary defense against heat stress, there is a clear need for all companies to ensure that access to water is uninterrupted and convenient. Employers can support this by setting up hydration stations strategically around the job site and encouraging regular drinking breaks, especially during peak heat hours. Additionally, providing electrolyte replacement drinks or supplements could enhance hydration, particularly on extremely hot days when workers are at higher risk of dehydration.

Training and education on heat safety should be tailored to address the specific needs of roofers. Many roofers already understand the value of simple adjustments like taking breaks and seeking shade. However, formalizing these practices through structured work/rest schedules and clearly defined cool-down periods can help standardize these behaviors across all job sites. Employers must consider integrating rest schedules into daily work plans, ensuring that workers have adequate time to recover during the hottest parts of the day. Training programs that include practical implementation strategies that encourage rest breaks, unique approaches to providing shade, rest areas, and managing workloads during extreme heat will reinforce these practices.

The study also highlights the need for more emphasis on protective clothing and equipment suitable for working in the heat. Roofers noted the benefits of lightweight clothing, yet few mentioned using advanced cooling PPE, such as cooling vests, towels, or neck gaiters. Employers can enhance heat safety by providing workers access to these cooling technologies, particularly when high heat indices exist. Incorporating these items into the standard safety gear provided to roofers would promote their use and offer additional protection against heat stress. This approach not only supports individual comfort but also demonstrates a proactive commitment by employers to worker health and safety.

Another significant implication for practice is empowering roofers to recognize and respond to heat-related symptoms. While some roofers are already aware of the signs of heat stress, there is a need for more comprehensive education on early symptom recognition and first aid response. Companies should provide training beyond basic safety tips to include in-depth guidance on identifying heat exhaustion and heat stroke symptoms and the appropriate steps to take when symptoms are detected. By fostering a culture where roofers feel confident in identifying and acting upon these symptoms, job sites can reduce the severity of heat-related incidents and ensure quicker interventions.

Additionally, the study's findings suggest that companies should create a supportive work environment, encouraging workers to speak up about heat-related concerns and take agency in their safety. This could be achieved by establishing clear communication channels and empowering workers to halt work when conditions are unsafe. Management should actively encourage roofers to report when they feel overheated or observe unsafe working conditions, reinforcing that safety precedes productivity. Regular safety meetings, accessible feedback systems, and visible support from management can strengthen this culture of safety and responsiveness.

Finally, integrating controls like shaded rest areas and proper ventilation into job site designs can significantly enhance heat safety. Employers should evaluate job sites regularly to identify opportunities for implementing solutions that reduce heat exposure. Simple modifications, such as setting up portable fans or creating shaded work zones, can significantly affect how roofers experience and manage heat stress. Combined with ongoing training and robust safety protocols, these measures can create a more resilient workforce equipped to handle the challenges of working in high-heat environments. By leveraging the insights provided by roofers and aligning safety practices with their real-world experiences, the construction industry can develop comprehensive strategies that better protect workers and promote a safer, healthier job site.

Conclusion

The findings from this study reveal that roofers have a strong practical understanding of the risks associated with working in hot environments and the strategies needed to mitigate those risks. Roofers consistently identified key strategies such as staying hydrated, taking frequent breaks, and seeking shade as essential for managing heat exposure. Their responses emphasized the importance of immediate, actionable steps, such as drinking water regularly and using shaded areas, which are the most effective ways to reduce heat stress and maintain productivity. Roofers also highlighted the value of wearing suitable, lightweight clothing and adjusting work schedules to avoid the hottest parts of the day, demonstrating an awareness of how changing personal and work habits can mitigate heat risks.

However, roofers also highlighted areas where knowledge and practice could be strengthened. While commonly recognized strategies like hydration and rest breaks were well understood, other methods such as work/rest cycling, cooling PPE, and consistent symptom recognition were less frequently mentioned. This suggests that while roofers are aware of the core strategies for heat mitigation, there may be less emphasis or familiarity with more structured or technical approaches that could further enhance safety. Roofers' insights underscore the need for accessible resources, practical guidance, and ongoing training tailored to their specific working conditions, ensuring that both basic and advanced mitigation strategies are consistently applied across the workforce.

Ultimately, roofers' firsthand experiences provide valuable perspectives on effective heat mitigation, highlighting the strengths and gaps in recognizing current practices. Their emphasis on straightforward, readily implementable strategies reflects the day-to-day realities of working in high-heat conditions and points to reinforcing these methods through continuous education, company support, and improved access to resources. By integrating roofers' insights into heat safety planning and policy development, the construction industry can better protect workers and reduce the prevalence of heat-related illnesses on job sites.

Limitations

While the study has provided significant findings, it is important to acknowledge its limitations. The small and uneven sample sizes across different categories limit its representativeness and do not allow for generalizability to the population of roofers across different groups. For example, underrepresenting some roles means that findings may not fully capture the diversity of experiences and practices within a group. Additionally, the cross-sectional design restricts insight into the increased recognition of issues and knowledge of best practices over time. Other variables, like the amount of heat safety training or education received by roofers, are not fully accounted for. As an exploratory approach, the responses received may not be exhaustive, requiring more follow-up. The research relies heavily on self-reported data, possibly introducing biases and inaccuracies;

for example, a participant identifying work/rest cycling as an approach may differ from what was reported.

Overall, while the study offers critical insights into the knowledge and practices of roofers regarding heat safety, these limitations highlight the need for further research that broadens the sample, incorporates quantitative measures, and directly assesses the effectiveness of the identified strategies. Addressing these limitations in future studies would provide a more comprehensive understanding of heat safety in the roofing industry and support the development of targeted interventions to protect workers from heat-related risks.

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Evaluating Project Close-out for Sheet Metal and Mechanical Contractors through a Comparative Analysis

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Abstract: Closing out a project influences the overall project's success and requires coordination and planning between the owner, general contractor, and subcontractors. One of the subcontractors that play a significant part in project close-out is the sheet metal contractor, who often works with the mechanical subcontractor. A prior study examined the close-out practices for mechanical contractors. This study evaluates case studies developed with the support of seven (7) sheet-metal contractors. It then compares the processes they used on specific projects to that of the mechanical subcontractors to determine if the prior findings are generalizable to other related segments of the industry. The developed case studies documented existing close-out processes, methods for planning for project close-out, communication protocols, and support processes. Themes related to successful project close-out challenges, success measures, and planning strategies were identified. Findings identify several key tasks that mechanical and sheet metal contractor close-out processes have in common. However, there are differences between the two based on required work tasks.

Key Words: Sheet metal contractors, project close-out, information handover, project controls

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Introduction

Construction is a complex process involving many different stakeholders (Moon et al., 2015; Arantes & Ferreira, 2021). The owner evaluates project success by its completion on time, budget, the desired quality of the final building, meeting the overall project goals, and sometimes the social and environmental impact of the project (Leon et al., 2018; Mavi & Standing, 2018). Most of these success measures fall under the responsibility of the contractor, often the general contractor (GC). One of the critical roles of a GC when pursuing a successful project is the need to effectively close out the project. Project close-out is the completion verification process typically performed at the substantial completion phase to get final payment and deem the project's scope complete (Kaul, 2014; Shay, 2019). Though coordinated by the GC, the GC is not the sole stakeholder in the close-out process. Specialty subcontractors are hired to perform various aspects of the project scope within their respective fields and supply the data to the GC (McCord and Gunderson, 2014). If not properly planned, the close-out process can prove strenuous to all parties involved and negatively impact the owner's view of a successful project.

Mechanical systems on smaller projects in the United States can account for over 12% of the overall project cost (Ford, 2020). This percentage gets larger when looking at more complex jobs, like those of healthcare facilities and laboratory buildings. Ensuring that mechanical subcontractors and their team can effectively close out their scope can significantly impact overall project completion. As part of the mechanical contractor team, the sheet metal contractor is responsible for the fabrication and installation of sheet metal ductwork and their connection to various HVAC systems (West et al., 2016). In most cases, sheet metal contractors are subcontracted by a mechanical contractor. The GC or mechanical contractor often requires sheet metal contractors to provide as-built drawings, operations and maintenance guides, and testing and balancing reports. Without these documents, delays in both project completion and final payment could occur for all parties involved. When the close-out process does not go as planned, the associated schedule and budget repercussions can lead to issues with overall project success.

This paper discusses a study conducted in part with the Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) that documents the industry's current close-out processes. Qualitative analysis methods and developed case studies examined the sheet-metal contractors' current close-out processes, project controls, planning processes, and documentation processes. The case study analysis identified common problems and potential solutions that offer more efficient close-out processes in support of successful project outcomes. Additionally, these findings are discussed in comparison with mechanical subcontractor close-out processes previously published (Magxaka et. al, 2022) to determine the generalizability of the findings between different segments of the industry.

Literature Review

Efficient project close-out can affect overall project success. The definition of project success varies depending on the owner and the desired project outcomes. Defining project success is critical for project close-out. In the construction industry, project managers face ever-changing internal and external factors while aiming to achieve the desired success (Al-Hajj & Zrauning, 2018). Gacasan et al., (2016) credits this complexity to the lack of predictability within the industry and the uniqueness of every project. Effective strategies to help achieve project success include support from company leadership through the engagement of all project team members, monitoring project plans against the schedule and budget, and effectively using lessons learned (Alias et al., 2014;

Larsen et al., 2018).

Effective project planning during the earlier project phases helps with overall project success and identifies what is needed from various stakeholders to properly close out the project. It is during the planning phase that stakeholders with differing objectives have the opportunity to positively affect project outcomes (Heravi et al., 2015). The relevant stakeholders include project leaders and core team members, the project sponsor, suppliers, and the end user. Gerth et al., (2012) notes early incorporation of construction knowledge in project planning reduces the risk of creating designs that cannot be efficiently constructed. Thus, preventing problems that could arise and delay project completion later in the project.

The utilization of formal processes to document and learn from "Lessons Learned" helps promote future project success by allowing project managers to forecast and resolve likely problems before they happen (Larsen et al., 2018). This is often completed through formal meetings with the project team to discuss what happened on the job so lessons can be applied to the next job (Gacasan et al., 2016). The use of lessons learned helps a team to proactively account for known weaknesses during the project planning phase, which can significantly impact project outcomes (Larsen et al., 2018; Yussef et al., 2019).

Another documented measure of project success is the relationship between the project stakeholders (Al-Hajj & Zrauning, 2018). According to Leon et al. (2018), the quality of the relationship among stakeholders and flexibility in incorporating changes can influence customer satisfaction. Construction project management teams tend to focus on the quality of the delivered physical product. In contrast, a client's values and quality expectations often consider the overall construction services provided, including customer service and contractor/client interactions (Aliakbarlou et al., 2017). Part of the construction service is the work of subcontractors. Subcontractors are typically specialty contractors hired to perform specific tasks and, in most construction projects, perform 80-90% of the work and significantly impact the project's overall success (Keshavarz-Ghorabaee et al., 2018). Literature evaluating relational methods of project management relies on high relationship quality between the stakeholders for success (Martin & Benson, 2021).

One of the key factors that feed into project success and can often define the close-out process is the project controls. Project controls are those activities and practices that help keep a job on time, on budget, and to the expected quality. They are processes that should be planned for and incorporated throughout the project's life to measure project performance. These project performance measures help gauge how companies utilize their resources to complete activities pertinent to the project's objectives (Alias et al., 2014; Demirkesen & Ozorhon, 2017). Even though the project might seem successful from a management perspective (on time, on budget, profitable, etc.), the project could fail if it does not meet the customer's satisfaction in other areas of measurement (Al-Hajj & Zrauning, 2018).

One of the project controls for construction is the tracking and continuous updating of the project schedule. Delays impact the contractor's ability to complete the project within the specified duration agreed upon in the contract (Kaul 2014). In construction, delay analysis is often handled through a subjective addition of a contingency (Gunduz et al., 2013). Proper and effective use of time is important to meeting project objectives and affects stakeholders' contractual obligations and project success (Abbasi et al., 2020).

Specific to project close-out for sheet metal contractors, it typically occurs at the end of the project with supporting functions such as testing and balancing reports, inspections of the completed project, and punch lists developed by the owner (Roger, 2012; Shay, 2019). HVAC commissioning and start-up are critical steps within the close-out process that allow for testing and balancing integrated systems within the building as a comprehensive operational unit (O'Connor & mock, 2019). A single problem arising during the project close-out can significantly delay the project (Johnson et al., 2017). A lack of defined procedures, changes in project personnel, and incomplete or changing punch lists are often challenges that delay this process (Shay, 2019). Project close-out efficiency can be enhanced by planning, utilizing quality control checklists, and securing document management systems that support the GC or owner's data turnover needs (Johnson et al., 2017). Since project close-out is the last activity performed on any construction project, it can significantly impact the owner's perception regarding the company performing the work and overall project success. Using the phrase "last but not least," Tummalapudi et al., (2022) notes that it is important to give adequate attention and proper planning for the successful completion of close-out activities.

Other delay factors include improper scheduling, design issues, inadequate drawing details, and changes in client requirements (Gacasan et al., 2016; Babaeian Jelodar et al., 2021). Delays during the closeout of a project can be especially frustrating for subcontractors and vendors waiting for final payment. One way to help minimize close-out delays is through formal documentation processes. Process documentation involves a rigorous description of a process that is used to improve current standards and is not merely for communication purposes but also to provide a framework for developing process thinking (Roy et al., 2005). In a study evaluating project close-out delay factors, Tummalapudi et al., (2022) found that 80% of the participants noted "difficulty in receiving required close-out documentation" and "dealing with open claims or litigation between the [client] and the contractor" as the top two factors causing close-out delay.

Quality control and improvement should start at the beginning of the project's planning phase and not at substantial completion (Heravi et al., 2015). Quality is often seen as passing the final inspection and satisfying the contract agreement (Moon et al., 2015). However, quality control should be incorporated to help with project success, especially in terms of documentation turnover and project close-out. One method commonly used to help with quality control is the use of punch lists. The GC and architect are the parties primarily responsible for generating project data that subcontractors receive in the form of QA/QC reports and punch lists (Kaul, 2014). Completing a punch list was identified as one of the most common reasons for project close-out delays (Tummalapudi et al., 2022).

Based on the literature review, there is a current gap between project success, project controls and its relation to project close-out, specifically for sheet metal contractors. Also, there is no current documented close-out process for sheet metal contractors in the construction industry.

Methodology

The research aimed to develop an understanding of the challenges and potential solutions that occur during project close-out that affect overall project success of the sheet metal contractor's scope of work. This was an extension to prior research that examined close-out processes used for mechanical contractors discussed below (Magxaka et al., 2022). The research aims to determine the generalizability of the prior findings by developing a series of case studies to document sheet metal subcontractor processes for supporting the close-out of projects.

The study methodology used to develop the case studies contained three phases: (1) a study framework for developing the interview questionnaire (the questionnaire contained the same key questions utilized in the mechanical contractor study with wording changed as appropriate for the sheet metal contractors), (2) data collection, and (3) data analysis through transcription coding (Fig. 1).

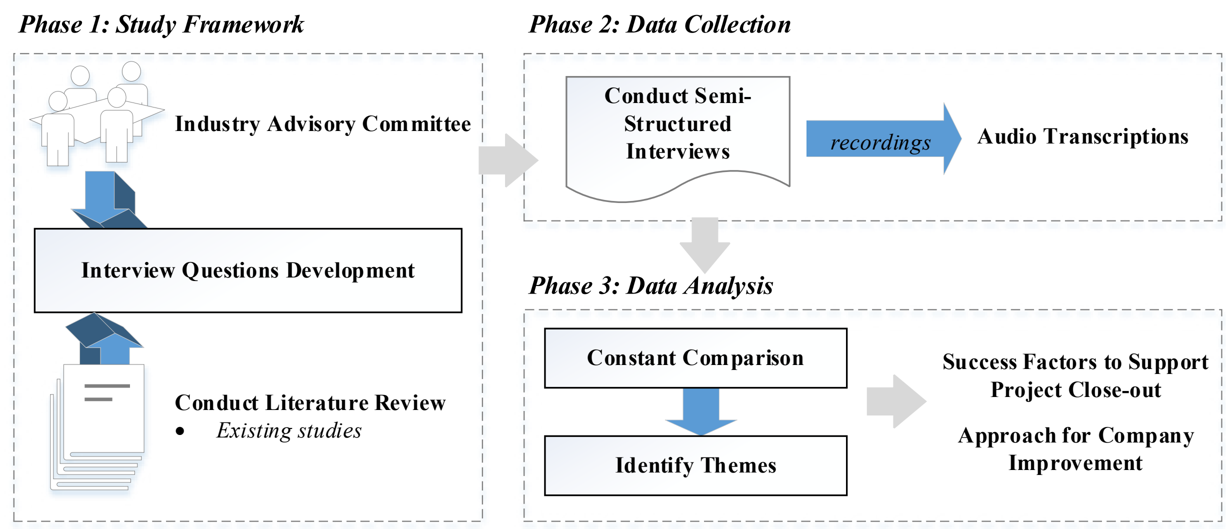

Figure 1: Study Approach

Once the cases were developed, they were then compared to a prior study of mechanical subcontractors that utilized the same process. The comparison identified common activities between the two sectors and determined the level of generalizability of the findings to other trades. This was completed by mapping the activities that supported project close-out for each segment in a flow-chart of major.

Prior Study – Mechanical Close-out

The mechanical subcontractor close-out study utilized a similar framework for research as shown above but focused on mechanical subcontractors (Magxaka et al., 2022). In total, individuals from fourteen (14) companies participated in semi-structured interviews to develop case studies to document their companies' close-out processes, challenges, and success measures. Notable key findings were that, of the companies, three (3) out of five (5) of the large companies, five (5) out of six (6) medium companies, and one (1) out of three (3) of the small companies had documented close-out procedures. Common delay factors, close-out strategies, and success measures were identified. These factors and other findings are referenced below in comparison to the findings of the sheet metal contractor's processes.

Current Study – Sheet Metal Close-out

Phase 1: Study Framework

An interview questionnaire was developed based on a literature review of existing project close-out studies (Roger 2020; Shay 2019; Kaul 2014) to identify project close-out success factors. In addition, an industry advisory committee comprised of nine (9) SMACNA industry professionals was formed to assist in validating the study. Committee members were industry professionals with various backgrounds and served in leadership positions on various committees within SMACNA. They offered a diverse understanding of the industry and represented companies from throughout the different regions of the U.S. The committee was consulted at various stages throughout the study to help interpret and validate the study findings.

Interview Questionnaire Development.

The interview was organized to target five (5) general outcomes with an additional section for company and participant demographics.

1. General demographics
2. Identification of project close-out processes used by the companies (both formal/documented and undocumented)
3. Identification of project controls that each company used to support project close-out processes
4. Determination of internal and external communication strategies used to support project close-out procedures
5. Identification of the technology systems used to support project close-out activities or activities related to close-out
6. Identification of key project close-out documentation requirements that help lead to successful project close-out

Phase 2: Data Collection

For this phase of the study, the data was collected through semi-structured interviews with representatives from seven (7) sheet metal companies. These companies were identified through a partnership with SMACNA and represented companies within their association that conducted work throughout the country. Each of the selected companies focused on mechanical sheet metal work. Semi-structured interviews were used because they allow for developing an understanding of a phenomenon through investigative-type questions, as explained by Yin (2009). The investigative nature of the study worked well with this data collection method. Each interview was conducted over Zoom and lasted between one and one and a half hours. The interviews were recorded to allow for transcription and further analysis. The protocol used was approved with exempt status through the institution's Institution Review Board for ethical research practices.

Phase 3: Data Analysis

The recorded interviews were transcribed utilizing the automatically generated transcripts from Zoom. The transcripts were then reviewed and edited as a Word document to ensure adequate representation of the interviews in terms of grammar, punctuation, and clarity. Each transcript was then uploaded to the qualitative data analysis software QDA Miner (Provalis, 2016). Constant comparison analysis of verbatim transcripts allowed for defining themes in developing a framework that emerged through the data set. This framework was based on the first study's findings (Magxaka et al., 2022) with options for identifying other themes should they arise. Utilizing this framework allows for a better understanding of the studied phenomena where the findings from the two subsequent overlap and where there were differences between the two groups. Within the software, the initial set of coding categories was created in the first round, followed by the second round of analysis, which identified data relationships that were then categorized into overarching theoretical themes in a final analysis. The overarching themes identified through the analysis are presented as part of the findings later in the paper. The methods of analysis utilized were similar to those of other studies (Parida et al., 2019; Leech & Onwuegbuzie, 2007) and are also defined in Magxaka et al. (2023).

Results and Findings

Respondents

A total of seven (7) sheet metal contracting firms participated in the interviews. The companies were of various sizes, based on annual volume, and represented markets from across the United States. Table 1 provides the case study participants' role and company demographic information. For this study, companies were categorized into size by volume: (1) small, less than $25 million; (2) medium, between $25 and $60 million; and (3) large, $61 million or greater. Additionally, they are identified by location or region and their range of work areas. The work area included: (1) Local – less than 100 mile radius of office, (2) State/Regional – home state and/or neighboring states with more than 100 miles, and (3) National – multiple states across the country.

Table 1: Company Interview Participants and Demographics

Company	Role	Size	Employees	Location	Work Area
A	Vice President	Medium	150	Mid-West	State/Region
B	Project Manager	Medium	150	Mid-West	National
C	Project Manager	Large	225	North-West	State/Region
D	Vice President	Medium	100	Mid-Atlantic	State/Region
E	Vice President	Medium	170	Mid-West	State/Region
F	President	Small	40	West	Local
G	President	Small	25	North East	Local

The participants all performed sheet metal work as their scope of work and built a variety of projects including healthcare/hospitals, office buildings, industrial projects, and schools as the most common types of projects. Retail and data centers were less frequently reported project types. In terms of project delivery type, companies reported working mostly on design-build or plan-spec projects (hard bid, firm price). Others worked with negotiated contracts. Design assist, where the subcontractor would assist the mechanical contractor with the final design, was the least used though identified as growing in popularity.

Formalized Close-out Process

This study defines the "close-out process" as the group of activities utilized to capture all necessary project, material, and structural information for final project completion. The formality of the process can influence its success in supporting project completion. Out of the developed case studies, only one large company (11% of the total) had a formal documented close-out process. This is significantly less than the mechanical subcontractors where 71% of the companies had a formal process. The rest of the companies relied on the responsible project management staff to ensure the close-out process was adequately supported. Most of the companies stated that their close-out processes were driven by the mechanical or general contractor of the project, and the sheet metal contractor's PM would need to determine the best way to fulfill requirements specific to their job.

When discussing the general structure of the close-out process, contractors identified that the project size and availability of personnel participating in the close-out process were typically the key factors to the complexity of the process. Company A noted that *"if it is a big enough job, we bring in the main players for some progress checks every other month,"* but "*the smaller projects are more difficult to close out... The bigger projects have more eyes on them and more people questioning how far progress is. It is easier to grab everyone and have a meeting for a $2,000,000 project as opposed to a $50,000 project. Those smaller projects are the ones that sometimes suffer as far as close-out is concerned."*

Especially for smaller projects, a theme emerged that the close-out process should incorporate an internal process, through some structure as easy as a checklist of requirements, that supports the team in meeting the project goals even if the GC or primary subcontractor does not require it. In defining their process, Company D stated "*…we have a close-out checklist that we sometimes employ very successfully, and sometimes it is forgotten about.*" When discussed with the companies that did not have a formal process, they agreed that utilization of these internal processes and checklists would help ensure all project managers were at least starting from the same place.

Project Close-out Delay Factors

Project close-out delay factors are identified barriers impacting successful project close-out as scheduled, thus preventing the meeting of set goals and expectations. Table 2 lists the identified delay factors from the data analysis of the sheet metal contractor case studies. The table compares the frequency and ranking of the factors between the sheet metal and mechanical contractors. The column labeled "SM" lists which sheet metal companies identified the factors as well as the percentage of respondents. The column labeled "Mech" identifies the percentage of mechanical company's case studies where the factor was identified with a corresponding number in parenthesis representing the rank of that factor. A "T" designates a tie in frequency.

The majority of the sheet metal contractors identified workload stresses, communication protocol, and documenting change orders as the three most common close-out delay factors. Workload stresses, communication issues, and long (delayed) punch lists were the top three identified by the mechanical subcontractors. Regarding workload, the companies discussed the amount of work allocated to the employee responsible for project close-out influences the employee's priorities for completing close-out activities. *"…Once you reach that…close-out procedure point, that team is already focused on trying to make money on the next one [project]"* stated Company F, who went on to discuss the need to ensure that they allot specific time to the PM to finish out the closeout process before moving to the next project. Balancing the employees' workloads was noted as one way to try and help them keep on top of the close-out process so it does not get delayed.

Table 2: Close-out delay factors			
Delay factor	**Description**	**SM**	**Mech**
Workload	Deals with the work stress teams face and how it impacts their ability to prioritize close-out activities.	A,B,D,E,F (71%)	71% (1)
Poor Communication	Poor information protocols for both internal communication and communication between parties.	A,B,C,D (57%)	64% (2)
Change Order Tracking and Rework	Work performed out of the original scope of work, creating additional tracking and documentation needs during close-out.	A,C,D (43%)	29% (T8)
Early Demobilization	After completing their part of the requirements, project teams leave an existing project, causing added expense and complication to complete late punch list items and collect close-out data.	B,C,F (43%)	29% (T8)
Retainage/ Final Payment Delay	The portion of the contract agreement - compensation withheld until substantial completion and typically tied to close-out documentation turnover requirements.	A,G (28%)	36% (T4)
Documentation Submissions	Delays in sending the necessary construction project close-out documentation to the GC or Mechanical Subcontractor due to late close-out documentation creation, updates, or information exchanges from vendors.	C,G (28%)	36% (T4)
Knowledge Base	Maintaining informed project team members or the information to complete a project or work with an existing client. Lack of this knowledge base causes close-out delays.	D (14%)	36% (T4)
Long Punch-list	Longer punch lists with tasks that should have been corrected with internal QA/QC processes can require remobilization of personnel and overall project delays and added costs	B (14%)	50% (3)
Scheduling	Inaccurate planned schedule activities can cause scheduling conflicts and delays for certain close-out activities.	E (14%)	36% (T4)

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Poor communication protocols that cause misunderstanding of information, delays in the timeliness of communication, and lack of feedback during close-out were also identified as causing delays. There is value to having clear and documented communication. *"It seems weird, but email has helped because now there is a "paper trail" with all the information… We get emailed change orders, confirmation, and get it done. The job is over with, we still do not have the paperwork, and now [the architect or engineer] is going back on that email and saying there was a different process we should have done [for the change order] (Company A)".* Identifying this process early in the project reduces the possibility of delays that impact the ability to complete the project successfully. The PMs are often under pressure to stay on schedule and resolve change orders quickly, so they take risks in performing the work and keep moving while waiting for formalized processes to be completed. If these formalized processes are not followed up, they can delay ultimate project completion or issues with final payment.

Effective Close-out Strategies

Effective close-out strategies identified through the data analysis are shown in Table 3, with an identification of which case studies identified these strategies.

Table 3: Effective Close-out Strategies			
Strategy	**Description**	**SM**	**Mech**
Internal checklists	A documented list of close-out activities and documentation necessary to complete a project.	B,D,E,F (57%)	64% (3)
Accountability	Reiterating project team members of the implications their work, including tasks that may seem minor, has on the overall project success.	D,F,G (43%)	79% (1)
Lesson learned	Making the discussion of strengths and weaknesses a project team's culture. Allowing team members to evaluate and understand what needs to be done to meet project goals and how they would approach the next project based the results of the current one.	D,F,G (43%)	50% (T5)
Proper planning	Strategically planning with project stakeholders to reduce potential delays later in the project.	D,E (28%)	71% (2)
Inspection	Establishing a physical inspection as a project activity.	B,E (28%)	36% (7)
Understanding of scope	Ensuring that the scope of work is understood by all necessary stakeholders involved.	B,D (28%)	57% (4)
Scheduling - milestones	Use close-out tasks in the setting up of project milestones.	E (14%)	50% (T5)

The companies discussed the value of having or creating an internal checklist for successful completion of various tasks and establishing internal processes as minimum company standards to support close-out activities. The establishment of an internal checklist can be effective in reducing the long punch list that tends to create delays. Towards defining a company standard through an internal checklist, Company E noted, *"we probably should have a check sheet…because [on a project] you are running late, and you are trying to get ahead of everybody. So, by the time you get to close-out, everybody kind of drops their guard and does not pay attention … there's a lot of money lost there."*

One strategy to help reduce close-out delays was noted as assigning and holding members of the team responsible for close-out required activity. Company D noted, "*[construction workers] are strong-willed people. They are used to getting people to bend to do what they want. And all of a sudden, you are shining a spotlight on them and saying, 'hey, we didn't handle this well – we went over material handling, and now that we look at it, we should have done this' – the people who were being criticized accepted it."* Those accountable start to take responsibility and do better. They take pride in what it is they are doing. The number of case studies that placed a person of accountability in charge of the process was significantly lower than those of the mechanical case studies.

Another strategy discussed by the participants was planning for close-out by strategically allocating tasks as early as possible in the schedule to contribute to project close-out, thus helping to reduce unexpected delays. If companies do not start planning earlier, the general contractor may plan for them, and that schedule might not yield desired results best for the company. Company D expanded on this stating, *"What we are seeing more and more of is [GCs] are asking for [close-out] documentation earlier and earlier… you get an assistant project manager at the GC level, and the number one item on that checklist is as-built [documentation], and he is asking for them [early]."*

The top three most frequently occurring items are in the top four of the mechanical subcontractors. However, the order and frequency of these factors identified by mechanical subcontractors were different. Mechanical subcontractors placed more emphasis of placing responsibility on project managers to run the project and recognized the importance of pre-project planning with a clear understanding of the scope required by the GC. Mechanical subcontractors found that Accountability (79%) was a much better strategy, than those in the sheet metal study (43%). They also identified Proper Panning (71%) to be more impactful than the sheet metal case studies (28%).

Project controls

"Project Controls" are the internal control systems and procedures designed to monitor and strategically manage the project for effective project close-out. Seventy-one percent (71%) of the sheet metal case studies documented initiating the close-out process at the end of the project with similar responses to 50% of the mechanical subcontractors that did the same. Company E stated, *"When 75% of your costs or that much of the job is completed. Then we will start [the close-out process]. Because at that point, your construction drawings are complete, everything has been stamped, all your submissions have been approved, sometimes you have to bring in spare parts, you need to start scheduling training, so at 75% is when we start."* Company F reported the value of initiating the close-out process in the pre-construction/planning phase to make sure the company is prepared when the information is asked for. Noting that collecting the information as it is created and approved allows for better organization and less time going back to look for something that was not filed correctly. This aligns with 36% of the mechanical contractors who began planning for their close-out processes in the preconstruction/planning phases. One case study, Company D, identified starting the process when the GC or client requests it.

Project Close-out Success Measures

Table 4 documents measures used by respondents to promote successful project close-out.

Table 4: Project Close-out Success Measures

Measure	**Description**	**SM**	**Mech**
Review and inspection meetings	The scheduling of meetings to ensure quality control and to forecast potential punch list items (or change orders) helps to satisfy GC, Mechanical Sub, and owner project expectations	B,C,D,E (57%)	71% (1)
Operational expectations	The understanding of project-specific operational expectations (often imposed by the GC, Mechanical Sub, or Owner) to effectively be able to complete close-out requirements	A,D,E (43%)	50% (T2)
Documentation triggers	Establish milestones within the project to trigger internal close-out documentation creation/handover.	C,F (28%)	50% (T2)
Technology Workflows	Use of technology or software to manage, track, and store close-out documentation.	A (14%)	21% (4)

When reviewing the sheet metal case studies for project close-out success measures, significantly fewer companies indicated a proactive approach in their actions for fulfilling project close-out requirements. The findings aligned with the mechanical subcontractor study; however the frequency of all items was less. For instance, over two-thirds of the mechanical subcontractors actively scheduled review and inspection meetings to review the work and ensure the work was meeting the scope required. About one-half of the sheet metal contractors did the same.

Scheduled review and quality control inspections was noted as a success measure for timely close-out and project success. The scheduling of periodic review and inspection meetings during project execution with the stakeholders was discussed in over half (57%) of the case studies. Where parties jointly inspect, review, and resolve issues proactively, potential punch list items or changes are identified before crews demobilize allowing for timely correction allowing minimum negative impact on activities at the end of the project. Company D stated, *"When we start a project, we have a couple of meetings. One is a kick-off meeting [to understand expectations not in the contract]…and it is for the field foreman and the planning department. And it was to go over, say 'hey, logistically right – this building has very small elevators. We have trailers that we can load ductwork in that we can lift with a crane. Right now, the general contractor has windows out in the building. So, we should be talking to them on day one to say, 'hey, you got to leave those windows open for us.' If you are early enough and they say, 'no we can't do it' then you can say, 'well wait a minute – this isn't what we signed up for – this isn't how we bid the job; where in the bid documents does it say I can only bring [our materials] in on Tuesday mornings, and I have to use the elevator?"* This discussion catches issues early and can only happen if the project team collectively reviews the scope of work to identify expectations and potential problems. Another key project component noted by the participants was the need to understand external (GC/Owner) specific requirements, or operational expectations, for project close-out. Similar to the benefits of a review or inspection meeting, if the team does not understand the current job operational expectations, they will experience more challenges later in the project. Company E discusses this concept as, *"[Operational expectations] is the new thing, they have a whole planning meeting that they have at these projects, and they get us involved… We get brought in, and we help develop a schedule from [the given starting point], but it is just more collaborating at that point. It is right at the project kick-off."* This planning meeting allows for discussions of expectations and appropriate planning for activities that may cause difficulties during the project to be identified earlier so they can be planned for.

The use of documentation triggers as scheduled activities to proactively incorporate essential close-out documentation into the project execution was also discussed by participants to ensure things get done on time. According to Company F, *"We will actually tie specific milestones like turning in O&M manuals or phased out portions of the building for drawings, things like that. We will tie payment to completing those milestones."* These documentation activities are completed by using a document management system or stored within the project tracking software used on the project. This can be set up and monitored internally and expected as a part of the internal checklist throughout project execution.

The use of technology was another strategy that assists with successful project close-out. Properly designed technology workflows support the close-out process both internally within the company and externally between project stakeholders. Developed communication protocols and operational expectations should both contain aspects of technology use. The used technology varies between different companies, and participants perceived both advantages and challenges for its use. The most widely used software used to support project close-out was AutoCAD (or a similar drafting/modeling application) (46%) for updating as-built drawings and Excel (46%) to track close-out activities and document data. Procore (29%) was primarily used if mechanical or general contractors made it a project requirement.

Project Close-out Documentation

Project documents are generated and collected throughout the project. The key project close-out documents most frequently discussed in the case studies included operations and maintenance (O&M) manuals (86%), as-built drawings (71%), and warranties (57%). There could be other project close-out documents required, but the participants discussed the "critical" close-out documents for their typical scope of work.

Discussion

As part of the post-interview analysis, the study investigated the connection between the delay factors and project close-out success factors. All 21 cases (from sheet metal and mechanical subcontractors) were utilized. The delay factors identified through the coding analysis and the strategies and success measures identified in the case studies to help mitigate these delay factors were used. Most of these proactive strategies and measures were put in place by companies to address the common delay factors that other companies identified. Part of the value of utilizing the multiple-case study approach for this research is identifying these phenomena between use cases, thus approaching the development of best practices. Table 5 shows the connection between the delay factors, strategies, and success measures. Those strategies and measures in parenthesis are secondary but still relevant to address the related delay factor.

Table 5: Addressing Project **Delay Factors**

Delay Factor	**Possible Strategies***	**Success Measure****
Employee Workload	A, PP	OE
Poor Communication	CP, A, SM, (IC)	OE, TW, (DT)
Change Orders (Rework)	SC, IR, IC, A, LL	IM, TW, (OE)
Change Orders (Documentation Delay)	SC, IR, IC, SM	OE, DT, TW
Early Demobilization	PP, IR, (SC), (SM)	IM, (OE)
Scheduling Issues	CP, PP	OE
Long Punch Lists	IC, PP, SC, LL, SM	IM, (OE)
Lack of Knowledge Base	LL, (A)	OE
Submitting Documentation	SM, CP, (SC)	DT, TW, (OE)
Retainage/Final Payment Delay	PP, IR, SC	IM, DT, TW, (OE)

* CP = Communication Protocols; IC = Internal Checklists; A = Accountability Program; PP = Preplanning; IR = Inspection and Review; SC = Scope Meeting; LL = Develop Lessons Learned; SM = Scheduled Milestones

** OE = Developed Operational Expectations; IM = Scheduled Inspection and Review Meetings; DT = Internal Documentation Triggers; TW = Appropriate Technology Workflow

Possible Strategies

"Communication Protocols" can help in overcoming most challenges but were specifically address delays related to poor communication, scheduling issues, and document submissions. A theme that emerged through several case studies when talking about multiple challenges is timely and effective communication, in both understanding who needs to be involved and what information is needed. Linking these communication protocols to a review of the documentation processes utilized through the process can help increase the chances of project success and align with Roy et al. (2005). The use of internal checklists was accredited to helping with Quality Control and minimizing delays. Additionally, the use of internal checklists helped reduce long punch list by stakeholders later in the project and smoothly working through change orders. This aligns with Johnson et al. (2017) who identified internal checklists a way to overcome challenges related to a lack of defined procedures.

Accountability programs were listed by companies D, F, and G, and by 79% of the mechanical subcontractors, as one strategy that could be tied with other processes to increase quality control and close-out success. The accountability program would include documentation and identification of someone on the job who is responsible for project close-out. This program may include making sure project close-out was part of the project manager or superintendent's job description. This program would also need to ensure that other strategies, like checklists for quality control, were in place and usable by the accountable person.

Preplanning activities were something identified by only sheet metal companies D and E but by 71% of the mechanical subcontractors. Strategically planning activities with all stakeholders can assist in identifying appropriate expectations for project outcomes in minimizing rework and punch list items (Heravi et al., 2015; Gerth et al., 2012). It can also help with minimizing issues related to scheduling delays and final payment. Internally, it can align employee workloads by ensuring tasks are planned within the schedule to complete close-out activities.

Companies B and D (and over half of the mechanical subcontracting companies) identified a specific scope meeting that takes place during pre-project planning. This meeting is designated to identify acceptable scope outcomes and responsibilities for all project stakeholders. A goal is to make sure that everyone's expectations align. As identified by Demirkesen & Ozorhon (2017) it is important for the project stakeholders to understand the owner's expectations in terms of quality, time, and other elements of satisfaction.

Company E identified periodic inspections and reviews as a method to reduce the need for rework by ensuring that the scope is being met throughout the project. This was more popular with the mechanical subcontractors, where about half of the companies identified this as a common practice. All relevant stakeholders, including the GC and owner, should be included in these periodic and planned reviews. Project success is greater when the owner and contractor are able to work toward common objectives. By holding these meetings, issues related to early demobilization of the workforce and more costly punch lists are minimized.

Lessons learned help a project team to account for future process success by bringing in the project team to provide feedback and learn from past experiences (Larsen et al., 2018). Companies D, F, and G identified a benefit from developing lessons learned and sharing them among managers to learn from past mistakes and plan better for the next job. They identified the use of lessons learned as a good strategy to overcome lack of knowledge base in preparing for a project by improving internal checklists for quality control and minimizing the need for rework.

Success Measures

Four methods for measuring the success of a project and the close-out processes were identified through the case study analysis. These included using developed operational expectations, scheduled inspection and review meetings, internal documentation triggers, and appropriate technology workflow.

As identified by Companies B, C, D, and E, operational expectations are identified by the project team during pre-project planning to set the stage for successful project outcomes. Operational expectations for all stakeholders and the owner are set to provide an understanding of who is responsible for what, when it is needed, and how it needs to be provided.

Scheduling inspections and review meetings helps to align the operational expectations that were set at the beginning of the project and ensure that progress is aligned with those expectations. As identified by Companies A, D, and E, these inspections and review meetings with project stakeholders allow for identifying potential issues in terms of project quality before the issues become punch list items. These companies identified that the results of this measure helped to promote smooth transitions to close out the project, a better relationship with the GC and owner, and easier final payment.

Internal documentation triggers connected to the progress of the project also allow for smoother project close-out. As identified by Companies C and F, these triggers can include documenting of manufacturing information upon submittal approval, recording of the start-up information when it happens, and marking up as-builts as change orders are approved.

Company A emphasized the success they had once implemented appropriate technology workflows to support project close-out. Having an internal workflow that is standardized for all projects help ensure processes are followed. Since many GCs and owners may have a technology workflow of their own, it is important that the internal process is flexible to work with these external requirements.

Conclusion

This study documented and evaluated close-out workflows by sheet metal contractors through a multiple case study cross-sectional analysis. Best practices to overcome close-out delay emerged through this analysis. Key findings from the case studies include the lack of a formal close-out process and internal operational procedures for most sheet metal companies. Most companies allowed the project manager to determine the best approach to close out the project and fulfill contractual obligations. This approach resulted in varying success and a list of common challenges mostly related to poor planning and unclear operational expectations with other project stakeholders.

To address most of these challenges, it was found that clear communication protocols, specifically planning for close-out in the planning phase, and having mechanisms to document information as it becomes available are some strategies to improve successfully closing out the project. Four measures were identified that can help identify if a company has prepared for project close-out. These include (1) developed operational expectations, (2) scheduled inspections and reviews throughout the project, (3) internal documentation triggers, and (4) appropriate technology workflows that support close-out information documentation and turnover. If a project team has these four items put in place, they are setting themselves up for successful project close-out and minimizing internal factors that may cause delays.

Study Limitations

The limitation of this study is access to sheet metal industry contractors due to the limited access and evolving work environment presented by the COVID-19 pandemic. Case study participants were not collectively interviewed or consulted to arrive at a consensus of the finding. However, the advisory committee reviewed and commented within an iterative process to evaluate incremental findings, the overall analysis, and final findings and measures.

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Quantifying Faculty Impact on Graduate Readiness: Developing and Applying the Construction Faculty Qualifications (CFQ) Score in Construction Management Education

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Abstract

This mixed-methods research study holds significant importance as it aims to identify and analyze the contributing factors of Construction Management faculty members' education and industry experience on the construction education outcomes of construction science and management students and recent graduates. The construction industry, with its specific educational needs, relies on its Construction Management (CM) postsecondary academic partners in higher education. Although CM is interdependent with engineering and architecture, it is a profession whose labor force is closely affiliated with, but not a subset of, architecture and engineering. This study focuses on the industry's opinion of baseline knowledge requirements of CM graduates and their readiness for work upon receipt of an undergraduate degree in Construction Management, Construction Science, or other similarly titled degree, and those significant statistical ties to faculty members' own education (degree) and industry work experience. The research not only provides valuable insights into the factors affecting construction education outcomes but also guides the modification of accreditation requirements for Construction Management degrees issued through institutions accredited by ACCE (American Council for Construction Education) and ABET (Accreditation Board for Engineering and Technology), thereby enhancing the quality of construction education and ensuring the industry's needs are met.

Keywords: Construction Management education, accreditation, industry experience, construction faculty qualifications.

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Introduction

Much has been written about the importance of industry work experience for Construction Management (CM) faculty in higher education. The construction industry and, to a smaller degree, accrediting agencies recognize the importance of faculty having some level of practical industry work experience to effectively educate the future leaders of the construction industry (McCuen 2007; Holliday et al. 2014; Burgett et al. 2017; McCuen & Gunderson 2019). What has not been studied in past research are the amounts of industry experience, or even the number of faculty with industry experience in a program, and the subsequent effects on the educational outcomes of recent CM graduates when entering the workforce. Construction Management, as an applied human science, differs from natural sciences by its focus on the practical application of scientific principles to real-world problems, and encompasses the human component inherent in everyday practice (McCuen 2007). It is a program of study borne of the professions of engineering (Young & Duff 1990) and draws faculty from diverse educational and experiential backgrounds, including engineering, architecture, and education (Badger 2002). However, while faculty with backgrounds in engineering and architecture offer valuable insights, their lack of practical knowledge in Construction Management may lead to gaps in undergraduate education (Tennant et al. 2015).

CM programs face challenges in delivering specific educational outcomes due to faculty perceptions and curricular delivery methods influenced by their varied educational and industry backgrounds, specifically the differences between theory-based disciplines like engineering and applied disciplines like CM (Gunderson & Gloeckner 2006). This study aims to quantify the relationship between faculty qualifications and the readiness to work of CM graduates within their first three years post-graduation. The theoretical framework emphasizes the importance of faculty qualifications in delivering high-quality CM education while attempting to balance accreditation requirements, the desire of university administrations for doctoral degreed faculty with research programs, and valuable industry work experience for the faculty.

Literature Review

Reginato (2010) defines construction management education as applied, emphasizing preparation for industry careers. This contrasts with academia's current trend of elevating construction education's status (McCuen & Gunderson 2019) by requiring more CM faculty with doctoral degrees. While industry experience is vital, academic credentials at the doctoral level are increasingly valued as programs evolve (Reginato 2010). The lack of research on topics critical to the construction industry further highlights the need for faculty with deep understanding and practical experience in CM, paired with a doctoral degree and a desire to pursue research applicable to the field (Ghosh & Bhattacharjee 2013). Faculty requirements in CM education are multifaceted, demanding a blend of industry experience and academic credentials in accordance with accreditation requirements of the main accrediting agencies for CM programs, including the Accreditation Board for Engineering and Technology (ABET) and the American Council for Construction Education (ACCE) (ABET n.d.; ACCE n.d.). The push for doctoral programs in CM highlights the discipline's evolution and the demand for academic rigor (Senior, 2006). However, balancing industry experience with academic qualifications poses challenges in faculty recruitment (Gunderson 2005; McCuen & Gunderson 2019).

A comparative analysis of faculty job postings in 2010 (Reginato 2010) with December 2023 reveals shifts in academic credential requirements over time. While there's a growing preference for doctoral degrees, the emphasis on industry experience has also intensified.

Table 1 – Comparison of Faculty Job Postings 2010 vs 2023

	Reginato (2010)		December 2023	
Academic Credentials	Count	% of Data	Count	% of Data
Master's Degree required	6	33%	26	46%
Terminal Degree required (i.e. Master's of Architecture or J.D.	1	6%	4	7%
All but dissertation (finishing a doctorate)	3	17%	7	13%
Doctoral Degree	8	44%	18	32%
Professional Construction Experience	Count	% of Data	Count	% of Data
Two years+ of construction industry experience	2	11%	6	11%
Three years+ of construction industry experience	4	22%	16	29%
Five years+ of construction industry experience	*0*	*0%*	15	27%
"Relevant" construction industry experience	1	6%	3	5%
Construction industry experience is "desired"	1	6%	13	23%

Notably, there's a rising demand for faculty with at least a master's degree and significant industry exposure, while at the same time, the overall number of positions requiring a doctoral degree has more than doubled. While there has been a measurable increase in the requirement for construction industry experience in faculty job postings, there has been a softening of the requirements at least from the ABET accrediting agency from requiring at least one faculty member who has had full-time experience and decision-making responsibilities in the construction industry (McCuen 2007) to industry experience simply being a consideration in faculty qualifications (ABET n.d.). ACCE accreditation requirements remain that "Evaluation of faculty competence must recognize appropriate professional experience as being equally as important as formal educational background" (ACCE n.d.). Neither accrediting body has progressed toward requiring specific numbers or percentages of faculty within a program to have industry experience or defined an appropriate minimum amount of industry experience. Pressure from both academia and industry necessitates a delicate balance between academic prowess and practical expertise (Badger 2002; McCuen & Gunderson 2019) which requires further specificity. Understanding the need for this balance is only the first step in preparing graduates for work readiness, and establishing measurement tools to gauge faculty qualifications in CM programs against student performance is the next step in maintaining and improving program quality.

Methodology

The research design employed a Sequential Explanatory Mixed-Methods Design, comprising two sequential phases: a quantitative phase followed by a qualitative phase (Ivankova et al. 2006). In the quantitative phase, data was collected through surveys to quantify faculty demographics of degree type (i.e. major field of study) and industry experience, as well as an evaluation of the work readiness of recent graduates from the perspective of the faculty, recent graduates themselves, and industry hiring managers. The subsequent qualitative phase delved deeper into participants' perceptions to provide context and explanation for quantitative findings (Ivankova et al. 2006).

Research Approach

In considering the best approach to this research, it was necessary to evaluate quantitative or distinctly measurable outcomes with respect to the recent graduates' readiness to work upon completion of a CM degree. Measuring the perceptions of the three distinct groups affiliated with recent CM graduates was essential to describe the phenomenon. Limiting the number of university programs to 30 accredited by ACCE was necessary because of the large number of associated respondents from three distinct groups.

Survey instruments were developed to collect both demographic information for the subjects, as well as a Likert Scale analysis of the readiness-to-work of recent graduates with less than 3 years of experience post-graduation. Those readiness-to-work evaluation topics were based on a Likert Scale analysis of 16 specific Student Learning Objectives (SLOs) excerpted from the ACCE accreditation body. The Likert Scale utilized rankings of 1 – extremely unprepared; 2 – somewhat prepared; 3 – neither prepared nor unprepared; 4 – somewhat prepared; 5 – extremely prepared. Surveys were created in Qualtrics and distributed through direct email contact and via online and social media apparatus. In addition to the quantitative survey data, each survey respondent was asked to provide a yes or no response as to whether they would be interested or available to participate in a follow-up interview with the principal investigator to further discuss their responses and general impressions of the survey, the data collected, and to offer additional insights as to their perceptions of readiness to work of the recent graduates. This journal paper focuses solely on the quantitative portion of this mixed-methods study.

Data Analysis

Quantitative data analysis was supported by the tools available through the Qualtrics system, as well as additional analysis performed through the Data Analysis Toolkit available in Microsoft Excel. The data analysis utilized for this research project included descriptive analysis and simple linear regression analysis to determine the correlation between the dependent and independent variables. The descriptive statistics provide insights into faculty qualifications and evaluations of readiness to work by each of the surveyed groups. The simple linear regression analysis aimed to find a linear relationship to describe the relationship between aggregate faculty qualifications and readiness to work.

Findings

The survey and follow-up research gathered demographic data for 465 full-time faculty members at 30 different ACCE-accredited CM programs geographically distributed across the United States. The data applicable to this study included the earned degrees (i.e., major field of study) of the CM faculty members, as well as the years of construction industry-specific work experience of each of the same faculty members. Civil engineering undergraduate degrees represent the single most common undergraduate degree held by CM faculty, at 28% of those 465 faculty members surveyed and reviewed for this project. Perhaps more telling, however, is that only 18% of all CM faculty have a CM degree, meaning that 82% of faculty have some other type of undergraduate degree in engineering, architecture, or business. Possessing a master’s degree in CM is only represented by 15% of all faculty surveyed, leaving 85% of faculty to have a Master’s degree in some “other” discipline in engineering, architecture, or business (if they have a Master’s degree at all). Civil Engineering Master’s degrees, are still the most common degree held by faculty in CM programs, representing 29% of those faculty surveyed, while the distribution of degrees held in “other” disciplines becomes broader and widely distributed.

Terminal degrees in CM (or Construction Science) account for an even smaller fraction of degree attainment by CM program faculty, standing at only 7% of the faculty surveyed for this project. This means that 93% of CM program faculty, if they have earned a terminal degree at all, hold that degree in a discipline other than CM. Perhaps even more notable is the data summarized in Figure 1 below, which indicates that 75% of terminal degrees held by CM faculty are in one of the engineering disciplines.

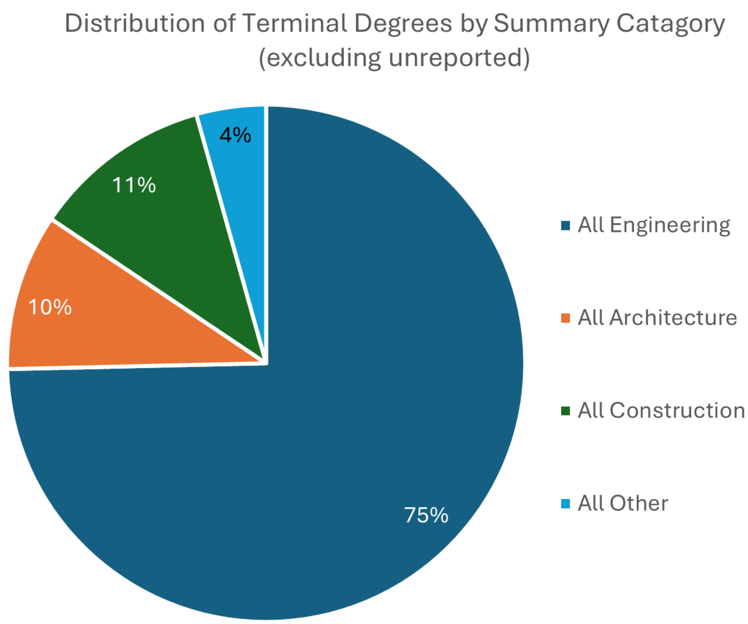

Figure 1: Distribution of Terminal Degree by Summary Categories of CM Faculty

Faculty Construction Industry Experience

The same 465 faculty members in 30 programs were evaluated for their industry work experience. The type of work experience was evaluated as either applicable or not applicable as CM-specific work experience by the P.I. This assessment was based on several factors, including the faculty member's own evaluation of their work experiences and a review of each faculty member's curriculum vitae and other work experience information, including their LinkedIn profile, when available. To be considered as applicable work experience, the faculty member must have demonstrated work experience in one of the following categories:

(a) Reported work experience in a common role (field engineer, assistant project manager, estimator, project manager, superintendent, etc.) for a construction company (not engineering or architecture) or;

(b) Identified work experience in performing at least 3 of the 16 (or 18.75%) SLOs upon which recent graduates are evaluated.

The faculty work construction industry work experience is displayed in Figure 2.

This data collected in 2024 can be compared to similar data collected by Reginato (2010) for trends. The data from 2010 reflects that 32% of a select group of faculty do not have any construction industry experience (Reginato 2010), compared with 47% of a broader cross-section of faculty surveyed under this research project. That number could reach as high as 55% when considering the 8% of faculty whose applicable construction industry experience could not be ascertained.

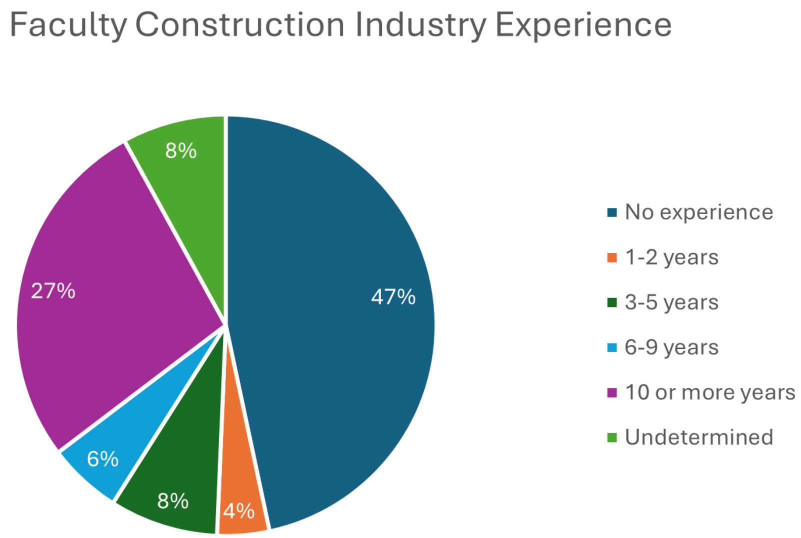

Figure 2: Faculty Construction Industry Experience

Readiness to Work

The data in Appendix 1 identifies the mean and standard deviation of the Likert Scale responses by each of the three surveyed groups for each question. This data includes the industry, faculty, and recent graduate evaluation of the 30 programs surveyed in aggregate. Notable here is the significant difference in opinion regarding readiness to work between the faculty and the industry supervisors. Industry supervisors consistently evaluated the readiness to work on these surveyed topics as a mean of less than 4, equivalent to being less than 'Somewhat Prepared'. What is reflected in this data is a significant disconnect between the opinions of the industry on work readiness and the opinions of the faculty and graduates themselves on the same topics.

Attempting to quantitatively tie the data in Appendix 1 to faculty degrees and work experience was accomplished through an additional survey question regarding which university and/or CM program(s) the industry respondents routinely hire from and evaluated recent graduates on behalf of. Significant data was received for 19 of the 30 total CM programs surveyed. The table in Appendix 2 establishes the mean score of each readiness-to-work question for each university for whom there were applicable responses from industry, as well as an added calculation for the mean of means (X_{GM}), intended to establish a single net score for each university program. This evaluation method only represents the industry respondents' evaluation, as the industry evaluation was the most critical of the recent graduates' readiness to work and was the most varied in responses as compared to the surveys of faculty and recent graduates themselves.

The Construction Faculty Qualifications Score (CFQ)

The correlation between recent graduate performance and faculty degrees and construction industry work experience must be further explored. The performance, or readiness to work, data discussed above indicates a high level of performance variability among CM programs based on the opinions of the industry respondents. To evaluate the relationship between faculty industry work experience and recent graduate readiness to work, we need an independent metric for evaluating faculty qualifications within a CM program. The academic achievement of CM faculty is easily quantifiable, based on the degree level and type (i.e., major program of study) each faculty member possesses. Again, accrediting agencies recognize the need for academic achievement and industry experience but, in their requirements, fail to quantify or provide a measurable metric regarding either.

These broad, subjective statements regarding faculty industry experience and academic qualifications fail to provide measurable goals by failing to define appropriate levels of academic qualifications and professional experience. While it may not be reasonable to establish minimum requirements or standards for each individual full-time faculty member due to the documented lack of candidates with doctoral degrees in CM paired with significant industry work experience to satisfy the needs of hundreds of CM programs (Badger 2002; McCuen 2007; McCuen & Gunderson 2019), there is value in creating a scoring metric for the faculty overall within an entire program. The scoring metric created here, entitled the Construction Faculty Qualifications (CFQ) Score, aims to provide a measurement tool for continuous improvement, of paramount importance to future reaccreditation and overall program success. Improvement in the CFQ score for a faculty body at a given program can be achieved by (a) increasing the number of doctoral degreed faculty in CM and (b) increasing the number of faculty with CM industry-specific work experience. It also provides a method to establish a minimum CFQ score for accreditation of a CM program to ensure that appropriate levels of academic achievement and industry experience are represented within the program.

The Construction Faculty Qualifications (CFQ) Score is developed around a basic mathematical ranking of academic achievement and industry experience evaluating what can be considered the ideal faculty candidate for CM programs. Clues as to what comprises the ideal faculty candidate can be construed from the literature in that academia places an emphasis, and increasingly a requirement, on the attainment of a Ph.D., as well as accrediting agencies' requirements and industry's desire for appropriate industry experience (McCuen & Gunderson, 2019). Rankings for the various degree types can be assigned on a ranking scale of 1-10, as can the assessment of appropriate industry experience. It is important to note that both assessments are given equal weight, in accordance with the requirements of ACCE accreditation, which requires evaluation of each as equally important (ACCE, n.d.; McCuen & Gunderson, 2019). With specific regard to the number of years of industry experience being capped at 10-plus for a maximum score of 10 points, recent CM graduates generally enter roles in the construction industry that include titles such as "field engineer," "project engineer," "assistant project manager," or "junior estimator," among others, which are developmental positions with few decision-making responsibilities. While credit, or points in this calculation, should be given for industry experience, greater weight should be given to increasing levels of experience where decision-making authority is earned, which anecdotal evidence suggests is often encountered in employment years 5-10. It is those years when graduates commonly enter job titles such as "assistant superintendent," "superintendent," "project manager," and "estimator," among others.

For this model, sufficient decision-making authority and ability are estimated to be gained by year 10 of industry work experience, which is the maximum point value achievable for appropriate years of industry experience. This effectively equates 10 years of experience, in CM specifically, with a Ph.D. in CM (or Construction Science) for this evaluation. The ideal candidate, therefore, is an individual with a Ph.D. in CM (or Construction Science) with at least 10 years of applicable industry experience. The evaluation scale for each faculty member (or potential faculty candidate) is included below in Table 2.

Table 2 - Construction Faculty Qualifications (CFQ) Score Evaluation Matrix

Academic Qualifications		Industry Experience	Points
PHD in CM/Construction Science	10	10+ years CM experience	10
PHD or other doctoral degree	7	9-10 years CM experience	9
Master's in Construction Management/ Construction Science	5	8-9 years CM experience	8
Master's in other concentration	3	7-8 years CM experience	7
Bachelor's in Construction Management/Construction Science	1	6-7 years CM experience	6
		5-6 years CM experience	5
		4-5 years CM experience	4
		3-4 years CM experience	3
		2-3 years CM experience	2
		1-2 years CM experience	1
		Less than 1 year CM experience	0

The evaluation of a single faculty member, or potential faculty member, (CFQ_{IND}) is calculated based on the average of the two scores, utilizing the following formula:

$$\mathbf{CFQ_{IND} = Academic\ Qualifications\ Score\ (AQ_S) + Industry\ Experience\ Score\ (IE_S) / 2}$$

For example, a specific faculty member, 'Faculty 1', has an earned Ph.D. in a discipline other than CM and has 6 but less than 7 years of verifiable, applicable industry work experience. This result is a numerical score, necessarily between 1 and 10, and can be demonstrated in the following Table 3.

Table 3 - CFQ_{IND} for Single Faculty Member (Sample)

	Academic Achievement Score	Industry Experience Score	Average or CFQ_{IND}	Total Faculty
Faculty 1	7	6	6.5	1

However, this metric's critical nature is supported when applied to the entire faculty body for a given school, department, or CM program. It is not intended to be utilized as a method for evaluating an individual faculty member, other than as their individual contribution to the overall score of the program faculty at large, which aids in determining overall program success in delivering quality CM education through improved readiness to work by recent graduates. By performing an additional step in the calculation, which summates the individual scores (CFQ_{IND}) and determines an average score across the entire faculty population, the program's Construction Faculty Qualifications (CFQ) Score can be demonstrated by the following formula:

$$\mathbf{CFQ = (CFQ_{IND(1)} + CFQ_{IND(2)} + \ldots\ CFQ_{IND(N)}) / N}$$

Again, the result is a numerical score, necessarily between 1 and 10, which can then be assessed as an evaluation of the program's aggregate faculty qualifications. Table 4 below includes an example of a mock program comprised of six faculty members.

Table 4 - CFQ for Mock CM Program (Sample)

	Academic Achievement Score	Industry Experience Score	Average or CFQ_{IND}	Total Faculty
Faculty 1	7	6	6.5	6
Faculty 2	5	5	5	
Faculty 3	1	1	1	
Faculty 4	5	5	5	
Faculty 5	10	10	10	
Faculty 6	10	10	10	
			CFQ Score	6.3

However, the overall CFQ Score has little meaning without determining a minimum or target score requirement for program accreditation. This minimum or target score should consider both academic achievement and industry experience and should not be easily achieved by programs with significant deficiencies in either category. Determining an appropriate minimum CFQ score for program accreditation should consider the correlation between the program's CFQ score, and its mean of means (X_{GM}) for overall performance on readiness to work topics, as evaluated by the industry.

Application of the Construction Faculty Qualifications (CFQ) Score

The Construction Faculty Qualifications (CFQ) Score has applications for determining the overall success, or readiness to work, of CM graduates with less than 3-years of post-graduation experience. As discussed above, the surveys collected in this research produced actionable data for 19 total CM programs where a direct comparison can be made between the readiness to work scoring, or mean of means of the individual means, of 16 SLOs evaluated by industry (X_{GM}) and the CFQ score of those same universities. That data is reported in Table 5.

Interpreting these Descriptive Statistics has some value as the data clearly indicates that the lowest CFQ Score of 3.9 directly equates to the lowest performance (X_{GM}) score of 3.12 for Program 3. The upper end of the scale is less apparent, as the data shows that the highest X_{GM} score of 3.89 is represented by a CFQ score of 6.3 for Program 17, though that CFQ score still is in the top third (at 31%) of the scores sampled.

A simple linear regression analysis was conducted using bivariate data to determine the degree of linear relation between X_{GM} and CFQ, with X_{GM} as the dependent variable and CFQ as the independent variable. In this simple linear regression test, the hypotheses considered were:

> **Null hypothesis – There is no linear relationship between X_{GM} and CFQ**
>
> **Alternative hypothesis – There is a linear relationship between the X_{GM} and CFQ**

The regression statistics of this simple linear regression test are given in Table 6.

Table 5 - Comparing X_{GM} and CFQ

Program	X_{GM}	CFQ
Program 1	3.37	4.5
Program 2	3.32	6.4
Program 3	3.12	3.9
Program 4	3.13	5.6
Program 5	3.38	5.8
Program 6	3.14	4.7
Program 7	3.46	4.0
Program 8	3.66	7.1
Program 9	3.62	4.7
Program 10	3.44	4.0
Program 11	3.77	6.5
Program 12	3.24	4.2
Program 13	3.82	6.7
Program 14	3.61	6.8
Program 15	3.12	4.3
Program 16	3.18	5.1
Program 17	3.89	6.3
Program 18	3.27	4.6
Program 19	3.40	5.1

Table 6 - Regression Statistics

Regression Statistics	
Multiple R	0.630985987
R Square	0.398143316
Adjusted R Square	0.362739982
Standard Error	0.199537187
Observations	19

This prediction model accounted for approximately 40% of the variance of X_{GM} to CFQ (R^2 = 0.398).

The Analysis of Variance (ANOVA) data provided by the simple linear regression analysis is included in Table 7.

Table 7 - ANOVA Results

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.4477576	0.4477576	11.24592707	0.00376842
Residual	17	0.6768565	0.0398151		
Total	18	1.1246141			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.645863441	0.2348491	11.266228	2.6254E-09	2.150375152	3.14135	2.150375	3.141352
CFQ	0.146328212	0.0436345	3.3534948	0.00376842	0.054267373	0.23839	0.054267	0.238389

The ANOVA data in Table 7 above indicates p-values for both the intercept and the CFQ, both of which are less than 0.05 indicating that CFQ is a significant variable that impacts X_{GM}. The determination that CFQ is a significant variable that impacts X_{GM} allows for the prediction that, if the program's CFQ is known, its X_{GM} can be calculated based on the predictive formula:

$$\mathbf{Y = m * (X) + b}$$

Where Y = predicted Y variable (X_{GM}), m = slope (CFQ coefficient), X = X variable (CFQ), and B = intercept. The CFQ Line Fit Plot, included in Figure 10, displays the equation, linear relation, and positive correlation (Pal & Bharati, 2019) between CFQ and X_{GM} from this research.

Conclusions and Recommendations

This study aimed to interpret the relationship between faculty-earned degrees and construction industry work experience with the work readiness of recent CM graduates with less than 3 years of experience. The data gathered from this research study can help improve construction education and faculty qualifications within CM programs and satisfy the needs and desires of academia to validate programs with faculty holding doctoral degrees while continuing to improve graduates' readiness to work. One such improvement method may be to create a quantitative measurement tool for Construction Management faculty qualifications, entitled here the Construction Faculty Qualifications (CFQ) Score. Creating a rating system based upon the qualifications of the "ideal" faculty candidate, with respect to their academic achievement and desired levels of applicable industry experience, will help CM programs to better target faculty for full-time hiring within their programs. Averaging this measurement across the entirety of each individual program's faculty composite will create a valuable measuring tool for accreditation bodies by providing the ability to both (a) establish a minimum CFQ Score for accreditation purposes; and (b) provide the ability to measure continuous improvement, a core tenet of accreditation in higher education. Creating a metric for scoring full-time CM faculty qualifications across the entirety of the school, department, or program that establishes a minimum acceptable score will be important to the validation of quality Construction Management programs as the discipline continues to grow and expand in higher education.

This CFQ Score will contribute to improving Construction Management education by providing an unbiased evaluation of the aggregate faculty qualifications of each program seeking accreditation. This will, of course, require an agreement between and among the various accrediting agencies, most notably ACCE and ABET, who are currently the primary accrediting bodies for CM programs in the U.S. for inclusion within their accreditation standards. This tool, if utilized correctly, can aid department chairs, school directors, or faculty hiring committees with evaluation of candidates that contribute to the overall improvement of the department or program by providing another metric for analysis of candidates for interview and hiring. This type of metric may also have broader implications for accreditation of other, similar programs where a combination of academic achievement and industry experience (or other similar variables) affect the outcomes of improving faculty profiles for corresponding improvement in overall program performance.

The insights gained from this research offer other actionable steps to enhance Construction Management education. Apart from the proposed CFQ Score, another avenue for improvement is fostering and expanding partnerships between academia and industry. Collaborative efforts can lead to curriculum development that is more aligned with industry needs, ensuring graduates are well-prepared for the evolving challenges of the construction sector. Furthermore, continuous professional development opportunities for faculty, including expanded opportunities for internships and externships, can provide them with important industry experience and keep them updated with the latest industry trends and practices, enriching their teaching and mentoring capabilities.

As the construction industry evolves and Construction Management programs in higher education continue to expand and grow, the need for CM faculty with practical industry experience and terminal degrees becomes critical (Gunderson & Gloeckner, 2006). The shortage of qualified faculty poses challenges in meeting industry demands and delivering high-quality education. Moreover, the lack of pertinent research in critical areas underscores the disconnect between academia and industry (Ghosh & Bhattacharjee, 2013). Based on the results of the data analysis, the research presented here indicates a likelihood that there is a strong link between faculty with doctoral degrees in CM and significant and measurable industry experience positively affecting the quality, or readiness to work, of recent CM graduates. This study provides a roadmap for determining appropriate levels of degree attainment and industry experience for CM faculty for the improvement of programs and delivery of high-quality graduates. The results of this research indicate that this phenomenon should be studied in greater depth and detail, including differentiating between field supervisor perspectives versus office supervisor perspectives on graduate readiness to work. Further studies may also investigate the use of adjunct or per-course faculty and industry guest lecturers on improving student outcomes for readiness to work within Construction Management programs.

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Appendix 1 - Evaluation of Readiness to Work by Industry, Faculty, and Recent Graduates

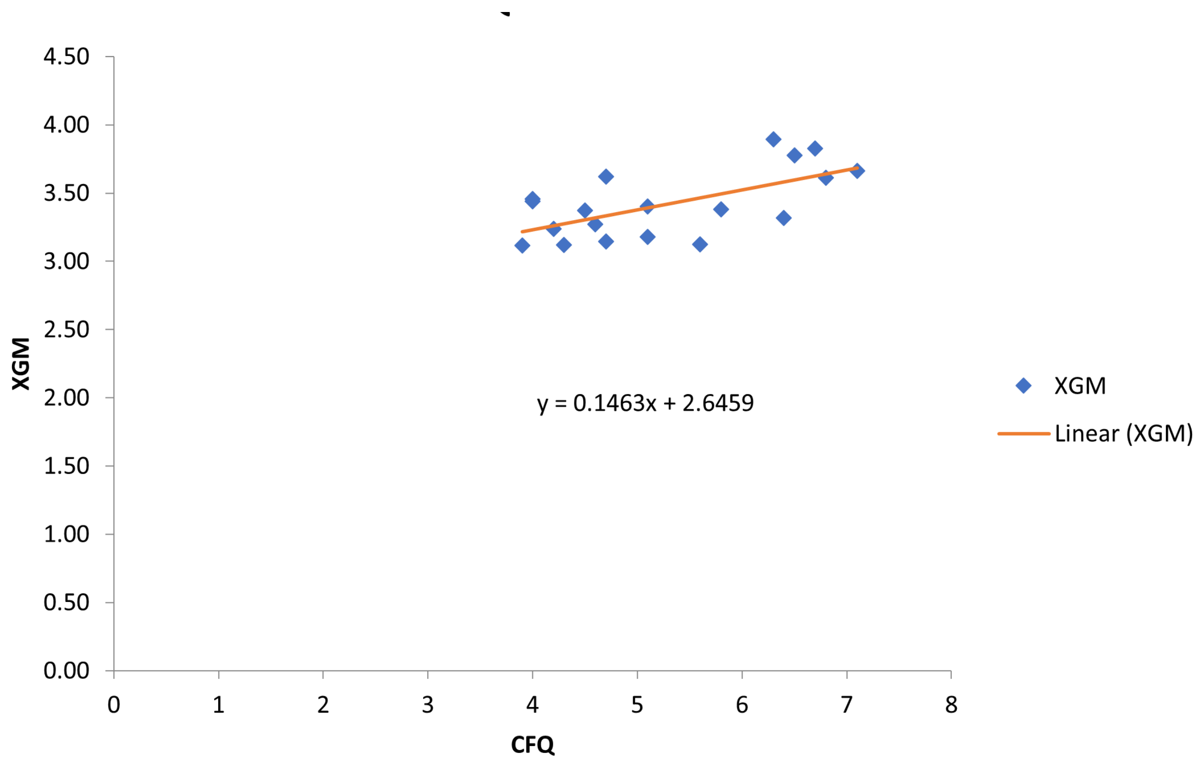
Question		Industry Standard		Faulty Standard Deviation		Graduate Standard
Q12. Reading and Comprehending plans and specifications	3.65	0.97	4.55	0.50	4.45	0.83
Q13. Performing quantity takeoffs of construction documents	3.67	0.82	4.48	0.55	4.34	0.67
Q14. Preparing cost estimates for construction projects	3.19	1.07	4.29	0.55	4.03	0.94
Q15. Soliciting subcontractor and supplier bids for construction projects	3.25	0.99	3.76	0.82	3.86	1.13
Q16. Preparing subcontract or purchasing documents (including scopes of work)	2.78	0.98	3.79	0.75	3.72	1.13
Q17. Preparing and/or controlling project management documents such as RFI's, CO's, PCO's, ASI's, etc.	3.36	0.94	4.29	0.64	4.07	1.1
Q18. Preparing and/or updating project schedules	3.34	1.14	4.21	0.56	4.17	0.89
Q19. Preparing and/or updating and/or utilizing project job cost reports	2.85	1.24	3.93	0.68	3.38	1.24
Q20. Reviewing and processing project submittal documents/managing the submittal process	3.41	0.97	4.24	0.66	3.90	1.14
Q21. Preparing written communications with project stakeholders	3.44	1.13	4.19	0.89	4.10	1.05
Q22. Understanding safety regulations and requirements in the construction industry	3.74	0.95	4.40	0.63	4.38	0.94
Q23. Preparing and/or utilizing BIM models or other VDC applications	3.32	1.07	3.88	0.92	3.31	1.39
Q24. Writing technical proposals (i.e. responses to RFP, RFCSP)	3.02	1.14	3.74	0.94	3.72	1.1
Q25. Understanding materials, means and methods of construction projects	3.56	0.93	4.33	0.57	4.21	0.86
Q26. Understanding the legal aspects of construction contracts	2.95	1.18	3.95	0.79	4.00	0.96
Q27. Understanding project controls and project management processes	3.51	0.92	4.31	0.56	4.38	0.62

Appendix 2 - Industry Evaluation of Readiness to Work by Program

	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24	Q25	Q26	Q27	X_{GM}
Program 1	3.67	3.52	3.36	3.22	3.05	3.48	3.31	2.96	3.56	3.45	3.85	3.36	3.00	3.50	2.99	3.65	3.37
Program 2	3.54	3.67	3.25	2.88	2.68	3.55	3.33	2.98	3.45	3.65	3.91	2.94	3.15	3.55	2.88	3.70	3.32
Program 3	3.38	3.55	2.85	3.17	2.75	3.15	3.28	2.65	3.35	3.10	3.55	3.10	2.65	3.22	2.65	3.45	3.12
Program 4	3.00	4.00	4.00	3.00	2.00	3.00	3.00	3.00	3.00	2.00	4.00	3.00	3.00	4.00	2.00	4.00	3.13
Program 5	3.25	3.76	3.45	2.77	3.65	3.10	3.68	2.79	3.77	2.95	3.28	3.85	2.77	4.12	3.92	2.95	3.38
Program 6	3.45	3.26	3.10	2.95	2.56	3.25	3.29	2.72	3.40	3.06	3.67	3.29	2.90	3.52	2.53	3.35	3.14
Program 7	3.44	2.95	3.65	3.42	3.05	3.44	4.17	2.75	3.68	2.77	4.12	3.45	3.24	3.76	3.55	3.89	3.46
Program 8	4.22	3.95	3.52	3.41	3.55	3.65	3.44	3.25	3.55	3.65	4.25	3.55	3.25	3.65	3.51	4.22	3.66
Program 9	4.15	3.92	3.45	3.65	3.25	3.51	3.55	2.88	3.45	4.00	3.65	4.15	3.65	4.15	2.98	3.51	3.62
Program 10	3.85	3.76	3.60	3.44	3.45	3.28	3.52	2.15	4.15	4.15	3.55	3.10	2.53	3.25	3.42	3.86	3.44
Program 11	4.14	4.02	3.62	3.53	3.72	3.44	3.25	4.15	4.47	3.76	4.22	3.55	3.35	3.62	3.60	3.95	3.77
Program 12	3.33	3.56	3.06	3.20	3.02	3.41	3.25	2.35	3.65	3.44	3.28	2.77	3.55	2.98	3.45	3.51	3.24
Program 13	4.00	4.00	3.65	3.42	3.77	3.65	3.85	3.56	3.51	3.89	4.15	3.85	3.92	4.06	4.00	3.91	3.82
Program 14	3.99	3.86	3.95	3.66	3.21	3.19	3.31	3.05	3.52	3.45	4.10	3.35	3.25	3.76	3.98	4.15	3.61
Program 15	3.12	3.22	2.95	3.11	2.46	3.16	3.06	2.55	3.65	2.89	3.34	3.44	2.77	4.14	2.85	3.22	3.12
Program 16	3.65	3.45	3.10	3.51	1.00	3.25	3.65	2.23	3.68	3.92	3.05	2.95	3.65	3.10	3.00	3.65	3.18
Program 17	4.33	4.33	3.65	3.65	3.42	3.56	4.25	3.89	3.86	3.45	4.67	3.56	3.66	4.56	3.81	3.65	3.89
Program 18	3.53	3.42	3.65	2.98	2.00	2.99	3.45	2.33	3.51	3.45	3.05	3.55	3.25	4.00	3.76	3.45	3.27
Program 19	2.77	3.05	3.25	3.51	3.92	3.65	3.55	2.87	3.10	2.53	4.15	3.76	3.28	3.44	4.15	3.42	3.40

Note: The data represent the mean score of the industry evaluations on each question (or SLO) evaluated via the Qualtrics survey tool. X_{GM} represents the mean of means, or grand mean, of the evaluation scores for all 16 questions.

Appendix 3 – CFQ Line Fit Plot



Root and Causes of Skilled Labor Shortage in Construction Industry: a deep dive into the decision-making process and identification of impactful factors and people concerning the pursuit of a career in the skilled trades

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Abstract
The skilled labor shortage is well documented from a historical perspective via studies focusing on various construction trades such as carpentry, mechanical, electrical, and plumbing, and tile setters. Causes of such shortages such as industry image, college as a preferred choice after high school, and construction being a last resort have been investigated extensively. Consequently, possible solutions ranging from amplifying shop classes in high school to intensifying recruiting efforts for union training programs have all been addressed throughout the last 40 years. However, recent studies have focused on identifying the magnitude and reach of the skilled labor gap while limited attention is given to the impacting factors that played a role in the decision to pursue an education and eventual career in construction, especially on the management side of the industry. This study, therefore, builds on the efforts of previous work by this effort and identifies the methodology utilized in the development of a new survey tool focused on the influences and impact factors of the decision-making process to pursue a career in the skilled construction trades.

Keywords: Survey Development, Skilled Labor, Construction Labor Shortage, Career decision-making, mentors, role models

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INTRODUCTION

Skilled labor shortage is gripping the skilled trades that make up an ever-growing gap illustrated by the findings of Ken Simonson, Chief Economist of the Associated General Contractors, May 2022 report that found construction unemployment at an all-time low level in the 22-year history of Simonson's reporting for the AGC of America of 4.5% (Simonsen, 2022). Akomah, Ahinaquah, and Mustapha (2020) identified areas of skilled labor shortage in the construction industry in central Ghana through a research questionnaire and found that skilled construction trades shortages included electricians, tile setters, and painters with motivating factors including socio-economic conditions, external forces, job attractiveness among others. The approach of the paper is from a hypothetical position with a focus on a decision not made, and large variances to be allowed for.

Chini, Brown, and Drummond (1999), cited the change in vocational education and technology, economic changes as well as a shift toward open shop contracting steering young people away from the trades. They developed a two-phase approach with the first phase consisting of a demand to retain existing workers and streamline work processes and the second phase consisting of a longer-term, recentering of construction education systems. While highly pertinent to the skilled labor shortage, their work does not investigate the decision-making process involved when choosing a career in the skilled trades. Koch (2007) investigated the decision-making process for students who decided to pursue an education and potentially a career in construction management (CM) and identified motivating factors and influences for those students in the decision-making process including family members, mentors, and role models as well as personal influences such as an interest in construction. And while this work focuses on the management/higher education path of the construction industry it both closely aligns with this research and provides clarity to the gap in the skilled labor in construction shortage body of knowledge.

Further review of the literature revealed that much of the existing data that makes up the body of knowledge on the topic of skilled labor shortage focused on the role of higher education as a potential source of relief. It, therefore, means that the role played by the trades in bridging the skilled labor shortage gap has not been explored extensively. Moreover, the questions asked, and methods employed including surveys and analysis of existing data sources, regardless of the focus of the study, could lend themselves to a new study focused on the skilled trades in the construction industry by using CM majors as the subject samples. Additionally, while the existing body of knowledge on the skilled labor shortage in construction is robust and thorough, gaps caused by a narrowed focus on various impacts and influences exist. Specifically, the work done by Koch (2007) created a series of data points that present a potential for new inroads into the decision-making process of those who have recently started a new education and career path in the skilled construction trades. Furthermore, the work published by Ostadalimakhmalbaf, Escamilla, Pariafsai, Saseendran, and Dixit (2021) focused on the impact of the family unit's impact on the decision of minorities and females to enter the skilled trades via a Community College training program and yielded limited results that could be considered significant within the body of knowledge.

This paper will cover the development of a new survey tool will be developed with a focus on the decision-making process of skilled tradespeople currently working in the industry and the influences of mentors, role models, industry image, and influencing factors that impacted this process with the intent of this survey tool will be to quantify the impact of those variables. This work builds on a previous paper by Hardy et. Al. (2024) which consists of a deep dive literature review into the skilled labor shortage in the construction industry.

1.2 METHODOLOGY

1.2.1 SURVEY DESIGN

The overarching effort of this research is to establish the validity of a new survey tool aimed at identifying the impactful factors and influencing people in the decision-making process to pursue a career in the skilled construction trades to allow others to build on this first-of-a-kind research and tool. A cross-sectional survey was developed to collect data to answer research questions regarding the skilled labor shortage focused on the decision-making process used to decide to enter the skilled construction trades. The questions in the Experiences and Influences/Mentors sections build on the research of Koch (2007) Koch et al. (2009), Thevenin and Elliott (2015), Bigelow et. Al. (2021) Haupt and Harinarain (2016), with questions being reformatted to improve the viability of the questionnaire and allow participants to provide insight into their personal experiences that made up the decision to pursue a career in the skilled construction trades.
Various factors were considered in the design of this survey including rating scales, rating format, response analysis, response format, open-ended vs close-ended questions, question wording, and question order. The survey was then segmented into 3 sections: Demographics, focused on age, gender, and rural or urban area of residence with the demographics focuses designed to allow for deeper data analysis in future work, Experiences section containing data focused on participants previous experience Hardy et Al., (2024) working in construction both paid and/or unpaid, and Influences/Mentors section containing data on people and factors, including industry image, that played a role in participants decision to pursue a career in the skilled construction trades.

1.2.2 QUESTION DEVELOPMENT

Once variables had been clarified new questions were developed via extensive discussion with both academic and industry professionals a 17-question survey was developed and designed for ease of participant completion and organized with the participant pool in mind. Slide selectors were determined as the preferred means of response for questions that engaged the Likert Scale, and demographic questions were moved to the end of the survey to lessen the likely hood a participant would not complete the survey due to fatigue.

Survey questions were developed to identify a participant’s education and work experience before joining a skilled trade training program (Table 1) with response options being yes/no or periods in months. Questions were developed to identify participants’ opinions of the construction industry image including prestige, pay, and opportunity for advancement amongst other variables (Table 2) with the intent to understand the participant pools previous experience and opinion of the construction industry using a 1 thru 5 Likert scale with 1 being strongly agree and 5 being strongly agree.

Table 1. Survey Questions

Skilled Labor Survey October 10	Column2	Column1
Q1	Q2	Q3
Did you participate in construction work experience through a vocational (i.e., Career or technical) program in high school?	How many total months of construction related experience did you complete as a volunteer (e.g. Habitat for Humanity, Scouts, 4-H, helping with family projects or other unpaid work) before entering the construction program?	How many months of paid construction related work experience did you complete before entering the skilled construction trades training program?

Table 2. Survey questions

Q4_1	Q4_3	Q4_6	Q4_8	Q4_9
For the sake of this survey 'traditional office career' refers to any job not in the skilled construction trades. - A career in the skilled construction trades is prestigious	For the sake of this survey 'traditional office career' refers to any job not in the skilled construction trades. - A career in the skilled construction trades pays better than a non-construction job	For the sake of this survey 'traditional office career' refers to any job not in the skilled construction trades. - A career in the skilled construction trades was my first career choice	For the sake of this survey 'traditional office career' refers to any job not in the skilled construction trades. - A career in the skilled construction trades benefits society	For the sake of this survey 'traditional office career' refers to any job not in the skilled construction trades. - A career in the skilled construction trades has room for advancement

Survey questions were developed to understand the influencing factors and individuals in the career decision-making process, including personal preferences/interests, personal preferences, people, and role models/mentors (Table 3). The same 1 through 5 Likert scale was implemented using a slide selector as well as demographical questions specific to gender and affiliation with the construction industry.
The utilization of the Likert Scale allows the author to ensure the range of available statistical analysis is not limited provided that the hypotheses developed are properly configured for either one or two-tailed T-tests.

1.2.3 QUESTIONNAIRE VALIDATION

A team consisting of the author and a committee consisting of three PhD-level academic experts collaborated and scrutinized multiple iterations of the survey over 12 months the survey was submitted to the Internal Review Board at Louisiana State University for extensive review and approval.

Table 3. Questions

A career in the skilled construction trades is prestigious ()
A career in the skilled construction trades pays better than a non-construction job ()
A career in the skilled construction trades was my first career choice ()
A career in the skilled construction trades benefits society ()
A career in the skilled construction trades has room for advancement ()
Interest in Construction ()
Hands on work activities ()
Work/Volunteer experience ()
A work day that is not predominately centered in a traditional office environment. (i.e. not working behind a desk every day.) ()
Construction is a family business. (i.e. your family owns/ed a construction company or works/ed in construction.) ()
Construction industry outlook ()
Mother/Step-Mother ()
Father/Step-Father ()
Brother/Sister/Step-Brother/Step-Sister ()
Aunt, Uncle, Cousin ()
Other Relative ()
College Friend ()
High School Friend ()
Teacher ()
College Advisor ()
High School Guidance Counsellor ()
Work Supervisor ()
Co-Worker ()
Significant Other (Husband/Wife/BF/GF) ()

Artificial data was synthesized and analyzed to ensure responses were adequate to address the goal of this study. To recognize and eliminate measurement errors, the questionnaire was validated by pre-testing the questions on targeted respondents (construction management professors and qualified industry experts) to review the questionnaire's reliability and consistency in responses. After developing the questionnaire, the questions were tested with various industry and academic professionals from across the construction industry including industry economists, educational resourcing and training development, and general contracting executives from across the US. The questionnaire was sent out to these two groups via email that included a Qualtrics link. The first group was a collection of five graduate students at a university in the southern region of the United States and an individual with academic educational accreditation. The second group of five individuals consisted of construction industry professionals ranging from individuals with 1 year of experience to over 20 years of industry experience. These two groups were hand-selected by the authors and the response rate was 100%. Both groups were asked in follow-up in-person and phone interviews for their input on the content of the survey based on their point of view with Group One being academically focused and Group 2 being industry-focused. Group 1 provided feedback to the authors focused on the ease of the survey tool and the need for further understanding of the difference between a role model and a mentor. Group Two's feedback was consistent with that of Group 1 when analyzed during weekly survey development tool meetings held virtually. After discussion of the feedback from both groups, the authors developed a clear guideline for delineation between a role model and a mentor and incorporated the definitions into the survey questions in the form of question instructions. The pretesting questionnaires were analyzed for consistency. Consistency was assessed by comparing the responses from the two groups. The questionnaire was considered consistent given that the responses from the two groups were equivalent.

Structured follow-up discussions via both virtual meetings and in-person conversations were conducted to gain feedback on the clarity of wording, layout and style, and the general appropriateness of the survey questions to measure and assess the targeted constructs (content validity). The researcher took notes during the discussions on any issues raised concerning the questionnaire and noted key suggestions including input on tone of survey questions, opportunities for improvement of both survey questions, and available responses.

The data collected from the statement items in the *Methodology* section were ratings using an ordinal Likert-scale format with ratings of 1 = Extremely Negative influence (i.e. almost stopped me from entering the skilled trades.), 2 = Negative Influence, 3 = No influence, 4 = Positive Influence, 5 = Extremely Positive influence (i.e. this was the reason why I picked the skilled construction trades as a career path).

1.2.4 POPULATION IDENTIFICATION

The population for this study included students in skilled construction labor training programs (e.g., apprentice plumbers, apprentice HVAC-R technicians, apprentice pipefitters, and apprentice welders). The respondents to the survey were to complete the questionnaire drawing on their experiences when deciding to pursue a career in the skilled construction trades and consider the influences and factors that played a role in the decision-making process. The inclusion criteria required that participants be actively enrolled in their chosen skilled trades training program. Utah Pipe Trades Career Center was contacted and volunteered their students to participate in the initial data collection process. All students of the Utah Career Center were invited to participate in a discussion session where the survey was presented via a Qualtrics QR code. The career center has a student body of 280 students and 175 students participated in this study, a response rate of 62.5%. The Mountain West region has 14 similar UA Trade schools with an estimated student body of approximately 1500 students and a segmented response rate of just under 12%. The response rate does not allow for generalization of the Mountain Region we do have a sufficient participant pool to conclude specific to the Utah Career Center.

1.2.5 QUESTIONNAIRE DATA PROCESSING

Initial efforts for data processing were focused on using the following method:
The following hypothesis will be utilized for analysis of all collected data with a focus on a participant pool made up of individuals who decided to pursue a career in the skilled construction trades via the Utah Career Center:

$H1_0: \mu_{p_{m=1}} = \mu_{p_{m=0}} H1_0: \mu_{p_{m=1}} = \mu_{p_{m=0}}$

$H1_a: \mu_{p_{m=1}} > \mu_{p_{m=0}} H1_a: \mu_{p_{m=1}} > \mu_{p_{m=0}}$

Null Hypothesis 0 will be tested using a two-tailed t-test ($p = 0.05$); Alternative Hypothesis 1 will be tested using a two-tailed t-test ($p = 0.05$).

At this point in the study, it was determined appropriate to add a statistical researcher to the list of authors as her work on the statistical analysis portion was invaluable. After investigation of data processing methods discussion amongst the team and review of available inputs, including the use of an integer Likert Scale, the categorical as well as quantitative data, it was discovered that a logistic regression to be an additional means of analysis to allow for the categorical results generated by the survey tool.

The LSU Experimental Statistics department was engaged to ensure the most appropriate means and methods were implemented for the collected data and desired insights leading to the discovery that utilizing a Wilcoxon non-parametric version of a t-test due to the Likert scale not satisfy the criteria for a t-test.

The prescribed responses for the defined areas within the survey with yes/no questions being reflected with a 0,1 and the Likert scale being 0-5 or NA.

As previously mentioned, the Likert scale does not satisfy the criteria for a t-test leading to the implementation of non-parametric measures and the adjustment of the hypothesis to allow for a 2-tail analysis to be utilized.

1.3 SUMMARY

This section presents the development and validation process of a survey tool to be utilized in identifying the key impacts and influences of those who have decided to pursue a career in the skilled construction trades focusing on mentors and role models as well as impactful variables including industry image, pay, prestige, job satisfaction, and social impact. By isolating participants that identified as having a mentor or role model with the developed survey tool we have created the opportunity for potential data collection on similar participant populations.

SECTION 2: ROOT AND CAUSES OF SKILLED LABOR SHORTAGE IN CONSTRUCTION INDUSTRY: INITIAL DISTRIBUTION OF FIRST-OF-A-KIND SURVEY TOOL, ANALYSIS, AND FINDINGS

2.1 INTRODUCTION

This section presents the findings from the initial distribution of the first-of-a-kind survey discussed in section 1. Responses of 175 current skilled trade training program participants completed the survey and results were processed utilizing RStudio.

2.2 GOALS OF THE STUDY

The overarching goal of this study is to provide results and analysis of the initial distribution of a first-of-a-kind survey tool aimed at identifying the impactful factors and influencing people in the decision-making process to pursue a career in the construction skilled trades via a skilled trades training program. To that end, a singular goal was identified for this work.

1. Provide insight and analysis into identified key concepts to assist in closing the identified gaps in the body of knowledge in the skilled labor shortage in the skilled construction trades.

2.3 SCOPE OF THE STUDY

This study targets the skilled labor shortage in the construction industry from a research perspective utilizing a keyword search for initial findings and establishing the current body of knowledge via a comprehensive literature review. Gaps were identified in the body of knowledge in the areas of the decision-making process and the impact that role models and influencing factors have as well as the impact of the construction industry image. The data and findings generated by this research will benefit both industry professionals seeking to identify potential new skilled trade members as well as academics seeking to further the body of knowledge in skilled labor shortage in the construction industry.

2.4 METHODOLOGY

The questions in the Experiences and Influences/Mentors sections build on the research of Koch (2007) Koch et al. (2009), Thevenin and Elliott (2015), and Bigelow et al. (2021) Haupt and Harinarain (2016), with questions being reformatted to improve the viability of the questionnaire and allow participants to provide insight into their personal experiences that made up the decision to pursue a career in the skilled construction trades.

Various factors were considered in the design of this survey including rating scales, rating format, response analysis, response format, open-ended vs close-ended questions, question wording, and question order. The survey was then segmented into 3 sections: Demographics focused on age, gender, and rural or urban area of residence with the demographics focus designed to allow for deeper data analysis in future work, Experiences section containing data focused on participants' previous experience Hardy et al. (2024) working in construction both paid and/or unpaid, and Influences/Mentors section containing data on people and factors, including industry image, that played a role in participants decision to pursue a career in the skilled construction trades.

The survey tool developed by Hardy et al. (2024) was distributed to 175 Utah Pipe Trades apprentices enrolled at the Utah Career Center. The survey was delivered in small group sessions via Qualtrics survey QR code and executed on participants' devices. The survey provided thorough instructions and clarifications, verbal instructions were provided to the participant pool and no questions were asked during survey execution.

Hypotheses that include mentors and role models' responses were analyzed separately based on the selection of either a mentor or a role model.

For hypotheses that include the identification of the relationship of the mentor or role model and the legal relationship with immediate family members responses were further segmented to identify appropriate responses and those that did not meet the criteria were removed from the analysis.

2.5 HYPOTHESES

The following hypotheses were developed before analysis to provide via input and collaboration with the authors of this paper. Early analysis of the feedback from the initial distribution identified a trend related to the opinions on mentors versus role models, in turn, the hypotheses were further segmented and analyzed accordingly.

2.6 ANALYSIS

Based on the survey used for this study, which was conducted with Utah skilled trades construction apprentices, the participants were asked about their opinion on a Likert scale regarding careers in skilled trades and various related topics including industry prestige as well as the benefits of the construction industry to society and others. Additionally, participants were also asked about having mentors and/or role models and the relationship to those mentors and or role models. This study tries to understand the correlation between having a mentor and or role model and their opinion on skilled trade image and various other topics. For that reason, the null and alternative hypotheses were developed as:

H1: The opinion on the prestige of a career in construction is equal regardless of construction having a mentor or role model in the construction industry.

$H1_A$: Those who reported having a mentor or role model in the construction industry had a higher opinion of the prestige of a career in construction.

H2: The opinion of the benefits construction offers society is equal regardless of an immediate family member as a mentor or role model.

$H2_A$: Those who reported having an immediate family member as a mentor or role model had a higher opinion of the benefits construction offers society.

H3: Opinion on room for advancement in the construction industry is equal regardless of the presence of a mentor or role model.

$H3_A$: Opinion on room for advancement in the construction industry is higher for those who reported having a mentor or role model.

H4: The opinion of the construction industry pay is equal regardless of construction being a family business.

$H4_A$: Those who reported construction is a family business had a higher opinion of construction industry pay.

H5: The opinion of career options is equal regardless of construction being a family business.

$H5_A$: Those who reported construction is a family business had a higher opinion of different career options in the construction industry.

H6: The influence of hands-on work activities is equal regardless of the presence of a mentor or role models.

$H6_A$: Those who reported having a mentor or role model had a higher influence of hands-on work activities.

H7: The influence of a workday that is not centered around a traditional office environment is equal regardless of previous construction experience.

H7$_A$: Those who reported previous construction experience had a higher influence on a workday that is not centered around a traditional office environment.

For the sake of brevity, only those results that yielded significant results have been included in this publication.

Figure 1 represents the data distribution for the Role Model variable, and this data shows a difference in the pattern of prestige response for students with and without a role model. Furthermore, statistical methods were used to test the data. The first analysis considered the Chi-square test. This test is used when trying to analyze the correlation between two variables and no causal effects. Furthermore, the variables were found not to correspond to a continuous normally distributed distribution, so a non-parametric version of the t-test was conducted as well using the Wilcoxon test that compares two paired groups. The Chi-square test yielded a p-value of .084 where we once again fail to reject the null while the Wilcoxon p-value of .007 allows us to reject the null in favor of the alternate hypothesis.

In this instance, we can say that the potential impact of a Role Model on those who chose to pursue a career in the skilled construction trade had a higher opinion of the prestige of the skilled construction trade than those who reported having a mentor.

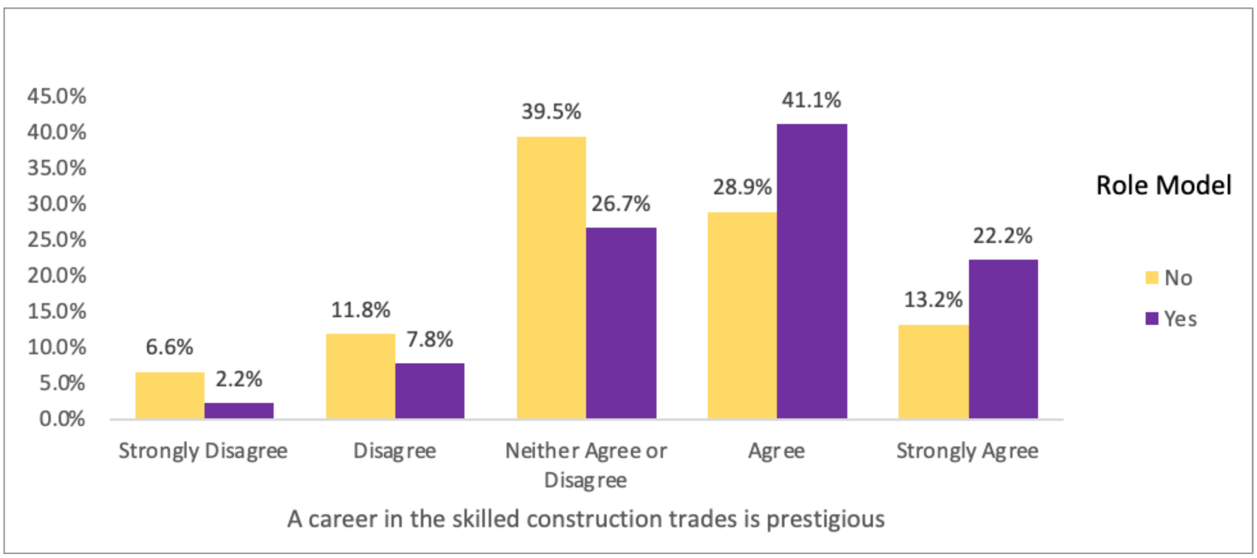

Figure 1. A career in the skilled construction trades is prestigious. (Role model)

H3: Opinion on room for advancement in the construction industry is equal regardless of the presence of a mentor or role model.

H3$_A$: Opinion on room for advancement in the construction industry is higher for those who reported having a mentor or role model.

Figure 2 represents the data distribution for the Role Model variable, and this data shows a similar pattern in the room for advancement response for students with and without a Role Model. Furthermore, statistical methods were used to test the data. The first analysis considered the Chi-square test. This test is used when trying to analyze the correlation between two variables and no causal effects. Furthermore, the variables were found not to be continuous and almost normally distributed, so a non-parametric version of the t-test was conducted as well using the Wilcoxon test that compares two paired groups. The Chi-square test yielded a p-value of .06 where we once again fail to reject the null hypothesis. Furthermore, the non-parametric test conducted Wilcoxon yielded p-values of .005 allowing us to reject the null hypothesis in favor of the alternative.

In this instance, we can say that the potential impact of a role model on those who chose to pursue a career in the skilled construction trades had a higher opinion of the room for advancement of the skilled construction trades than those who reported having a Role Model.

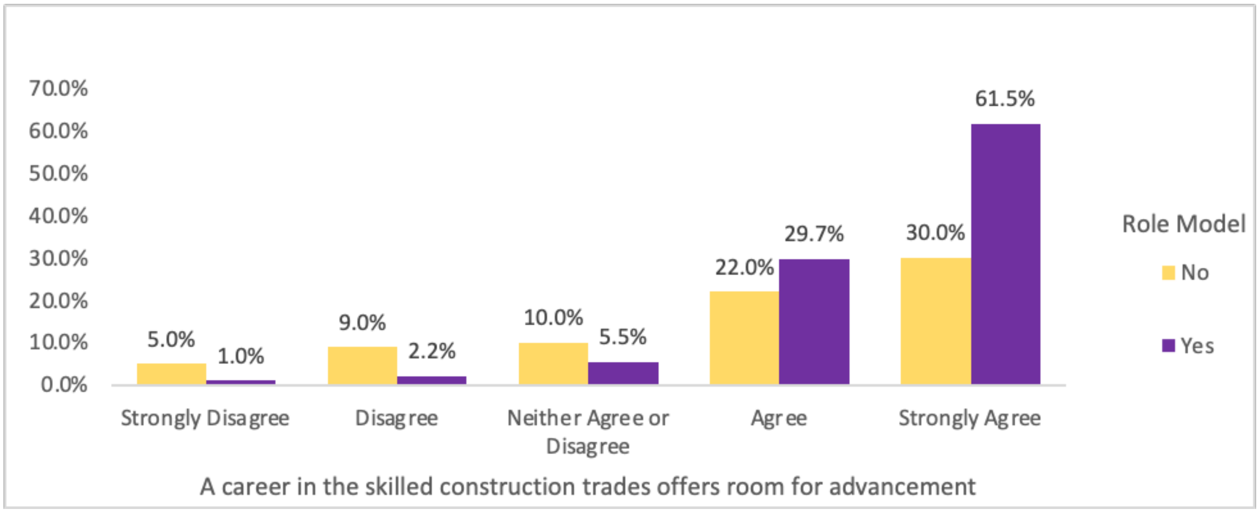

Figure 2. A career in the skilled construction trades offers room for advancement. (Role model)

H6: The influence of hands-on work activities is equal regardless of the presence of a mentor or role models.

$H6_A$: Those who reported having a mentor or role model had a higher influence of hands-on work activities.

Figure 3 represents the data distribution for the Mentor variable, and this data shows a similar pattern in the influences hands-on work activities had on the decision to pursue a career in the skilled construction trades along with the presence of a Mentor. Furthermore, statistical methods were used to test the data. The first analysis considered the Chi-square test. This test is used when trying to analyze the correlation between two variables and no causal effects. Furthermore, the variables were found not to be continuous and almost normally distributed, so a non-parametric version of the t-test was conducted as well using the Wilcoxon test that compares two paired groups. The Chi-square test yielded a p-value of .042 where we reject the null in favor of the alternative. Furthermore, the non-parametric test conducted Wilcoxon, yielded a p-value of .048 so we reject the null in favor of the alternate.

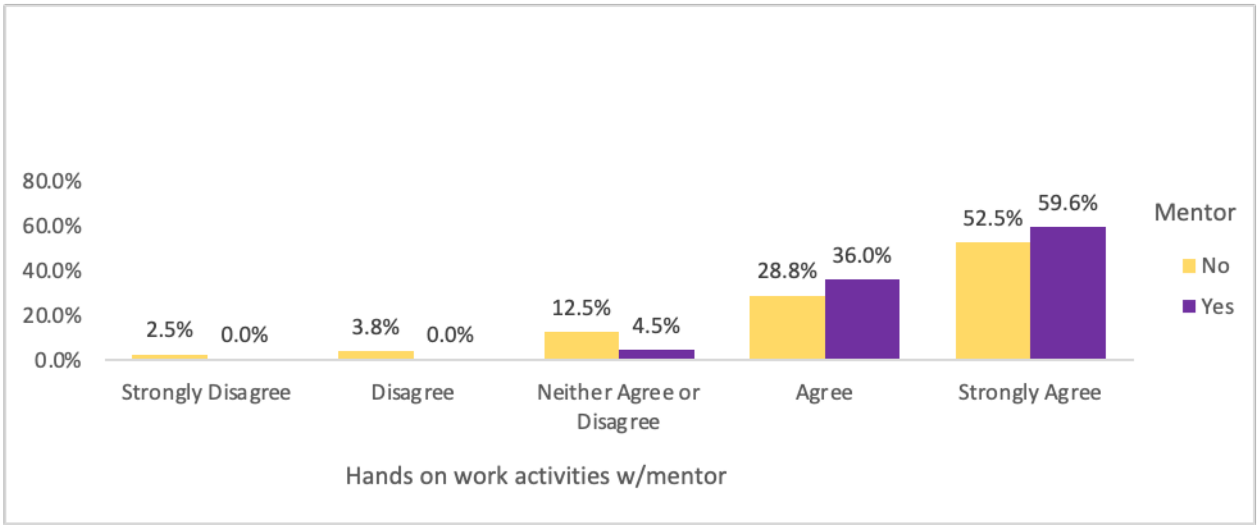

Figure 3. Influence of hands-on work activity. (Mentor)

Figure 4 represents the data distribution for the Role Model variable, and this data shows a similar pattern in the influences hands-on work activities had on the decision to pursue a career in the skilled construction trades along with the presence of a role model. Furthermore, statistical methods were used to test the data. The first analysis considered the Chi-square test. This test is used when trying to analyze the correlation between two variables and no causal effects. Furthermore, the variables were found not to be continuous and almost normally distributed, so a non-parametric version of the t-test was conducted as well using the Wilcoxon test that compares two paired groups. The Chi-square test yielded a p-value of .048 so we reject the null in favor of the alternate hypothesis. Furthermore, the non-parametric test conducted Wilcoxon, yielded p-values of .049 so we reject the null in favor of the alternate.

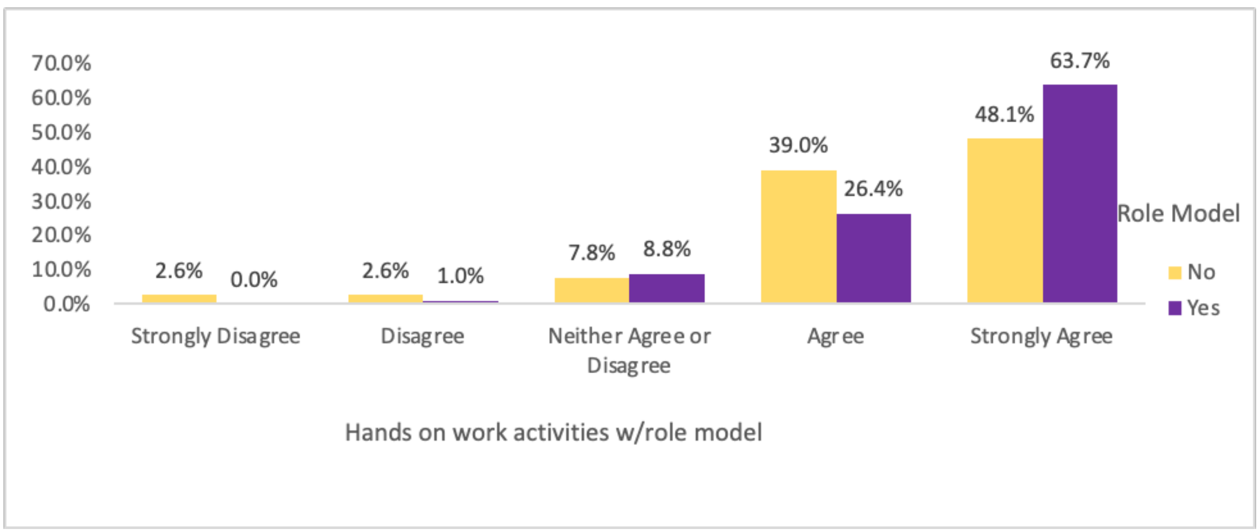

Figure 4. Influence of hands-on work activity. (Role model)

2.7 FINDINGS

Three of the seven tested hypotheses yielded findings that allowed authors to reject the null in favor of the alternate including hypothesis one, prestige and the presence of a role model, with a P-value of .007, hypothesis three, room for advancement in the construction industry and the presence of a mentor or role model with P-values of .02 and .005 respectively, hypothesis six, hands-on work and the presence of either a mentor or role model with P-values of .04 and .019 respectively.

Hypothesis one focuses on the opinion of the prestige of the construction industry and the impact of a mentor or role model proved to yield statistical significance from those who reported having a role model and less than significant results for those who reported having a mentor while using the non-parametric test.

Hypothesis three focuses on the opinion of room for advancement in the construction industry and the presence of a mentor or role model and proved to yield statistical significance for those who reported having a mentor or role model while using the Wilcoxon non-parametric test.

Hypothesis six focuses on the opinion of hands-on work and the presence of a mentor or role model and proved to yield statistical significance for those who reported having a mentor or role model on both the chi-squared test as well as the Wilcoxon non-parametric rest.

2.8 LIMITATIONS OF THE STUDY

This study provides a snapshot of a qualifying segment of those who have chosen to enter the skilled construction trades through a skilled construction trades training program in Salt Lake City, Utah at the Utah Career Center. The initial deployment of a cross-sectional survey tool made data available allowing authors to create valuable insight and analysis from the data collected it is constrained by a limited participant pool and the natural confines of a survey-based research methodology.

2.9 FUTURE WORK

The possibilities for future work range from additional distribution of the first-of-a-kind survey tool to larger study populations and different demographic areas, and the development of new hypotheses from the collected data of the initial distribution. Moreover, recruitment efforts for skilled trade training programs can benefit from the data collected from the initial distribution by focusing efforts on the differences between the importance of mentors versus role models.

2.10 CONCLUSION

For the sake of brevity, this study was limited to seven fully defined hypotheses leaving an opportunity for new hypotheses to be developed and tested utilizing the same survey tool on a new participant pool. The overarching conclusion of this and contributing work is that the first-of-a-kind survey tool developed for this work is successful in identifying impactful factors and people regarding the decision-making process of those who chose to pursue a career in the skilled construction trades via a skilled trades training program.

Moreover, the difference in opinion of the participant pool for this study suggests that a difference in opinion of the presence of a mentor versus the presence of a role model may exist, creating an opportunity for future work.

Based on the data provided by this first-of-a-kind survey tool, the potential for a paradigm shift in the recruitment approach utilized by skilled trades training programs, contractors, and educational universities. Furthermore, the potential for role model-based training programs for young people appears to be a logical next step based on results from this participant pool however, the survey tool needs to be leveraged against a larger participant pool now that it has been proven statistically significant.

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- Has awarded scholarships to deserving construction students at American colleges and universities.
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