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LEAN-BASED ANALYSIS OF FACTORS INFLUENCING METAL STUD FRAMING AND DRYWALL WORKERS' PRODUCTIVITY

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ABSTRACT
Over the past five decades, the U.S. construction industry has experienced a steady decline in value added per worker, prompting researchers and industry professionals to examine the root causes of production inefficiencies. While much of the existing research on labor productivity has focused on broader industry trends and certain project types, the unique challenges faced by individual trades have often been overlooked. This study seeks to fill that gap by investigating key factors affecting the productivity of metal stud framing and drywall workers on commercial construction projects, using four projects managed by a national general contractor in central and north Texas as a case study. The research employed a combination of lean construction tools—including process mapping, individual plus-delta interviews, and a big-room meeting—alongside structured descriptive surveys. Results identified 20 major factors influencing labor productivity, with workers emphasizing 10 as the most critical: inadequate or limited tools, scheduling conflicts with other trades, inconsistent material and tools storage points on jobsites, excessive phone usage by coworkers, frequent interruptions, poor overtime management, long commutes to the jobsites, limited choice in work partner selection, excessive heat during summers, and insufficient training. These findings provide valuable insights for metal stud framing and drywall trade contractors and researchers, highlighting specific challenges that impact labor productivity and offering a foundation for targeted interventions based on the reported factors in this study.

KEYWORDS
Labor Productivity, Factors, Lean Construction, Drywall, Metal Stud Framing

INTRODUCTION
Labor productivity is a complex concept with various implications depending on the context. In construction, it is generally defined as the ratio of output to input, with a strong focus on maximizing efficiency while making the best use of available resources (Jarkas and Bitar 2012). Productivity is a key factor in determining the success of construction projects, as it directly impacts costs, timelines, safety, and overall outcomes (Yates 2014). Despite its importance, the U.S. construction industry has experienced a steady decline in labor productivity, dropping by approximately 1% annually from the early 1970s to 2020.

This decline is particularly concerning when compared to the 260% increase in productivity seen in the broader workforce during the same period. Additionally, the value added per worker

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in the construction industry was 40% higher in 1970 than it was in 2020, which underscores the urgency of exploring this issue (Goolsbee and Syverson 2023). For trades such as metal stud framing and drywall installation, labor costs typically account for 55% to 65% of total project expenses, making labor productivity a critical factor in ensuring project success (Williams and Anderson 2016). While there is extensive research on general productivity challenges in the construction industry, trade-specific studies are relatively rare, especially those focused on internal jobsite factors. This gap is particularly evident in specialized trades such as metal stud framing and drywall, where jobsite-specific dynamics and challenges can significantly influence labor productivity.

This study aims to address this gap by investigating the internal jobsite factors that affect labor productivity of the metal stud framing and drywall workers on commercial projects. The research was conducted on four projects managed by a U.S.-based national general contractor, using lean construction techniques such as process mapping, plus-delta interviews, big room meetings along with structured descriptive surveys. The findings are intended to provide actionable insights for industry professionals and contribute to the ongoing conversation about improving labor productivity in construction.

LITERATURE REVIEW

Labor productivity plays a crucial role in the construction industry, directly affecting project costs, timelines, and overall outcomes. Productivity is broadly defined as the ratio of output to input and is often measured in terms of efficiency and resource optimization (Jarkas and Bitar 2012). While productivity improvements have been observed in other industries, the U.S. construction industry has faced a significant decline in labor productivity, highlighting the urgent need to address this issue (Goolsbee and Syverson 2023). Construction labor productivity is influenced by both internal and external factors. Internal factors include project characteristics, workforce skills, management practices, and technology adoption, while external factors are typically beyond a project team's control, such as regulatory compliance, macroeconomic conditions, and weather (Durdyev et al. 2018; Kuroshi and Lawal 2014). Lean construction principles, such as process mapping and Kaizen, have been increasingly applied to address productivity challenges. Frameworks differentiating internal and external factors provide a foundation for analyzing productivity determinants (Thomas et al. 2003). Despite extensive research on the factors affecting construction productivity around the world, there is a lack of focus on specific trades such as metal stud framing and drywall installation.

These trades face unique challenges, including workforce skill deficits, environmental factors, and inefficiencies in scheduling (Williams and Anderson 2016). Research on trade-specific factors is critical for addressing productivity gaps in this context. Key internal factors include project fragmentation, workforce management, and the learning curve effect. Fragmentation has been shown to create inefficiencies due to miscommunication and delays, particularly in drywall trades (Alashwal and Fong 2015). Rework is another critical factor, often caused by change orders and labor skill deficits, which significantly reduce productivity (Ibbs 2005; Arashpour et al. 2014; Mahamid 2020). External factors such as extreme weather further compound these challenges by reducing worker output and delaying material drying times (Grimm and Wagner 1974; Hancher and Abd-Elkhalek 1998). Meanwhile, advancements in technology, such as Building Information Modeling (BIM) and prefabrication, have proven to streamline workflows, although their implementation requires significant training and cultural shifts (Konchar and Sanvido 1998; Kog and Loh 2012). Table 1 represents a summary of previous peer-reviewed studies on factors affecting labor productivity in various parts of the world.

Table 1: Peer-Reviewed Studies on Factors and Subfactors Affecting Labor Productivity in the Owner, Architect, Contractor, and Engineer (OACE) Industry

MAIN FACTOR	SUB-FACTOR	REFERENCES
Change orders	Creation of new sequences Workflow interruptions Causes rework Exacerbation of the cumulative impact	Ibbs (2005); Hanna et al. (1999); Moselhi et al. (1991)
Rework	Lack of labor skills Noncompliance with building codes Excessive change orders Inadequate job planning and coordination	Arashpour et al. (2014); Mahamid (2019)
Weather Conditions	Physical discomfort Difficulty in handling materials Heat stress reduces crew stamina and focus	Grimm and Wagner (1974); Li et al. (2016); Hancher Abd-Elkhalek (1998)
Project Fragmentation	1. More encounter between different teams increases the chances of miscommunication and delays	Alashwal and Fong (2015)
Impacts of learning curves	1. Learning new methods and familiarity with new tools can slow down production rates for the time being. 2. Human errors	Everett and Farghal (1994)
Motivational Factors	1. Weak incentive programs 2. Lack of transparent communication 3. Non efficient leadership 4. Absence of the culture of respect	Maloney (1981)
Excessive overtime	1. Fatigue 2. Rework 3. Human error 4. Production per hour declines after longer than 40hr/week	Hanna et al. (2005)
Balance of Skilled Vs Unskilled Labor	1. Unskilled tend to make more mistakes 2. Lack of training and experience are identified as main causes	Bröchner and Olofsson (2012); Jarkas and Bitar (2012)
Role of Project Management Team	1. Poor scheduling. 2. Jobsite workers mobility limitations.	Ballard and Howell (1998)
Role of Technology	1. Lack of technologies like Building Information Modeling. 2. Lack of prefabrication. 3. Lack of software training.	Konchar and Sanvido (1998); Kog and Loh (2012)
Complexity of Building design	1. Complex projects are prone to higher percentage of errors.	Nguyen et al. (2004)

While much has been written about general labor productivity challenges in construction, limited research focuses on internal jobsite factors affecting productivity in specific trades. This study aims to address this gap by investigating the determinants of labor productivity in metal stud framing and drywall installation, providing actionable insights for industry stakeholders.

RESEARCH METHOD

This study employed a systematic four-step methodology, supported by a comprehensive literature review, to identify the factors influencing metal stud framing and drywall jobsite labor productivity. The research was conducted across four active commercial drywall projects in Texas, USA. Workers were randomly selected for this study on the four commercial projects based on their willingness and availability. First, the process began with two full days of site observations at each project site. These observations focused on analyzing the existing workflows and identifying inefficiencies that hindered productivity. Second, individual plus-delta interviews were conducted with metal stud framing and drywall workers.

These plus delta interviews aimed at gathering insights into specific aspects of their jobs, three things that they appreciated about their jobs, three challenges that made their work difficult, and three suggestions for improvements to enhance job satisfaction. Subsequently, building on insights from literature, interviews and site observations, descriptive surveys were developed assessing 23 factors. The surveys were designed based on theoretical framework presented by Mbachu and Nkado (2007) and distributed to workers to capture their perspectives quantitatively. Finally, a "big room meeting" was convened to conduct a root cause analysis of the main factors affecting jobsite workers productivity. This session involved group brainstorming around the same three questions asked during the individual plus-delta interviews (Prabaharan et al. 2024). These four steps, summarized in Figure 1, align with lean principles of kaizen, process mapping, root cause analysis through plus delta interviews, big room meeting and descriptive surveys particularly in identifying and addressing jobsite wastes.

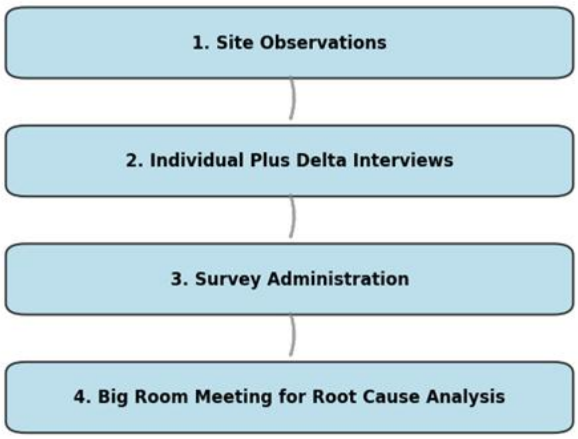

Figure 1: Research Methodology

WORKERS DEMOGRAPHIC AND SOCIOECONOMIC PROFILES

This study analyzed data from four metal stud framing and drywall projects by a national contractor in central and north of Texas. The Observational phase included 126 workers, with 68 participating in plus-delta interviews, 69 responding to the descriptive surveys, and 43 attending a big room meeting. Survey data, collected anonymously, provides key demographic and workforce insights. Figures 2A and 2B highlight demographics: 94.6% of workers were male, and roles are distributed as 44.9% laborers/helpers, 40.6% apprentices, and 14.5% journeymen, reflecting a hierarchical structure of the company.

Figures 3A and 3B depict experience and age distributions of the workers. Most workers (26) had over 10 years of experience, while 22 had 1–3 years. The majority were aged 26–40 (27 workers), followed by 41–55 (15 workers), demonstrating an experienced, mid-career workforce.

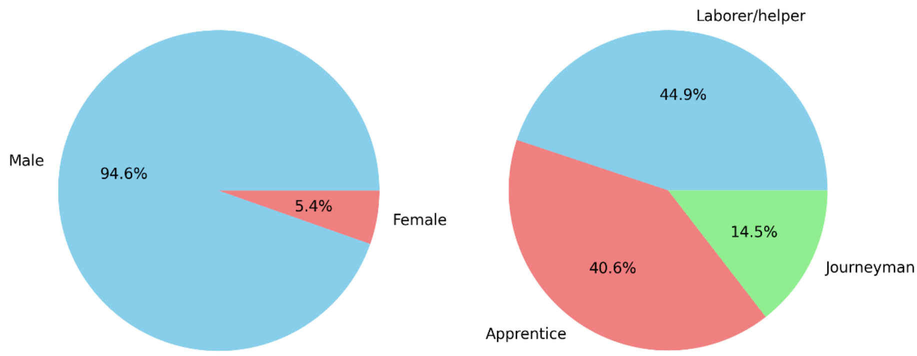

Figure 2: Part A (Workers Gender Distribution); Part B (Workers Roles within the Company)

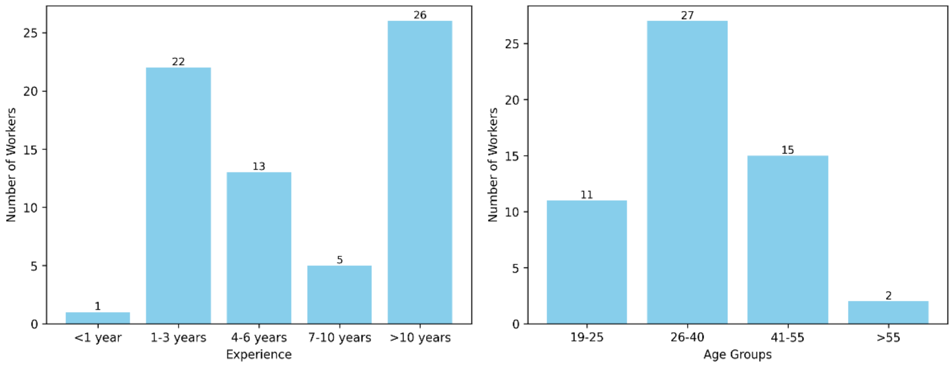

Figure 3: Part A (Workers Experience); Part B (Workers Age Groups)

Figures 4A and 4B show the annual household income of workers. Most workers earned \$25,000–\$49,000 annually, with the majority (30) holding a high school diploma or equivalent. Education levels amongst workers ranged from elementary school to vocational training. These findings provide a comprehensive view of the participating workers demographics, and socioeconomic context, which plays a critical role in the analysis of jobsite labor productivity.

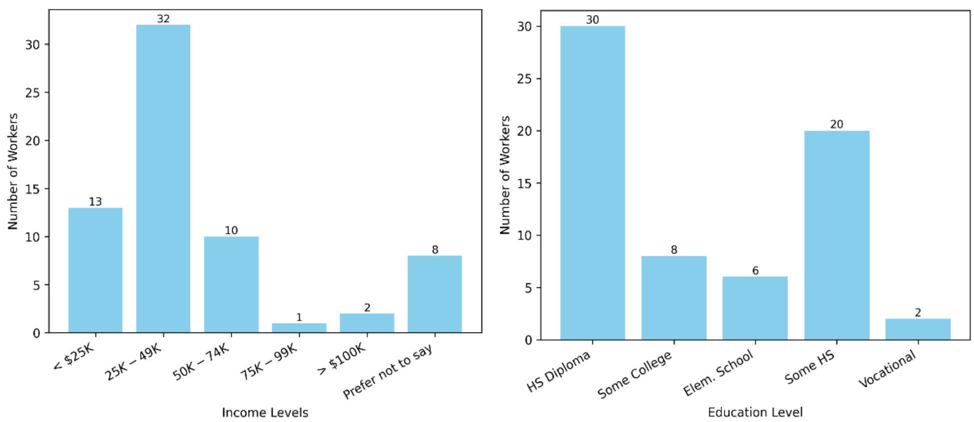

Figure 4: Part A (Workers' Household Income Distribution); Part B (Workers' Education)

DATA ANALYSIS

To analyze the 23 factors assessed in the descriptive survey, Multi-Attribute Analytical Technique (MAAT) was employed to evaluate the mean ratings provided by the survey respondents. This method, recommended by Chang and Ive (2002) and Mbachu and Nkado

(2007), is widely recognized as a robust approach for assessing group ratings across a set of variables, particularly in contexts like construction labor productivity studies. The analysis involved calculating the Mean Rating (M), which serves as the representative rating for each factor in the dataset. The calculation of the (M) was performed using the following formula:

$$\mathrm{M} = \sum_{i=1}^{5} \left(P_i \times R_i\%\right) \tag{1}$$

Here, M represents the Mean Rating for the factor under consideration, which is calculated as the sum of the product of each rating point (P) and the corresponding percentage response to it (R%) out of the total number of responses (Mbachu and Nkado 2007). Pi is the rating point (ranging from 1 to 5) where 1 signifies "Strongly Agree" and 5 represents "Strongly Disagree." Ri% is the percentage response to the rating point for the variable under consideration. The parameters derived from the Likert scale survey data were grouped and analyzed using equation (1). Significant and non-significant constraint factors were distinguished based on their Mean Ratings (M). Factors with an (M) greater than 2.5 are categorized as significant, indicating areas requiring improvement or greater attention. Conversely, factors with an (M) less than 2.5 were classified as non-significant, representing less concern or satisfactory performance. This analysis method provides an understanding of the survey data and identifies key factors affecting the productivity of metal stud framing and drywall workers.

$$\text{Significant constraint factor: M} > 2.5 \tag{2}$$

$$\text{Non-significant constraint factor: M} < 2.5 \tag{3}$$

The data collected from two days of observations at each of the four projects were systematically organized into a single medium level *Process Map.* Additionally, the responses from 68 workers who participated in the plus-delta interviews, along with the input from the 43 workers who attended the big room meeting, were analyzed using *Pareto charts*. Three distinct Pareto charts were developed, each based on the frequency of responses to the three primary questions asked during the interviews and in the Big Room meeting. These charts provide a visual representation of the most significant aspects that workers like about their jobs, the difficulties that they face and their suggestions for improvements.

RESULTS AND DISCUSSION

Figure 5 shows a medium-level process map developed during the initial observational phase of this study. It outlines a step-by-step workflow of the metal stud framing and drywall construction process, starting with marking the layout on the floor and ceiling, followed by stacking materials, installing metal tracks, measuring and cutting studs, and completing MEP rough-ins. The process-map workflow integrates corrective actions when necessary, such as reorganizing materials or reinstalling components to ensure accuracy.

Figure 6 presents a Pareto chart summarizing 179 responses from 68 workers to the plus-delta interview question, "What are three things that you like about your job?" While most workers provided three responses, some listed only one or two, resulting in 179 responses instead of the expected 204 (68 × 3). The most frequently mentioned positive aspect was "not feeling rushed," highlighting workers' appreciation for a manageable pace that supports effective task completion. This was followed by "opportunity to learn daily" and "having an impactful job," reflecting the importance workers place on skill development and meaningful contributions to their projects. Additional positive aspects included "high safety standards" and "friendly co-workers," emphasizing a secure and supportive work environment.

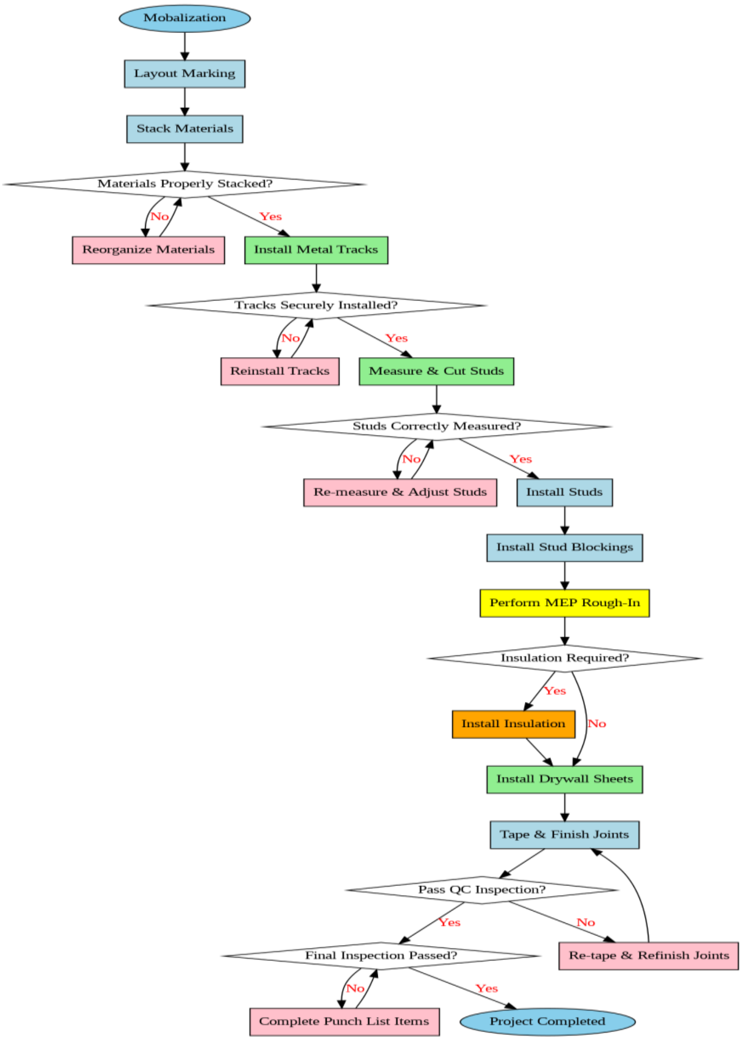

Figure 5: Medium Level Process Map of the Metal Stud framing and Drywall processes generated based on the observational phase of this study.

Less frequently mentioned were factors such as "overtime availability" and "flexible project schedules." The second question in the plus-delta interviews and the big room meeting asked, "What are three things you do not like about your job?" Figure 7 illustrates 192 responses in a Pareto chart, highlighting the challenges and areas of dissatisfaction reported by workers. The most significant issue identified was "limited/ inadequate tools," emphasizing the need for improved access to tools and equipment. Workers also frequently mentioned "schedule clashes with other trades" and the "lack of a specific materials and tools storage points on jobsites", which often led to time spent searching for items across the site. "Longer commute time to jobsites" was another major frustration.

Additional concerns included "no choice of co-workers selection," "lack of regular feedback," and "overtime mismanagement," reflecting systemic communication and organizational shortcomings. Environmental issues such as "excessive heat on jobsites" and "lack of lighting early in the morning and in the evenings" were also reported. Although less common, issues such as "language barriers with supervisors" and "trash on jobsites" were raised and remain areas that require attention.

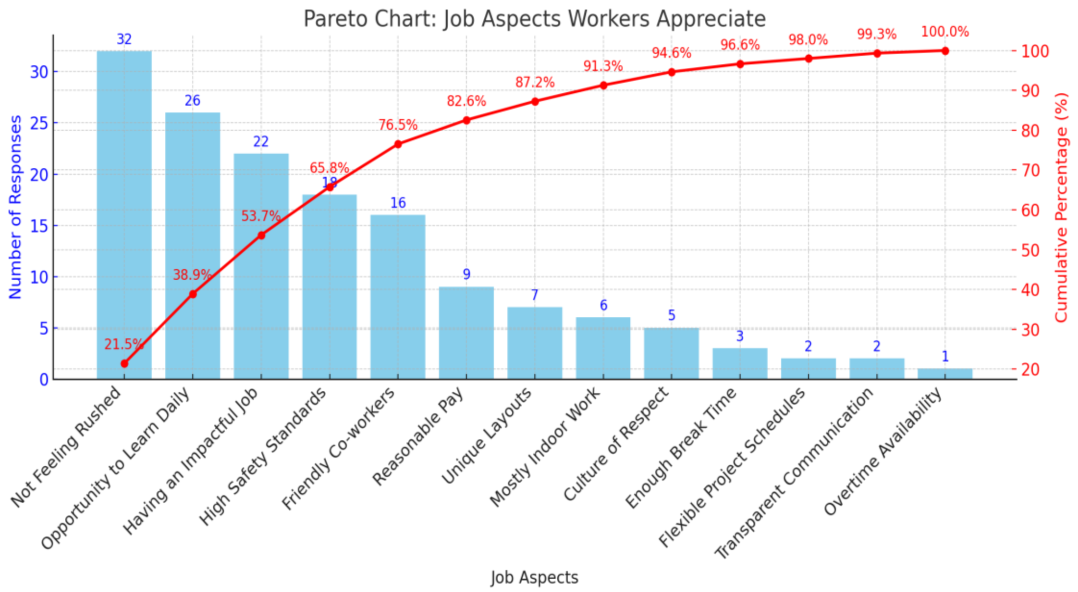

Figure 6: Pareto chart ranking aspects of the job that metal stud framers and drywall installers appreciated—results from plus-delta interviews and big room meetings

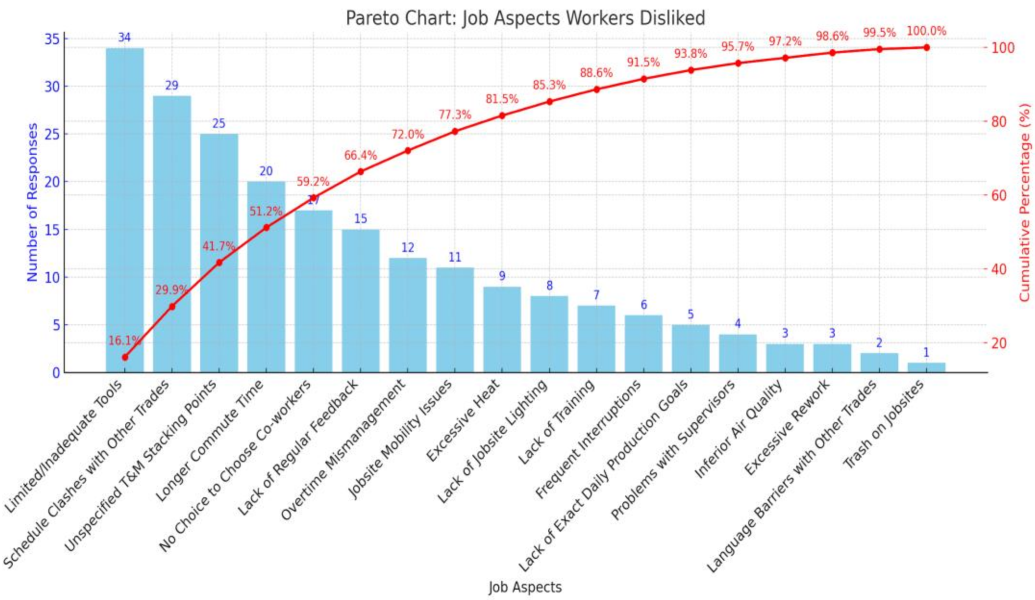

Figure 7: Pareto chart ranking aspects of the job that metal stud framers and drywall installers disliked—results from plus-delta interviews and big room meetings

Figure 8 depicts the workers' responses to the question, "What three improvements would you suggest to make your job easier?" A total of 115 responses were collected because some workers provided fewer than three suggestions. The most common recommendation was "tools should be provided to non-permanent workers also," reflecting dissatisfaction with the availability of adequate tools. Workers also suggested "specified stacking points for tools and materials on jobsites" and "equal benefits for permanent and non-permanent workers," aiming to improve fairness and resource organization. Other suggestions, such as "consistent foreman feedback" and "more training for new hires," highlighted the need for better guidance and skill development. Suggestions such as "closer parking lots for workers" and "better lighting on jobsites" addressed logistical issues.

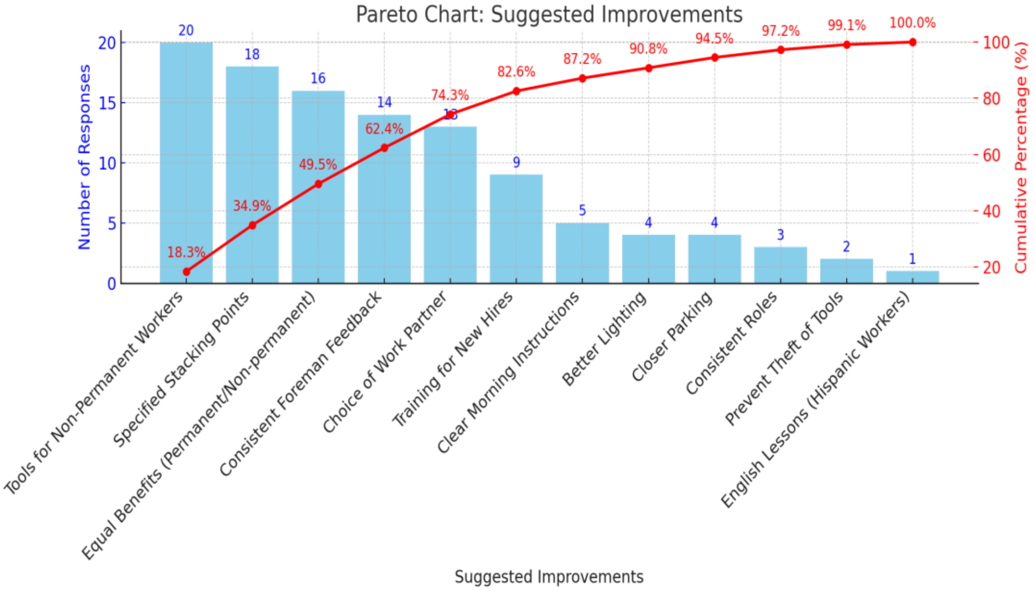

Figure 8: Pareto chart ranking aspects of the job that metal stud framers and drywall installers wanted to improve—results from plus-delta interviews and big room meetings

The descriptive survey results, summarized in Table 2, provide an overview of the mean ratings (M) for 23 productivity-related parameters assessed among the 69 participating workers.

Table 2: Mean Ratings of the 23 productivity parameters assessed in descriptive Survey.

Parameter	**Mean Rating (M)**
I have heard about Pull Planning.	3.82
Other trades (e.g., plumber, electrician) collaborate with me on jobsites.	3.40
I have some information about Lean Construction Principles.	3.30
I experience frequent interruptions.	2.94
I regularly receive feedback from my supervisor.	2.85
I am satisfied with my screw gun and shotgun.	2.80
I experience issues with my measuring tape.	2.70
Temperatures on jobsites are satisfactory.	2.60
I experience issues with my tool belt.	2.50
I experience issues with scaffolding, stilts, or ladders.	2.30
Team morale is high on jobsites.	2.20
I experience issues with my cutting knife or saw.	2.20
Indoor air quality on jobsites is satisfactory.	2.10
I collaborate with other trades on jobsites.	2.10
I receive adequate training.	2.00
I eat breakfast on workdays.	1.91
The current workflow and scheduling system are useful.	1.80
I feel that my concerns are taken seriously by my supervisors.	1.78
I drink enough water while working.	1.54
Communication with my supervisor is effective.	1.52
I prefer to do overtime.	1.49
My daily tasks and responsibilities are clear.	1.46
I do stretch or exercise before my work starts.	1.25

An (M) below 2.5 indicates a non-significant constraint, while an (M) above 2.5 signifies a significant constraint. In other words, the lower the (M), the less serious the issue. Several areas reflected positive practices on the jobsites, such as "I eat breakfast on workdays" (M = 1.91), "I drink enough water while working" (M = 1.54), and "Communication between me and my supervisor is effective" (M = 1.52). However, there were notable concerns, particularly regarding "I experience frequent interruptions" (M = 2.94) and "I regularly receive feedback from my supervisor" (M = 2.85), highlighting opportunities for improvement in productivity and workflow. The survey responses also revealed limited awareness of lean construction principles (M = 3.30) and pull planning (M = 3.82), emphasizing the need for enhanced training and education. Additionally, tool-related issues, such as difficulties with measuring tapes (M = 2.70) and scaffolding or ladders (M = 2.30), point to the need for addressing equipment-related inefficiencies. Overall, these results highlight both strengths and areas needing attention to improve jobsite productivity and worker satisfaction in the metal stud framing and drywall sector.

CONCLUSIONS

This study investigated factors influencing labor productivity among the metal stud framing and drywall workers by analyzing data from four active commercial projects managed by a national general contractor in central and north Texas. The research included two days of observations at each site, resulting in the development of a process map outlining the steps involved in the metal stud framing and drywall workflow. Semi-structured plus-delta interviews with 68 workers, summarized in three Pareto charts, revealed aspects that workers liked about their jobs, such as not feeling rushed while working, extensive opportunities for learning, and the ability to contribute meaningfully to their projects. However, workers reported numerous challenges impacting their productivity, including inadequate/limited tools, scheduling conflicts with other trades, a lack of consistent storage points for tools and materials on jobsites, long commutes to jobsites, limited choice in work partner selection, limited feedback from supervisors, excessive phone use by coworkers, jobsite heat in summers, poor lighting in early mornings and evenings, inadequate training for new hires, frequent interruptions, and the absence of clear daily targets. Suggestions for improvement largely aligned with the issues raised in the interviews, a desire for practical solutions to address worker concerns.

The survey, which assessed 23 productivity-related variables along with non-traceable biographic information, further identified significant constraints such as lack of information about Pull Planning (M = 3.82), lack of coordination from other trades (M = 3.4), frequent interruptions (M = 2.94), limited feedback from supervisors (M = 2.85), insufficient knowledge of Lean Construction principles (M = 3.30), equipment-related inefficiencies, including issues with measuring tapes (M = 2.70) and scaffolding and ladders (M = 2.30), were also highlighted as relatively significant barriers to productivity. This study leveraged lean techniques to identify key productivity factors in the metal stud framing and drywall trade, as lean provides tools such as plus-delta analysis, process mapping, and a clear delineation between value-added and non-value-added activities that proved instrumental during the observational stage. One major *limitation* of this study is that it examined only a single general contractor and focused solely on right-to-work, non-union workers.

Future research can concentrate on identifying factors that affect labor productivity of drywall workers across various general contractors and union settings as well. Additionally, implementing countermeasures that target the identified root causes and assessing their impact on workers' productivity and overall jobsite performance would help validate the findings, offering a valuable launch point for research with other companies as well.

REFERENCES

Akinci, B., Fischer, M., & Zabelle, T. (1998). Proactive approach for reducing non-value-adding activities due to time-space conflicts. *In Proceedings of the 6th Annual Conference of the International Group for Lean Construction IGLC-6*. Guaruja, Brazil.

Alashwal, A. M., & Fong, P. S. W. (2015). Empirical study to determine fragmentation of construction projects. *Journal of Construction Engineering and Management,* 141(7), 04015016. https://doi.org/10.1061/(ASCE)CO.1943-7862.0000986

Arashpour, M., Wakefield, R., Blismas, N., & Lee, E. W. M. (2014). Analysis of disruptions caused by construction field rework on productivity in residential projects. *Journal of Construction Engineering and Management*, 140(2), 04013053. https://doi.org/10.1061/(ASCE)CO.1943-7862.0000804

Ballard, G., & Howell, G. (1998). Shielding production: Essential step in production control. *Journal of Construction Engineering and Management*, 124(1), 11–17. https://doi.org/10.1061/(ASCE)0733-9364(1998)124:1(11)

Bröchner, J., & Olofsson, T. (2012). Construction productivity measures for innovation projects. *Journal of Construction Engineering and Management*, 138(5), 670–677. https://doi.org/10.1061/(ASCE)CO.1943-7862.0000481

Chang, C. Y., & Ive, G. (2002). Rethinking the multi-attribute utility approach based procurement route selection technique. *Construction Management & Economics*, 20(3), 275-284. https://doi.org/10.1080/01446190110117608

Durdyev, S., Ismail, S., & Kandymov, N. (2018). Structural-equation-model analysis of the factors affecting construction labour productivity. *Journal of Construction Engineering and Management,* 144(4), 04018007. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001452

Everett, J. G., & Farghal, S. (1994). Learning curve predictors for construction field operations. *Journal of Construction Engineering and Management*, 120(3), 603–616. https://doi.org/10.1061/(ASCE)0733-9364(1994)120:3(603)

Goolsbee, A., & Syverson, C. (2023). The strange and awful path of productivity in the U.S. construction sector (NBER Working Paper No. 30845). *National Bureau of Economic Research*. https://doi.org/10.3386/w30845

Grimm, C. T., & Wagner, N. K. (1974). Weather effects on mason productivity. *Journal of the Construction Division,* 100(3), 319–335. https://doi.org/10.1061/JCCEAZ.0000438

Hancher, D. E., & Abd-Elkhalek, H. A. (1998). The effect of hot weather on construction labour productivity and costs. *Cost Engineering*, 40(4), 32.

Hanna, A. S., Russell, J. S., Nordheim, E. V., & Bruggink, M. J. (1999). Impact of change orders on labour efficiency for electrical construction. *Journal of Construction Engineering and Management*, 125(4), 224-232. https://doi.org/10.1061/(ASCE)0733-9364(1999)125:4(224)

Hanna, A. S., Russell, J. S., Gotzion, T. W., & Nordheim, E. V. (1999). Impact of change orders on labour efficiency for mechanical construction. *Journal of Construction Engineering and Management*, 125(3), 176-184. https://doi.org/10.1061/(ASCE)0733-9364(1999)125:3(176)

Hanna, A. S., Taylor, C. S., & Sullivan, K. (2005). Impact of extended overtime on construction labour productivity. *Journal of Construction Engineering and Management*, 131(6), 734–739. https://doi.org/10.1061/(ASCE)0733-9364(2005)131:6(734)

Ibbs, W. (2005). Impact of change's timing on labour productivity. *Journal of Construction Engineering and Management*, 131(11), 1219–1223. https://doi.org/10.1061/(ASCE)0733-9364(2005)131:11(1219)

Jarkas, A. M., & Bitar, C. G. (2012). Factors affecting construction labour productivity in Kuwait. *Journal of Construction Engineering and Management*, 138(7), 811–820. https://doi.org/10.1061/(ASCE)CO.1943-7862.0000501

Konchar, M., & Sanvido, V. (1998). Comparison of U.S. project delivery systems. *Journal of Construction Engineering and Management*, 124(6), 435–444. https://doi.org/10.1061/(ASCE)0733-9364(1998)124:6(435)

Kog, Y. C., & Loh, P. K. (2012). Critical success factors for different components of construction projects. *Journal of Construction Engineering and Management,* 138(4), 520–528. https://doi.org/10.1061/(ASCE)CO.1943-7862.0000464

Kuroshi, P. A., & Lawal, M. (2014). Study of internal factors affecting labour productivity in medium sized construction firms in Nigeria. *International Journal of Education and Research,* 2(12), 83–92. https://ijern.com/journal/2014/December-2014/08.pdf

Li, X., Chow, K. H., Zhu, Y., & Lin, Y. (2016). Evaluating the impacts of high-temperature outdoor working environments on construction labour productivity in China: A case study of rebar workers. *Building and Environment*, 95, 42–52. https://doi.org/10.1016/j.buildenv.2015.09.005

Maloney, W. F. (1981). Motivation in construction: A review. *Journal of the Construction Division,* 107(4), 641–647. https://doi.org/10.1061/JCCEAZ.0000994

Mahamid, I. (2020). Study of relationship between rework and labour productivity in building construction projects. *Revista de la Construcción*, 19(1), 30–41. http://dx.doi.org/10.7764/rdlc.19.1.30-41

Mbachu, J., & Nkado, R. (2007). Factors constraining successful building project implementation in South Africa. *Construction management and economics*, 25(1), 39-54. https://doi.org/10.1080/01446190600601297

Moselhi, O., Leonard, C., & Fazio, P. (1991). Impact of change orders on construction productivity. *Canadian Journal of Civil Engineering*, 18(3), 484–492. https://doi.org/10.1139/l91-059

Nguyen, L. D., & Ogunlana, S. O. (2004). A study on project success factors in large construction projects in Vietnam. *Engineering, Construction and Architectural Management,* 11(6), 404–413. https://doi.org/10.1108/09699980410570166

Prabaharan, R., Devkar, G., Rybkowski, Z. K., & Kannimuthu., M. (2024). The Repair-Co Game: A roadmap to demonstrate the importance of problem-solving capabilities of Lean tools. *Proceedings of the 32nd Annual Conference of the International Group for Lean Construction (IGLC32) (pp. 1303–1313).* https://doi.org/10.24928/2024/0211

Thomas, H.R., Horman, M.J., Minchin Jr, R.E., & Chen, D. (2003). Improving labor flow reliability for better productivity as lean construction principle. *Journal of construction engineering and management*, 129(3), 251-261. https://doi.org/10.1061/(ASCE)0733-9364(2003)129:3(251)

Williams, G. H., & Anderson, T. R. (2016). Impacts to productivity in metal stud framing and the hanging and finishing of gypsum Drywall. *In 2016 Portland International Conference on Management of Engineering and Technology (PICMET) (pp. 2290-2299).* IEEE. https://doi.org/10.1109/PICMET.2016.7806805

Yates, J. K. (2014). Productivity improvement for construction and engineering: Implementing programs that save money and time. *American Society of Civil Engineers.* https://doi.org/10.1061/9780784413463