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A Comparative Analysis of Lean Approaches Among Trade-Contractors

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Abstract

Question: Q1) What capabilities assist trade contractors in successfully implementing Lean Construction? Q2) How do different trade contractor organizations implement and sustain lean practices and initiatives? Q3) What distinguishes excellent adopters from their peers?

Purpose: The purpose of this paper is to compare how trade contractors adopt and sustain lean processes, training, and methods, based upon a framework of Lean Construction principles in their organizations.

Research Method: Seven case studies were selected from successful lean adopters among trade contractor companies to illustrate how a trade contractor can employ lean initiatives to improve their operations and construction processes. The paper presents a comparative analysis of each contractor's approaches to present common elements of successful contractors and highlight some variations among the firms.

Findings: The study identified eight categories common across trade contractor organizations to successfully implement Lean Construction for their projects. The results of the comparative analysis further indicate that although there are many similarities in how each company consolidates lean approaches into their activities, some variations in how they implement these approaches were recognized, differentiating highly successful firms from their peers. The attributes observed in the most successful firms that differentiated them from their peers are their emphases on continuous improvement, people, and process.

Limitations: Lack of a clear population of lean adopters among trade contractors necessitated purposeful sampling techniques rather than random sampling. Moreover, due to the time-intensive nature of the case study process, the results were drawn based on seven case studies.

Implications: By highlighting similarities and differences in how each organization pursues its methods and improvement process, the path to achieving continuous improvement for the trade contractor community can be more clearly identified.

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Value for authors: All trade contractor organizations can consider the provided approaches to start their transformation or become more successful adopters.
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Introduction

As the construction industry strives to improve performance, developing more productive working environments and advanced methods has become increasingly imperative. In this regard, lean philosophy offers a promising approach to enhancing productivity (Babalola et al., 2019). Lean thinking emphasizes reducing waste and continuously improving production, which makes it easy to incorporate into construction because it conforms to existing management practices, resulting in better project outcomes. To depict how lean principles can be implemented within the construction industry, Koskela developed the Transformation-Flow-Value (TFV) theory by incorporating elements from Craft, Mass, and Lean Production paradigms, along with a value management perspective. By deconstructing each paradigm and analyzing its attributes, elements from different paradigms were creatively combined to form TFV theory, focusing on value creation (Abdelhamid, 2004). The 'TFV' theory of production conceptualizes production in three complementary ways, namely, as Transformation (T) of raw materials into standing structures, as a Flow(F) of the raw material and information through various production processes, and as Value (V) generation and creation for owners through the elimination of value loss (Abdelhamid et al., 2008). Built on this, Lean Construction is defined as a "way to design production systems to minimize waste of materials, time, and effort in order to generate the maximum possible amount of value," (Koskela et. al, 2002). Accordingly, applying lean principles and methods provides construction companies with numerous benefits, including but not limited to improved productivity, increased predictability, better quality, reduced cost, shortened schedules, enhanced safety, minimized waste, and higher client/employee satisfaction and commitments (Koskela et al., 2002; Mossman, 2009; Asadian et al., 2022). Despite the wealth of literature concerning lean and Continuous Improvement (CI) in construction, little work has been performed targeting trade contractors. However, the approaches for how a trade construction company can adopt and maintain these practices must be clarified. This study, therefore, investigates how successful adopters currently use production methods and lean principles among trade contractors.

During the past few years, several case studies of construction companies recognized for their production approaches and lean emphasis have been conducted (e.g., Andersen et al., 2012; Li et al., 2017; Xing et al., 2021). In most cases, these studies offer limited generalizations outside of the specifics of one case or firm. This limits the ability of others to benefit from the findings that apply to a broader range of organizations. Further, none of these studies targeted comparison analyses of trade contractor companies that have prospered as successful lean adopters. It is through cross-organizational comparisons with successful adopters the trade community can be furnished with actionable insights aimed at their implementation of lean practices. To fill this gap, the present study offers a more comprehensive and varied base for discussion from seven case studies of successful lean adopters within the trade contractor community. For this purpose, data collected from the case studies were used for a comparative analysis to understand how and why different

strategies, approaches, and lean methods contribute to that success. The analysis and compilation of the approaches and methods used should be of value and interest to trade contractors, as showing the lean organizations' experience can play a significant role in promoting lean and accelerating the uptake of Lean Construction (LC) by trade organizations (Aslam et al., 2020). The study also presents practical recommendations to guide trade contractors' continuous improvement efforts.

Literature Review

Lean principles offer notable benefits to company operations while simultaneously improving quality, costs, and cycle times of production (Cudney et al., 2011). Therefore, many construction companies employ these principles and methods for their projects to improve the quality of their work and the efficiency of their operations. However, the degree to which a construction company can benefit from adopting lean practices varies. The general pattern within the industry reveals that prominent methods are primarily adopted by general contractors (GC) or construction management companies (CM), with trade contractors lagging in adoption. As Miller et al. (2002) pointed out, specialty contractors, or trade contractors, currently account for approximately 80% of the work performed by the industry. Yet, the industry places minimal emphasis on developing lean construction within the trade community of this subcontracted sector. The subcontracted firm is viewed as a component of the construction process rather than as an independent decision-making entity. Kim and Park (2006) further highlighted that although the workers and staff of the main contractor are familiar with lean tools, their subcontractors are often not aware or knowledgeable of basic lean principles. These construction trades can be key implementers of lean practices, as they perform activities that add value to the construction process by putting work in place on construction sites. This gap indicates that applying lean methods will benefit both their company and the construction industry in general. Due to the inherent distinctions in the nature of work between trade contractors and Construction Management/General Contractor (CM/GC) organizations, it becomes pivotal to delve into how lean practices can be explicitly adopted within trade contractors. Unlike CM/GC, trade contractors are directly accountable for executing on-site tasks, while CM/GC oversee the coordination among multiple trade contractors, often navigating conflicting procedures and demands. This dichotomy underscores the need to explore how their unique customer profiles and operational needs influence the application of lean methodologies in trade contractor contexts.

Based on the current adoption of lean methods by trade contractors in the construction industry, several barriers prevent their widespread use, including cultural and human factors, management commitment and support, skills and knowledge, fragmentation and procurement, and resources (Asadian et al., 2023). This suggests a deeper dive into the pathways and approaches that may better resonate with the trade community. Despite this need, little previous research has attempted to explore and compare successful trade contractors to show how they implement lean practices and initiatives to boost their performance and business outcomes. Depicting how successful trade contractors embark on lean in their organizations can help new adopters understand and customize the adoption and selected methods for their own companies. Torp et al. (2018) confirmed the importance of showing success from early adopters in the implementation by considering it as an important factor affecting lean adoption. As a

result, this research aims to perform comparative implementation analyses across seven case studies among trade contractors in the United States.

Conducting a comparative study among seven successful adopters will help the construction community understand the similarities and differences in how various trade contractors can implement lean practices for their projects from a practical point of view. This study does not intend to offer a guideline to explain how a construction company should adopt these initiatives or propose the best approach for a particular organization. Still, it will provide potential insights regarding how an array of methods, training approaches, and processes are currently employed. Meanwhile, the lessons derived from the practices of these construction companies can provide further context and insight to trade peers.

Lean Principles: Toyota Way

Lean philosophy was initially developed by the Toyota Motor Corporation (Toyota) as a strategic solution for Japan's financial crisis-era post-World War II (Shah et al., 2007). Toyota management established a novel production system, named “Toyota Production System (TPS),” to produce high-quality automobiles despite the difficult economic circumstances of those days, helping them to do more with less (Womack et al., 1997). Although the paradigm was initially recognized as a strategic means to better production outcomes, such as improved efficiency, quality, and productivity (Murray, 2008), lean soon gained its place outside the manufacturing industry as a performance improvement method (Jadhav et al., 2014), finding its application in a wide range of organizations, including construction. In this regard, efforts to encourage the application of lean theory in the construction industry, entitled Lean Construction (LC), have been growing worldwide. Despite using several names to describe a unique concept, lean is usually described as a philosophy of guiding principles and overarching goals through a strategic or philosophical lens or a set of management practices, tools, and techniques (Bortolotti et al., 2015). Therefore, to understand why some organizations are more successful in implementing lean practices, understanding the fundamental principles of lean and how they incorporate them into their organizational culture is crucial. Organizational culture (OC) refers to collectively held values and beliefs shaping individuals' perceptions, reactions, and actions. Embedding Lean principles within the fundamental culture is vital for enduring and successful Lean adoption, necessitating a prior understanding of organizational culture and its dimensions to inform a resilient change management approach (Simon et al., 2018). Thus, in this section, the underpinning principles of lean are presented.

Several researchers identified lists of principles for lean, namely (Womack et al., 1997; Koskela, 1992; Melles, 1997; Luo et al., 2005; Gambatese et al., 2017). Although each scholar presented different terms to itemize lean principles, some similarities, such as concentrating on the customer, focusing on the whole process, and continuous improvement, can be seen among them. In one of the most thorough versions, Liker presented 14 principles that drive the techniques and tools of the Toyota Production System (TPS) and the management of Toyota in general (Liker, 2004). For ease of understanding, Liker has divided the principles into four categories, all starting with “ P”:

- **Philosophy -** Long-term Philosophy: Toyota focuses on adding value to customers and society, deriving a long-term approach to building a learning

organization that can adapt to changes and survive as a productive organization.

- **Process -** The Right Process Will Produce the Right Results: Toyota is a process-oriented company that believes flow is the key to achieving the best quality at the lowest cost with high safety and morale. They trust that using the right process will lead to the results they desire.
- **People and Partners-** Add Value to the Organization by Developing Your People and Partners: Toyota applies a set of tools designed to support people in continuously improving and developing. Toyota's employee development goals are to the extent that management believes they build people, not just cars.
- **Problem-solving -** Continuously Solving Root Problems Drives Organizational Learning: The highest level of Toyota is organizational learning. Their continuous learning system concentrates on identifying the root causes of problems to prevent them from occurring. They try to standardize the best-known practices through analysis, reflection, and lessons learned communication (Liker, 2004).

*Toyota suggests the right combination of **philosophy**, **process**, **people**, **and problem-solving** can create a learning organization (Liker, 2004).*

Due to the wide variety of concepts covered by Liker's 4Ps suggested, as an organizational adoption of lean principles around production, this set of principles was employed for the current study.

Factors Affecting Lean Implementation

Several key enabling factors have been identified in the literature that contribute to the successful implementation of lean principles. For example, Pekuri et al. (2012) identified motivation, leadership, competence, people, and trust as the cornerstones of LC implementation. Sarhan et al. (2016) indicated several Critical Success Factors (CSFs) in LC, including top management's commitment and leadership, stakeholder education and training, and appropriate lean tools and techniques. Likewise, Torp et al. (2018) described that management support, information sharing and communication, marking of victories and recognition of successes, and commitment from key personnel are among the factors affecting the fruitful implementation of Lean Construction.

In a study conducted by Demirkesen and Bayhan (2019), 27 variables were identified through a literature review as CSFs for Lean Construction, clustering under six-factor groups: motivational, project, strategic and policy, company, technical, and workforce and resource factors. Using a survey to rank the variables based on their importance indicated that management commitment is ranked as the most important driver of lean implementation, followed by training, customer satisfaction with the project, adopting a lean culture, and leadership, respectively. Similarly, Koohestani et al. (2020) identified and prioritized factors that could significantly contribute to lean implementation success in a developing country. Based on a literature review, they identified 44 critical success factors in a global context. The factors were then classified into four categories: organizational, project management, external factors, and factors pertaining to

implementing lean practices. As a result of conducting a frequency analysis, organizational and project management factors were perceived as the most prioritized factors. Their analysis revealed that management and leadership, human resources, communication and knowledge management, supply chain relationships, training, and stakeholder management were the most common factors.

Aslam et al. (2020) explored factors for rapid initial success in LC implementation. They pointed out influential factors, such as motivation, provision of external and internal training, measuring performance, empowerment, and commitment, to name a few. Likewise, Watfa and Sawalha (2021) discerned 13 CSFs for lean implementation in construction projects under four main clusters: Managerial, Organizational, Structural, and External Factors. Their analysis further revealed that the most important factors are management commitment & involvement, leadership, employees' participation & motivation, training & knowledge, skills & expertise, and communication & collaboration.

Although LC advocates have been evaluating factors that can lead to greater lean adoption and success, the factors identified are very broad and thus pose difficult implementation challenges for downstream players, making the lean implementation process very complex (Aslam et al., 2020). To address this challenge, the present study portrays the approaches adopted by successful lean organizations at the trade contractor level to provide more tangible and workable suggestions about improving operations and business results for trade contractor companies using common lean approaches.

Research Methodology

This section explains the background for the research approach used to compare lean initiatives across trade contractors' implementation. First, the section overviews the comparative analysis between different trade contractor case studies. A brief description of the seven case studies is provided, and a discussion of the selection criteria follows. Finally, the data collection process and case study protocol are described to explain how the authors gathered data and analyzed the adopted parameters.

Comparative Analysis

A causal analysis determines whether a phenomenon (A) caused another entity (B), either quantitatively by assessing the effect of A on B or qualitatively by identifying if A even caused B in the first place. Conventionally, a comparative analysis is a subtype of analysis in which two conditions must be met (Pickvance, 2001):

- More than one case must be assessed, and
- Rather than simply describing something, an attempt should be made to explain the observed differences or similarities.

In this respect, a comparative analysis examines similarities and differences in several ways: values of variables, patterns of relations between variables, and occurrences of events or patterns of events. According to Pickvance (2001), comparative analysis aims to examine a small number of cases holistically to understand the processes that underlie observed similarities and differences. One can attain this goal from examples where similar conditions predict similar outcomes or determine if differences in conditions could explain similar or different outcomes. It should be noted that the study's goal is to establish a framework to identify key aspects of lean implementation within trade

contractor organizations. Understanding the similarities and differences among different contractors can provide insights into how adopters can begin their efforts to improve and possibly transform their company.

Case Studies: Selection Criteria and Companies' Characteristics

Yin (2003) defines a case study as a study in which a single case or a small number of cases are selected in their real-life context. Data obtained from these cases are analyzed qualitatively, without manipulation. This method is often valuable in understanding a phenomenon in greater detail. According to Dul and Hak (2007), practice-oriented case studies describe the design, implementation, and evaluation of some interventions, such as adopting lean methods, to illustrate the usefulness of an approach to a specific company or situation. Such studies use theories in practice to contribute to industry knowledge and support actions. Therefore, research into lean implementation would be considered a practice-oriented case study. The decision to use a qualitative case study approach for this research is also supported by Eriksson and Kovalainen (2016). They argued that studies that aim to create holistic, in-depth, and contextual knowledge are typical for the case study approach, highlighting that research questions starting with 'how,' 'why,' and 'what' are seen as a prerequisite of using the case study approach, which goes in line with the research question of "What capabilities assist trade contractors in successfully implementing Lean Construction?"

For this research study, multi-case studies are used, which means the lean adoption among trade contractors will be investigated using more than one case. This type of study, commonly called collective case studies or comparative case studies, involves collecting and analyzing data from many instances (Sharan, 2009). Therefore, we used seven different trade contractors to examine the adoption process and alignment of continuous improvement for business outcomes in different contexts. Using multi-case studies allows lean adoption to be evaluated within the trade contractors' community. For this problem, a single case study is insufficient. The research needs to capture trade contractor experiences, including both challenges and successes, resulting from their approaches within the different organizations and team settings. The more cases included in a study, and the greater the variation across the circumstances, the more reliable the interpretations that result. This strategy strengthens the findings' precision, validity, and stability (Miles et al., 1994).

The selection of appropriate cases is critical to developing valid research that can guide other construction firms. Choosing multiple case studies from different disciplines and locations helped the authors reach more compelling results, making the overall analysis more robust. To evaluate the possible instances of the case study, the following organizational traits or requirements were considered:

- A trade contractor;
- Previous experience with lean methods (minimum five years);
- Diversity of disciplines and specialties; and
- Varied geographic locations in the US.

The selection of trade contractors is an important step. In particular, identifying trade contractors with more than five years of experience using lean methods was used to ensure some longevity with lean processes, methods, and adoption. Having conducted a preliminary discussion with the Industry Advisory Group (IAG) on the selection criteria, it

was confirmed that five years seems an appropriate minimum criterion. It can take several years for a company to implement changes and realize the benefits across the organization. Since the research is intended to study their adoption, a longer time frame is valuable. Furthermore, by pursuing three or more case studies, the diversity of experiences and ability to compare the consistency, or variability, in the different methods and processes is more valuable for understanding the adoption process. The selection of geographical variation aims to control for potential market or cultural factors that may influence how the adoption of lean within a specific community may skew results and support broader interest in the results.

Once the case study criteria and a list of potential companies were identified, the next step was to reach out to each in order of descending priority to ensure access to necessary information, interviews with key personnel, and documentation to complete each case study. To verify this information, a kick-off meeting was held with the firm contacts to discuss the research goal and steps and confirm access to needed information. The logistics for conducting the case study were planned if all was appropriate. Seven case studies were conducted, with the firm details summarized in Table 1.

Data Collection

To understand how adopting lean methods aligns with a company's performance and workforce outcomes, the authors gathered observational field notes, interview transcripts with personnel, written documentation of firms' performance, and other material objects, such as photos or brief videos. Using direct evidence from current adopters, these cases help to gauge how lean has impacted their operations. Data collected from case studies were developed into a report for each trade contractor studied. These technical reports serve as a baseline for the comparative analysis to understand how and why different adoption strategies and methods contribute to performance. Further, the reports were shared with each firm to verify the accuracy of the observations or clarify details that emerged among interviewees. Known as "member checking," this technique has been described as "the most crucial method for establishing credibility" (Creswell et al., 2000). By taking data and interpretations back to the participants, they could confirm the credibility of the information and narrative account.

Table 1: Case Studies Overview

Characteristics	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7
Company Longevity (years)	100+	30+	50+	40+	100+	90+	100+
Headquarter	CA	CA	OH	PA	IA	MN	IA
# Offices across the US	16	6	17	2	3	4	8
Specialty	Electrical	Framing & Drywall	Concrete	Electrical	Electrical	Electrical	Piping + Sheetmetal

The technical memos capturing the full case studies in detail and how each company implements continuous improvement methods in their organization can be found at: https://fieldcrewhuddle.leanconstruction.org/resources/

Data collection consisted of two steps. The first was to observe their offices, job sites, and shop facilities to understand how these construction companies adopt lean principles into their operations and incorporate these principles into their projects. The second step was for the research team to conduct interviews with several individuals to obtain a more in-depth understanding of the company's approach and confirm the findings from direct observations. Each case study was undertaken through a two-day visit to the company's offices and included visits to a project, headquarters, and production innovation or prefabrication facilities. During the visit, the researchers interviewed personnel from the field, project management, company leadership, and leaders from several departments, including payroll, IT, safety, and construction design. In addition, the tours of the project site, office, and production facility served as observational data collection to capture ongoing operations, document how methods were implemented, and observe the behaviors of personnel in implementing lean principles.

At least eight interviews were conducted for each company to obtain as much information as possible, typically lasting 45 to 60 minutes. These interviews were used to explore themes of interest to these successful adopters. In addition to the two main steps, the data collection also used other documents, such as the company's training course descriptions, the performance tracking metrics, and the operational models, which incorporated lean principles to better understand how each organization implements its initiatives. These documents also allowed the researchers to confirm and verify the information obtained from observations and interviews. Having compared the lean implementation approaches among these companies, the initial comparison of cases and the study findings were presented to the project IAG to ensure appropriate conclusions were drawn. This step was important to ensure the reliability and credibility of the study's results, as well as helping researchers avoid errors and biases in their conclusions. It also helped to ensure that the external validity of the findings. While not providing certainty of the attributes to the entire population, it supports analytical generalization of the pattern in the results (Levy, 2008). The general information about the seven cases is presented in Table 2.

Results and Discussion

The case studies aim to understand the successful implementation of lean methods and principles within a trade contracting firm. Each organization is unique; thus, no two companies will implement principles and methods in the same fashion. Therefore, the research focuses on understanding how these principles can be framed or aligned to any trade contractor and how that framework might be used to support the elimination of wasteful practices and create momentum for continuous improvement in delivering successful projects. This can be achieved by searching for similar themes that these cases adopted to support methods and behaviors in their organizations.

Table 2: Details of cases and interviews

Description	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7
Specialty	Electrical	Framing & Drywall	Concrete	Electrical	Electrical	Electrical	Piping + Sheetmetal
# Of Observations							
Office	2	1	1	1	1	1	1
Job site	2	2	2	1	3	1	2
Shop Facility/ Prefab Facility	1	1	1	1	1	2	3
Interviews Conducted							
Higher Management	1	1	3	5	3	6	7
Lean Director / Coach	2	2	1	0	0	0	1
Field Leaders	2	2	2	2	3	9	7
Shop Manager	1	1	1	0	1	1	4
Safety Manager	0	1	0	0	0	0	1
Financial Manager	0	1	0	1	0	0	0
BIM Experts	2	0	0	1	1	0	3
Project Engineer	0	0	1	0	1	0	3
Total # of Interviews	**8**	**9**	**8**	**9**	**9**	**16**	**26**

*Location of offices visited

The comparative analysis among the case studies started with an in-depth study of technical reports, interview notes, and other observations to capture similarities across companies' approaches that help them apply lean. This step helped identify eight capabilities among these companies that commonly help them to succeed. To understand how these observable capabilities were aligned with management principles from Toyota (Liker, 2004), a comparison was made and summarized in Table 3. Each area is addressed with a summary of results and a discussion of alignment with past research.

To compare the implementation status of these observable capabilities within each case study, the rating system, shown in Table 4, was used. This rating system was suggested to identify common processes and key aspects of lean implementation in case studies.

In the following sections, the authors discuss each of the capabilities across the seven case studies, focusing on the approaches they pursued and the degree to which they implemented those approaches. This will help to highlight the similarities and differences across these companies' approaches that help them apply lean principles and methods. Observed examples are provided to help clarify both common elements and items that differentiate certain firms' approaches.

Table 3: Observable Capabilities and related Continuous Improvement Principles

Observable Capabilities	Principle (Liker,2004)
Cultural and Organizational Values (Company attitude towards continuous improvement)	Become a learning organization through relentless reflection (hansei) and continuous improvement (kaizen).
Training (Invest in their people)	Develop exceptional people and teams who follow the company's philosophy.
Mentoring and Cultivating Field Leaders (Engaging & Empowering)	Grow leaders who thoroughly understand the work, live the philosophy, and teach it to others.
Standardization (Standard Tasks/ Assemblies)	Standardized tasks are the foundation for continuous improvement & employee empowerment.
Process-based Approach (Process Mapping)	Create continuous process flow to bring problems to the surface.
Visual Management	Use visual control so no problems are hidden.
Access to Better Tools and Equipment	Use only reliable, thoroughly tested technology that serves people and processes.
Systematic Process (Empowering problem-solving mentality)	Make decisions slowly by consensus, thoroughly consider all options, and implement decisions rapidly.

Table 4: Rating System for Implementation Status

Status	Mark	Explanation
Not Observed	○	Evidence of adoption was not noted or directly observed during the case study.
Partially Implemented	◒	Evidence of the approaches was noted in some interviews or partially observed – suggesting some use but not standard across operations.
Fully Implemented	●	The approaches were commonly noted in interviews and/or observed as standard elements in company operations.

Cultural and Organizational Values

The first observable capability among these organizations is their culture and organizational values, which implies the companies' attitudes toward lean and continuous improvement. These principles have affected their relationships with both their employees and customers. Using the rating system, each approach's implementation status was identified based on the evidence observed in each case study. In Table 5, each column represents a company, and the cases were arranged based on their implementation status, from "Fully Implemented" to "Not Observed."

Table 5: Common Approaches in Culture and Organizational Values

Approaches	Highest						Lowest
Align lean principles with **organizational values**	●	●	●	●	◡	◡	◡
Adopt lean approaches in **long-term goals**	●	●	●	●	●	●	◡
Create an **organizational environment** that enables continuous improvement	●	●	●	◡	●	◡	◡
Empowering everyone to pursue continuous improvement	●	◡	◡	●	◡	◡	◡
Develop a **continuous improvement culture** in all divisions/ departments	●	●	●	●	○	◡	○
Consider employees as **internal customers**	●	●	●	◡	◡	○	○

*Note – company order changes for each table to re-order from highest to lowest observed adoption

A review of all cases revealed several similarities partially or fully observed across all the firms. First, embedding lean principles with company core values creates a natural alignment that allows lean methods to be easily grounded in how each firm does business, treats people, and makes money. Closely aligned with this approach was having the methods and processes related to continuous improvement efforts embedded into long-term goals, creating an organizational culture that supports CI, and trying to decentralize efforts so everyone across the company is engaged or empowered to pursue CI in their work. Many elements are needed to sustain these approaches. Still, the clear references to the principles in the company's core values guide all the company personnel to behave and create company routines that align with company values. Taking this further, defining company goals that support method adoption and creating a supportive environment are logical extensions for operationalizing those core values into company culture within the office or through job site team environments.

For example, one of the firm's core values was focused on setting its own direction. In their goals, they emphasized field leader training on certain planning methods that allow foreman to plan their work and empower each worker through daily huddles. The result is that the foremen can come to project meetings with general contractors with a clear understanding of the work their crew performed, constraints affecting their production, and any safety concerns, as well as a clear plan for where and how they want to work. That puts them in a strong position when planning and coordinating with the GC or other trades. That process is ingrained in their values but trickles down from the culture and goals into the training and daily routines of crews in the field.

While less common, the cases that stood out from other companies were more successful at empowering their employees to engage in the CI process. By constantly presenting and communicating fundamental concepts that build on core values, leadership empowers employees to do their work better, encouraging creative solutions to improve daily tasks in incremental steps. One electrical contractor coined the simple phrase, "fix what bugs you," to make the CI culture simple to understand and easy for employees to be empowered. A great example was observed in a payroll office process that used CI to reduce craft workers' paperwork time. As the accounting lead framed it– they are in the

construction business– so they make money when the craft workers are in the field, building the project. The payroll's job is to make the paperwork as simple and streamlined as possible so workers do not have to take extra time to fill it out or need to return from the field to a job trailer to correct mistakes. To fix it, they developed targeted training for the project leads responsible for helping craft workers fill out employment papers, such as I9 forms, to reduce errors. Over several iterations, they developed a streamlined but simpler electronic form that allowed the workers to cut down on filling out extra or redundant information that occurred throughout the complex forms. This view of the craft as the customers they serve allowed a different lens to save time and money but hints at the potential benefits of embedding these values and approaches across the different operating units of the firm.

Previous studies have extensively highlighted the importance of adopting lean culture as an influential factor in implementing Lean Construction. For example, according to Demirkesen et al. (2019), providing a lean culture was rated as the most important CSF among the strategic and policy factors, which helps people conceive the importance of lean practice, potentially leading to safer workplace practices. Bortolotti et al. (2015) reaffirmed the undeniable importance of organizational culture and soft lean practices for successful lean implementation. They indicated that adopting lean culture certainly contributes to developing successful lean practices and increases productivity through a well-planned lean implementation. Watfa et al. (2021) further argued that an organizational culture that doesn't accept failure or change would fail in implementing any new improvement initiative. By acknowledging that the transformation to lean requires significant changes, creating the right culture and conditions becomes the foundation for implementing changes toward CI. This culture requires encouraging people to participate in the CI process and convincing them to accept the changes. However, for the successful implementation of LC, employees should be empowered enough to participate in these changes (Bashir et al., 2015; Shang et al., 2014).

While the change or specific approach adopted by one company may not be the perfect fit for the other, the similarities mentioned above have been recognized in how successful adopters align lean within their trade organizations. If a trade contractor company wants to fully benefit from deploying LC, workforce engagement should be emphasized. Otherwise, if they change their direction without implementation, as Roth et al. (2006) explained, benefits will diminish from their change program investments.

Training

As part of the lean implementation process, the organization should ensure that all employees understand the importance and proper use of company culture, methods, and tools (Cudney et al., 2011). To ensure that all employees understand how to employ various methods or tools, all seven companies pay attention to the training programs provided for their employees. The approaches employed can be found in Table 6. Similar to Table 5, each column represents one company, and the cases were arranged based on their implementation status, from "Fully Implemented" to "Not Observed."

Table 6: Common Approaches in Training

Approaches	Highest						Lowest
Develop **training portfolios** as an integral part of their operations	●	●	●	●	◡	◡	◡
Training is **a core activity** for all employees	●	●	●	●	◡	◡	○
Balance of **lean training** with **technical methods training**	●	●	●	●	●	◡	◡
Invest in internal training and ongoing improvement of training quality	●	●	●	●	◡	◡	○
Provide training programs **beyond the industry standard** for **craft workers**	●	◡	●	○	◡	○	○
Define **specific certifications** for training programs	●	●	○	○	○	○	○

*Note – company order changes for each table to re-order from highest to lowest observed adoption

Comparing the common approaches these companies used to train their personnel illustrates that all seven organizations have developed well-defined training portfolios that include predefined training courses. They realized the value of investing in training employees and craft workers in lean principles and practices to improve their operations; thus, they view training programs as core activities rather than extracurricular activities, emphasizing the value of these programs for consistency and quality of how they perform their work. Adopting this mindset, these firms spent considerable time and investment training their employees. Many of them developed training content internally and employed lean in their training program topics, with a special concentration on balancing the lean principles and methods with the technical methods of their operations, as well as internal standards or operating procedures. To achieve this goal, they provided prioritized training to their employees, containing both fundamental principles of lean and technical aspects of their operations. For example, in addition to offering training courses, some electrical contractors implemented another training approach to prepare and deliver in-house, brief recorded videos on lean concepts or examples to share with all employees. LinkedIn Learning was another resource for their personnel on selected topics to help them better comprehend fundamental lean principles and how they can be implemented in their activities.

Analyzing the training approaches across these companies further revealed that for successful organizations, the training was further embodied in the ongoing pursuit of excellence in the continuous improvement processes. Embedding the methods and principles associated with lean into a training curriculum provides a consistent platform and message to spread values and culture to the entire organization. Under this mindset, the core values, such as respect for people, continuous improvement, trying to achieve perfection, and leadership, are embedded across operating units, divisions, and departments, from field personnel and project management to IT and Payroll. For example, one of the core features of one of the electrical contractors in implementing lean appears to stem from their ongoing dedication to training, notably field leadership, in lean principles and a shortlist of core methods they deploy consistently for their projects.

In these companies, training on lean methods, namely 5S, Visual Management (VM), and Last Planner System®/ Weekly Work Planning, and encouraging and empowering everyone to use them throughout the company activities were apparent. To encourage and support the implementation of these methods, several case studies employed a certificate or similar system to recognize the completion of key levels of training. However, variations were observed among these firms in how they defined certification to help encourage and recognize training and advancement. For example, one of the electrical companies employed the belt program through the Global Leadership Institute. They developed a yellow and green belt program, which comprised a deeper dive into lean principles and tools and how to apply them to construction projects. Another case study defined the Bronze Certificate all employees need to gain during their first year of employment.

The analysis also revealed some differences in their training approaches. Training programs vary in focus from concentrating on lean principles and methods to having separate training programs for their operations and continuous improvement knowledge. As an illustration, one contractor defined two separate cross-training and study action team approaches for training their personnel; the former concentrates on their operational process, while the latter tries to help them understand the philosophy of lean using the Toyota Way. They had a rotation program for all new employees to earn their 'field degree.' This rotated each employee through five core roles within their operations, typically for two to three months at a time, to develop core knowledge of the value-adding processes at the heart of their business. In addition to this program, all team members participate in ongoing training to ensure all employees understand their operational model and procedures. They also employ the study action team approach, with rolling training using the Toyota Way to introduce lean philosophy as personnel move toward leadership positions.

In contrast, other cases tried to integrate lean principles' application within its operations in establishing the training portfolio. Comparatively, successful companies highly emphasized providing training programs beyond the industry standards for their craft workers. For instance, as a union contractor, one of the electrical companies defined training programs as a way to be an appropriate complementary resource to training provided to their union craft workers. They both supported and benefited from the training provided to union craft workers in their careers, moving from apprentices to master electricians. They started the training program by investing in fully understanding the skills and capabilities of each worker sent from the union hall to work for them by asking each worker to engage in a skill test and then supporting further training and mentoring above and beyond the standards the union has already set. This helped instill the value of lean created through the apprenticeship mentoring model and provide value back to the workers directly by helping them grow their skills.

There is a strong alignment between this capability and previous research on success factors for lean implementation. Providing adequate training and understanding of lean tools and techniques are considered the greatest enablers for implementing Lean Construction (Shang et al., 2014). To ensure the continuous implementation of the lean process, it is vital to provide proper training and conceptual understanding to all employees (Torp et al., 2018). Organizations must determine which training methods are most appropriate for imparting the necessary knowledge and education, such as utilizing external facilitators or training services for new lean companies (Aslam et al., 2020) or

using predetermined lean courses taught by the company's lean champion or coach. Watfa and Sawalha (2021) explained that training should cover the basic lean concepts and the specific tools the company is interested in. This was observed in the successful lean adopters among trade contractors. Although the combination of topics covered by their training portfolio varies, a proper balance of providing a sufficient understanding of lean principles and the technical aspects of their operations was evident.

Mentoring and Cultivating Field Leaders

Another common theme in lean approaches for all these cases is a strong emphasis on extending beyond training to active mentoring programs and efforts to cultivate leaders, especially field leaders, as indicated in Table 7.

Table 7: Common Approaches in Mentoring and Cultivating Field Leaders

Approaches	Highest						Lowest
Empowering people through guidance, standards, and flexibility	●	●	●	●	●	◒	◒
Courses for training **field leaders**	●	●	●	●	●	◒	○
Develop and **promote people** into leadership roles	●	●	●	●	●	◒	◒
Emphasis on both **technical and leadership training**	●	●	●	●	●	●	●
Different mentoring programs to **develop leaders and grow coaches**	●	◒	◒	◒	◒	○	○

*Note – company order changes for each table to re-order from highest to lowest observed adoption

A review of all cases revealed that they provide new hires mentors with thorough onboarding into the companies' culture, processes, and standards. Once personnel move into their roles, they are provided with different opportunities, such as mentorship from supervisors or external mentors. For some companies, this approach and culture have been extended through an organic approach to succession planning that has encouraged all company leaders to consider their mentees as future replacements. This compels them to use an empowerment model that encourages the mentees to develop the capabilities and competencies needed for these future roles more quickly and more thoroughly. Similarly, it was observed in some cases that when they hire someone from another firm into a more senior role, they pair the new employee with an experienced person for approximately six months to support their transition. By developing objective, task-oriented mentoring programs, they concentrated on the foreman level, as they have the most influence over the workforce, in an attempt to support the development of their burgeoning management skills and related soft skills. However, the training did not start when workers reached foreman status; one unique program offered leadership and cross-functional training across all aspects of the company to apprentices in their final year. The company commented that the craft that was part of this program more quickly rose into leadership positions.

Another common attribute arising from these mentoring efforts was the link with internal promotions. This was apparent as many managers explained in interviews that

they came from the field. By defining mentoring programs to include both the technical work of planning and installing work in the field, with aspects of management and leadership, those craft employees with natural leadership potential more quickly rose to the top. The effectiveness of these programs made some cases stand out from other companies concerning their mentoring approaches and internal development. Providing proper mentoring programs that boost their field leaders' technical and management skills empowers them to take ownership of the CI initiatives in the field. At the same time, they tend to naturally serve as a role model and mentor for their crews.

Despite the ample literature emphasizing the important role of training for the successful implementation of Lean Construction, few studies have brought up the significant mentoring role in promoting a lean culture of an organization, with none focused on field construction personnel. It is important for management to foster a quality culture by empowering and motivating employees and creating an environment characterized by openness to remove the fear factor from the workplace (Asadian et al., 2021). This goal can be achieved faster by combining the proper mentoring services with the training provided.

Standardization

Standardization was the next concept widely implemented by all case studies, used in creating consistent approaches, resources, agendas, or other processes that could be easily ported across projects (Table 8). As a common theme in all these case studies, they constantly attempt to employ standards, sometimes referred to as best practices for processes, to make their work easier. To pursue this goal, in alignment with mentoring programs and cultivating leaders, all companies commonly concentrate on balancing the empowerment of their people with standards and structure that provide both guidance and flexibility. Empowering their people allows them the authority and flexibility to make their own plans, decisions, and sometimes mistakes. At the same time, they encourage using company standards and practices through onboarding and ongoing training. These provide structure and guidance regarding reference checklists for tasks, such as starting up a new project and standard processes, like production planning for prefabrication or modeling at the start of projects. Thus, teams are expected to use standards but are enabled to try new things regarding how they can mold or fit the company's processes to the unique project requirements.

Table 8: Common Approaches in Standardization

Approaches	Highest						Lowest
The standardization of **work processes**	●	●	●	●	◡	◡	◡
Reduce variation whenever possible	●	●	●	●	◡	◡	◡
Track, share, and display key metrics that result from production standards and common work practices	●	●	◡	◡	●	◡	◡
Tactics for standardization embody the **nature of the work**	●	●	●	●	●	●	◡

*Note – company order changes for each table to re-order from highest to lowest observed adoption

The review of how these cases adopt standardization for their projects revealed that they match the scale of their work with the standardization approach as another common approach among successful adopters. For example, the electrical contractors use standardization in grouping parts and assemblies sent to job sites from their prefabrication facility. Using standardization as a solution to reduce variation, they prepare components in kitting packages for their field personnel. When sending the assemblies out to projects, the shop groups assemblies by area and puts them onto wheeled carts or cages. This standard approach enables workers to quickly gather the necessary items to work continuously in a room or building section without frequently pausing to find or unbox materials. It also saves them time and effort by keeping their materials for current and future tasks close at hand. However, due to the nature of other construction tasks, from concrete to sheet metal work characteristics, they did not follow the same standardization approach for their material and logistics activities. Rather, they tried to standardize their operational procedures or documents but matched the principles for material movement and organization of their tasks. Introducing the "best way" of their processes in their operational model makes it a standard approach for their entire organization. In these companies, a standard agenda was created for daily stand-up meetings to ensure all key topics are touched on related to daily planning, constraints, CI mentality, and safety. Weekly work planning documents were standardized to keep them simple but structured to align with budget and material planning needs.

In the same way, the continuous improvement plans for training were standardized for core elements, with some targeted flexibility for individualized learning and improvement specific to each individual's role. Likewise, they defined how the process should work by creating Standard Operating Procedures (SOPs) for core tasks, such as modeling and prefabrication processes. At the same time, the SOPs further serve as a training resource when personnel are onboarded into the company or change roles. These SOPs are hosted online, allowing each to be easily linked or embedded into relevant documentation; for example, one firm used a Quick Response (QR) code for the rack fabrication SOP as a standard element in the template spool drawing for each rack sheet that is created.

Another common standardization approach among all these cases was that they developed standard metrics related to production that were consistently tracked, shared, and displayed across their projects and sometimes across the organization. Having common dashboards was observed among all the cases; however, the more advanced version standardized the visuals and common planning elements so a new foreman or worker walking into a job trailer could, within 30-60 seconds, assess the status of the production against the goals, where the crew(s) are currently working, and what major constraints they are actively trying to resolve.

LC advocates have consistently emphasized that standardization of processes, tasks, and methods is one of the most critical components to implementing lean, considering standardization and flexibility as essential ingredients. However, The construction industry does not warmly embrace this concept, as Aslam et al. (2020) indicated. They explained that the degree of standardization required could vary depending on the nature of the project and the environment. For example, organizations undertaking similar projects, such as health care, residential, and so forth, would benefit from standardizing their tasks, processes, and materials. Furthermore, the authors asserted that prefabrication companies

could devise standardized procedures to increase their success rates. The same observation was made about trade contractors. Because they are specialty contractors working within a defined scope, standardization capabilities could be widely adopted in their organizations. All case studies use the prefabrication process to some extent, which reduces field production uncertainty, making it easier to take advantage of the standardization process in identifying scopes to fabricate in their shops.

In conclusion, the comparative analysis of these cases demonstrates that a singular approach might not be applicable for all specialty contractors; rather, each company needs to implement standard work in alignment with the tasks and nature of their business. However, balancing autonomy and standardization, they all used stable, repeatable methods to maintain process predictability, regular timing, and consistent, high-quality output.

Process-based Approach

The lean approach focuses on identifying and eliminating waste in production processes. As Cudney and Elrod (2011) highlight, waste is present throughout organizational functions, from procurement to invoicing and accounting. This is important for recognizing the "Process Management" approach to improvement. The authors witnessed this approach during the observations of all these seven companies, as illustrated in Table 9. The comparative analysis of these cases revealed that these organizations constantly apply the concept of identifying and eliminating waste, emphasizing the whole production process. To achieve this goal, they build upon standards to create best practices that are integrated into training and evolving standards. They structured work packages across phases and departments to create consistency and transparency in how work is estimated, planned, fabricated in a shop, kitted or palleted, sent to projects, and installed. A great example of this was using detailed week-level task production and combining it with the budget, schedule, and workforce planning. The weekly task tracking aligned with budgets, prefabrication needs or needed orders, and billing to be submitted when that scope was complete.

Table 9: Common Approaches in the Process-based Approach

Approaches	Highest						Lowest
Identify and eliminate waste to support organizational functions	●	●	◡	●	●	◡	◡
Define processes for performing their tasks to bring consistency and clarity.	●	●	●	◡	◡	◡	○
Document current processes and refine them into **best practices**.	●	●	●	◡	◡	◡	◡
Work packaging is **standard across phases** for planning, fabrication, tracking and reporting.	●	●	●	◡	◡	●	◡
Measure how effectively new **processes or approaches** are relative to the baseline.	●	●	◡	◡	◡	◡	◡

*Note – company order changes for each table to re-order from highest to lowest observed adoption

Observing all these cases demonstrated that the process-based approach capability is not limited to incorporating various involved teams in defining their operational procedures; rather, they constantly measure how effectively new processes or approaches are relative to the baseline, using the PDCA (Plan-Do-Check-Act) concept. This enables them to revisit their operational procedures and apply required revisions to pursue continuous improvement. However, the frequency and extent of how often these companies measure and track their processes varied.

According to a literature review, many lean practitioners believe companies should focus on process improvement when implementing the LC. By simplification, reducing the number of steps, and removing waste, they aim to improve the process and achieve better results. However, it will take time for lean companies to succeed (Mitropoulos et al., 2001). Process documentation and standardization are essential to identify non-value-adding activities and increase quality. The organization should, therefore have well-documented processes to implement lean practices. However, to prevent misunderstandings regarding work processes and procedures, the company should standardize its operations (Watfa et al., 2021). To conclude, both standardization and process orientation concepts were observed as enabling capabilities helping trade contractors advance their lean implementation.

Visual Management

Visual management is a widely used lean method in all these cases. Using intuitive visual cues to make concise, accurate information within a workplace available was one of the common approaches observed. The case illustrations adopted this method to enhance their information sharing and communication, as shown in Table 10. Taking it further, visual controls can be used to quickly understand information and make problems visually apparent.

Table 10: Common Approaches in Visual Management

Approaches	Highest						Lowest
Apply VM **across operations** to support simple, effective **communication or tracking**	●	●	●	◡	◡	◡	◡
VM is **built into the inventory management** system and processes.	●	◡	●	●	●	◡	◡
Extensive use of **color-coding**	●	●	◡	◡	◡	◡	◡
Use VM for **information sharing**, such as productivity reports and project standards	◡	●	●	◡	●	◡	◡
Use VM for **communication and raising awareness**	●	●	◡	◡	○	○	○

*Note – company order changes for each table to re-order from highest to lowest observed adoption

Visual Management was observed to be used in three ways:

- Use for information sharing, such as productivity reports and standardization information sharing within or across projects, such as productivity metrics, color-coding tasks, systems, or status on weekly work planning boards.

Similarly, color coding spool drawings and providing 3D renderings consolidates information and reduces time trying to re-interpret information someone else has already planned.

- Use for communication and raising awareness: installing pictures such as the eight types of waste in their shop facilities and job sites to enhance awareness. This simple approach empowers the field to improve processes and remove waste before it impacts projects.
- Using it to help identify problems, such as shadow boards to identify missing tools, or color coding under consumables such as screws to make it visible when stock is running low. By using orange stickers under screw boxes, the worker can immediately realize they have limited stock and need to request more.

Other examples include marking job boxes and codifying them with standard tools or equipment to make it easy to find items or note if they were missing or color-coding the daily tasks within the weekly work plan to create a quick visual link between the crew, task, area, and materials across the different visuals used to plan and coordinate work.

Overall, visual management was observed as an essential element that reduces the time and effort workers in the field need to spend on support tasks, like tracking tools or trying to guess if they have enough materials for the next few days' work. Using this method, an organization can achieve employee engagement and generate ownership of goals and enthusiasm for progress that would otherwise be lacking. It further creates transparency in the goals and status of project information, removing the gap that sometimes arises between office and craft employees. As a result of shared visual management, no information is hidden, and the organization's goals and the team's shared status for achieving them are aligned.

Salem et al. (2005) state that increased visualization involves posting various signs and labels around the construction site to effectively communicate key information to the workforce. When workers visualize elements such as workflow, performance targets, and specific required actions, they are more likely to remember them. It can also include signs relating to safety, schedule, and quality, leading to the control of the production process. Since the nature of trade contractor organizations' business is highly dependent on their workforce, effective communication with the workforce to provide suggestions on improving productivity is highly sought. This aim can be achieved by utilizing proper visual management techniques, helping the workforce better understand lean concepts and production elements, such as performance targets.

Access to Better Tools and Equipment

Another emphasis that was widely observed among all case studies was their relentless pursuit of better tools and equipment. Common approaches to accessing better tools/equipment are listed in Table 11.

Breaking processes into small manageable pieces serves as a way to unbundle bigger changes, software training, or learning of new procedures. Something as simple as making small steps for using a new software tool to help employees master one process at a time instead of using multi-day workshops to train large groups. Breaking the Last Planner System® down into the component parts and training in each step in greater detail was

observed in several cases, including fieldwork planning, visual tracking, communication with crews, and planning the logistics and space. This aligns with one of the key findings of the study on factors for LC implementation for rapid initial success; the lean tools and techniques should be introduced gradually by introducing a few processes and then expanding their use to the entire project (Aslam et al., 2020). All these cases followed the gradual lean implementation to avoid overwhelming their employees; rather, they tried to steadily create the proper culture to advance their lean adoption in parallel with expanding their implementation scope. According to Chesworth et al.(2011), lean is not about short-term organizational wins but rather a long-term 'cultural' transformation, as evidenced by explicit changes in culture within the lean implementation process.

Table 11: Common Approaches in Access to Better Tools and Equipment

Approaches	Highest						Lowest
Unbundling of complex methods to **simple and easily understood** concepts	●	●	●	◡	○	◡	◡
Use better tools or equipment to **facilitate field operations**	●	●	●	●	●	◡	◡
In parallel with standardization, they **match their tools and equipment with their operations**	●	●	●	●	●	◡	◡
Allocate a specific budget for providing better tools, which is **separated from the project costs**	◡	◡	◡	◡	○	○	○

*Note – company order changes for each table to re-order from highest to lowest observed adoption

All of the firms were persistent in finding tools that make their work simpler safer, and improve the reliability of the resources provided for the craft. The authors witnessed several instances of this approach through their visits, such as using carts on wheels to help facilitate sending the assembly parts to their projects, buying better saws for field employees to reduce small hand injuries, or investing in shop equipment to move slow or labor-intensive work out of the field.

Systematic Process (Empowering Problem-solving Mentality)

Lean's ultimate goal is to have an organization that strives for continuous improvement (Torp et al., 2018). According to Liu et al. (2020), the shift from traditional organizations towards CI organizations results in higher organizational integration, decentralized decision-making structures, flexible communication channels, and a flow-centered operating system. This leads to a more systematic process toward CI by empowering a problem-solving mentality throughout the organization (Tapase, 2019). Common approaches observed in this capability can be seen in Table 12.

Comparisons of these seven cases demonstrated that they re-visited, checked, and analyzed their processes and monitored their operations. In some cases, they were pre-defined reviews or checks on production status or when projects hit a particular milestone. In others, they were structured as coaching and mentoring visits that met the same intent but used the visits or events as moments for engaging with the project team, mentoring them, and supporting their path to improvement. Using some form for monitoring changes, such as A3s or the PDCA processes, was seen to help them refine and document standard operating procedures to ensure each step of their process is conducted in the “best way.”

Table 12: Common Approaches in Systematic Process (Empowering problem-solving mentality)

Approaches	Highest						Lowest
Sustaining improvements to processes through **frequent reviews and coaching** to ensure they are being implemented	●	●	◡	●	◡	◡	◡
Gathering **input from all company stakeholders** to agree upon or refine processes and methods	●	●	●	◡	◡	○	○
Focus on **small improvements and appreciate new ideas** for improvement from the workforce	●	◡	●	◡	◡	○	○

*Note – company order changes for each table to re-order from highest to lowest observed adoption

Through interviews, it became apparent that the companies emphasized small, shared, and sustained improvements rather than trying to achieve large transformational changes. This was the key aspect of their continuous improvement efforts. As an illustration, one firm described the number of changes they made to their tool carts, from adding power strips to changing how the doors swung to lock placement so the lock was less likely to hit a wall or door. Aslam et al. (2020) suggested that immediate and rapid initial successes will greatly increase the morale of project participants. In addition, they will influence the culture and mindset of project participants toward lean, thereby defining future courses of action to sustain lean initiatives within the organization. As highlighted in previous capabilities, the case studies' ultimate goal was to make the field activities easier for their crews. As a result of this attitude, they constantly engage field crews in problem-solving to collect their ideas and get agreement on a path forward. Further, by making the small changes requested, they are engaging all people affected by that problem and showing that they are listening, opening a wider array of possible solutions.

Interpretation of Results: Differentiating characteristics

By comparing seven case studies of successful lean adopters within trade contractor companies, the study analyzed eight frequently observed capabilities among these firms' approaches. The comparative analysis revealed that the most successful firms differed from their peers in some cases by exhibiting the following characteristics:

- **Focus on Continuous Improvement**

Building upon the alignment of core values and strategic goals with lean, embedding continuous improvement into the mentality and culture of the company was observed through the methods used to constantly simplify their operations by breaking processes into smaller manageable pieces.

- **Focus on People**

In successful companies, the emphasis went beyond providing training to creating an active culture of coaching and mentoring to ensure all employees have a comprehensive understanding of the company's culture, processes, methods, and standards. Through proper training and mentoring programs, field leaders are empowered to take responsibility for lean initiatives by enhancing their technical and managerial skills, further enabling them to serve as role models and mentors to their crews.

- **Focus on Process**

In alignment with mentoring programs and cultivating leaders, successful adopters typically strove to balance empowering their people, standardizing their processes, and increasing process transparency. Using company standards provides structure and guidance on standard organizational processes while, at the same time, promoting team autonomy to fit the company's processes to the unique project requirements.

While these distinguishing attributes, recurrently identified among successful lean adopters within the trade partner community, hold the potential to provide insights from their successful journeys, it is equally imperative to take into account potential pitfalls and missteps during the implementation process. Among the challenges, firms noted they had to overcome or still were still working to address in scaling their adoption across offices. These included the reluctance of company leadership to invest in facets like education and training, the need for outside consultant support, benchmarking visits to other firms, and the execution of pilot projects. Ignoring these challenges or overcoming missteps, could potentially limit the efficacy of a company's transformation toward lean. Consequently, an emphasis on cultural alignment and leadership support was consistently highlighted for trade contractor firms aspiring in their pursuit of lean adoption.

Regarding the study's limitations, since there was not a pool of contractors for sampling the population of lean adopters among trade contractors, employing random sampling was not feasible. Instead, based on the Industry Advisory Group's recommendation of criteria and potential candidates, a purposeful sampling technique was used to ensure that companies selected as case studies provided rich access and experience. Moreover, due to the time-intensive nature of the case study process, the results were drawn based on seven case studies. Therefore, resource constraint in conducting more visits was another limitation of the data collection procedure. However, a more extensive survey involving more case organizations would provide greater insight. For the future direction to investigate strategies to support trade contractors' adoption of lean, devising robust guidelines for selecting lean tools that better resonate with their operations and proposing a roadmap for their lean implementation can be considered.

Conclusions

This study investigates implementation approaches within seven successful trade contractors to understand how trade contractors can apply lean principles and methods in their organizations. The case studies included 2-day visits to each of the seven companies, interviewing at least eight personnel from each, and observing how they consolidate lean principles and practices into their operations and activities. Using the data from each case study, a comparative analysis of real companies was conducted to provide insight into what capabilities have enabled trade contractor companies to succeed in lean adoption. Eight capabilities were identified to explain what organizational, cultural, and operational characteristics were prevalent within these companies. These include cultural and organizational value, training, mentoring and cultivating field leaders, standardization, process-based approach, visual management, access to better tools and equipment, and systematic process. Common approaches employed by the case illustrations to support these capabilities were then discussed. The comparative analysis further revealed that among all these common approaches, focus on continuous improvement, people, and

processes are the attributes observed in cases that differentiated the most successful firms from their peers within the studied firms.

This study focused on trade contractors' adoption of lean principles, methods, and practices. The procedures used to analyze the trade contractor capture a snapshot of the successful adopters' methods and practices throughout their operations. Conducting successful adoption case studies profiles the processes and business impacts. The seven case studies indicate some variation in the approaches they choose for their continuous improvement efforts, while a considerable extent of similarities.

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