Romo, R., Orozco, F., Moreno, F., Francesconi, C., Valdebenito, R. & Forcael, E. (2025). Lean Construction Barriers from the Organizational Culture Lens. In O. Seppänen, L. Koskela, & K. Murata (Eds.), *Proceedings of the 33rd Annual Conference of the International Group for Lean Construction* (IGLC33) (pp. 1321–1332). https://doi.org/10.24928/2025/0284

LEAN CONSTRUCTION BARRIERS FROM THE ORGANIZATIONAL CULTURE LENS

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ABSTRACT

Organizational culture is vital for adopting Lean Construction (LC) methodologies in the construction industry. LC maximizes customer value by minimizing waste and optimizing processes. Implementing this philosophy necessitates a shift in values, attitudes, and behaviors. A culture promoting collaboration, innovation, and continuous improvement aids the acceptance of Lean principles, enhancing efficiency and sustainability. Effective leadership and employee engagement are essential to tackle barriers, like resistance to change and lack of strategic alignment. Organizational culture aligns individual and organizational goals, fostering open communication and continuous learning. This study shows how organizations amplify LC benefits by integrating its principles with a culture of adaptability, shared responsibility, and operational excellence, boosting productivity and positioning companies as leaders in a competitive and innovation-driven sector.

KEYWORDS

Lean Construction, Organizational Culture, Barriers, Partial Least Squares.

INTRODUCTION

The construction industry faces challenges in efficiency, sustainability, and resource management. The LC philosophy, focused on maximizing value and minimizing waste, addresses these issues. However, the successful implementation of LC requires a cultural transformation for lasting adoption and sustainability.

Frameworks tailored to specific socio-cultural and operational contexts are critical for effective implementation. For example, Sarhan *et al.* (2019) demonstrated the importance of identifying critical success factors, such as leadership, stakeholder education, the application of appropriate lean techniques, organizational change, and aligning them with industry-specific characteristics to enhance the adoption of LC.

LC offers a framework for continuous improvement by delivering client value, eliminating non-value activities, and optimizing workflows. Success depends on a collaborative

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environment with open communication and leadership that inspires alignment of individual goals with organizational objectives.

Waste minimization, a core aspect of LC, involves reducing material waste and efficiently managing time, enhancing team coordination, and minimizing rework from planning failures. This comprehensive approach highlights the importance of organizational culture in realizing LC's full potential, promoting operational excellence and sustainable practices (Lui et al., 2024).

In this context, organizational culture plays a pivotal role. Its most important aspects (Romo et al., 2024) and that will be considered for the proposed model include:

1. **Shared Values:** A strong culture is based on continuous improvement, innovation, and teamwork, allowing employees to embrace Lean practices enthusiastically.
2. **Collaboration:** LC needs constant coordination among stakeholders. Promoting open communication helps reduce misunderstandings and optimizes the flow of information.
3. **Effective Leadership:** Leaders model behaviors and motivate teams to embrace change. Valuing feedback and fostering a shared vision are crucial for the LC's success.
4. **Adaptability and Learning:** In the construction industry, organizations must quickly adapt to new technologies. A culture of ongoing learning helps companies transition effectively to a Lean approach.
5. **Commitment and Motivation**: A culture that rewards individual and collective efforts is vital for employee motivation and active participation in LC implementation.

Adopting LC involves a cultural transformation. Addressing organizational culture's foundational elements is crucial for achieving the efficiency, sustainability, and operational excellence promised by this methodology. This article explores how LC principles and strong organizational culture can redefine success in construction.

Industry 4.0 transforms industrial processes through automation, connectivity, and digitization, playing a fundamental role in the construction industry (Forcael et al., 2025). The adoption of Lean concepts encounters barriers linked to organizational cultures. Examining these barriers is essential in the Industry 4.0 era. This study identifies cultural and structural obstacles to LC, aiding the construction industry by promoting effective transformation plans and training. It also uniquely combines Lean principles with emerging technologies to automate operations, cut costs, and boost productivity.

This study contributes to the construction industry by presenting a framework for organizational transformation. It offers insights into how culture affects LC adoption within Industry 4.0. The research highlights the importance of aligning technology with organizational dynamics, emphasizing that successful implementation requires attention to human and cultural factors as well as technical efficiency. It stresses the necessity of a culture of continuous improvement, collaboration, and adaptive learning for resilience and sustainability in a digital, automated industry. This approach enhances the understanding of LC, guiding stakeholders through organizational change in the digital era.

This study proposes a model of interrelationships among organizational culture variables affecting LC methodology adoption. The model is validated through a literature review and a structured questionnaire answered by construction industry experts specializing in LC practices.

LEAN CONSTRUCTION

Lauri Koskela's Lean principles advanced productivity and minimized waste in construction. (Koskela, 1992). Koskela's approach is based on three concepts —Transformation, Flow, and Value—, leading to the TFV theory. Table 1 shows several LC terminologies to enhance the industry's understanding and ability to adopt this methodology effectively.

Table 1. LC Definitions.

Definition	Author
LC is a production management-based approach to project delivery that takes inspiration from Lean production principles used in manufacturing industries. It represents a new approach to designing and building capital facilities, aiming to maximize value and minimize waste throughout the entire construction process.	(Mohammadi et al., 2022)
LC is the practical application of Lean manufacturing principles, also known as Lean thinking, to the construction industry. It involves adapting and implementing Lean methodologies and techniques to improve the efficiency and effectiveness of construction processes and project delivery.	(Li et al., 2017)
Lean is more effective at utilizing people, materials, and resources to enhance efficiency and project outcomes. It is not merely a matter of minimizing costs or maximizing the use of limited resources. Lean's key concepts include maximizing value while minimizing waste, which entails identifying and eliminating non-value-adding activities and refining processes to achieve the best possible results.	(Ahmed et al., 2021)
The benefits of the new production philosophy, in terms of productivity, quality, and other indicators, were robust enough to accelerate the adoption of new principles.	(Koskela, 1992)
LC aims to meet customer needs more effectively while using less of everything.	(Ballard, 2000)

The Lean principles, created in manufacturing and adapted for the building industry, were expanded to LC to enhance value, reduce waste, and improve efficiency in construction.

The foundational ideas of LC create a framework for improving construction outcomes and processes, as shown in Figure 1. This strategy's guiding principle, "Value," removes operations with no inherent value in favor of understanding client demands. "Value Stream Mapping" techniques facilitate the identification of waste and inefficiencies. The "Flow" principle emphasizes a smooth, uninterrupted workflow while minimizing disturbances. The "Pull" method adjusts projects to manufacture and deliver only what is necessary, reducing waste and surplus. Finally, the "Perfection" principle encourages continuous improvement, teamwork, and problem-solving at all project levels and ultimately enhancing overall processes.

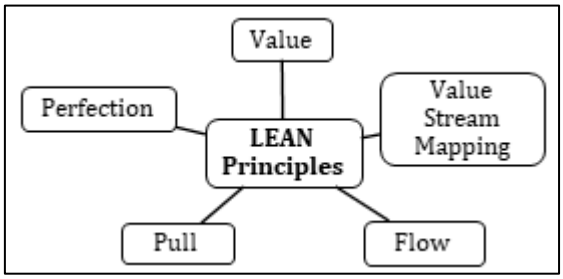

Figure 1. LC principles (adapted from Lohne *et al.* (2022)).

The main principles of LC are the following (Benachio et al., 2021; Lohne et al., 2022).

- **Value:** it is defined by what the customer sees as worth paying for in a product or service. It focuses on meeting the customer's needs and expectations. The goal is to identify what matters most to the customer and align all activities to deliver that value effectively.
- **Perfection:** it is about continuously improving processes to eliminate waste and deliver products or services with zero defects. It requires constant effort to refine and innovate, ensuring that all operations are as efficient and effective as possible.
- **Value Stream Mapping (VSM):** a visual tool for mapping out and analyzing the flow of materials and information in delivering a product or service. It highlights value-adding and non-value-adding activities, optimizes flow, and enhances value delivery.
- **Pull:** Pull systems are driven by customer demand rather than forecasts, ensuring resources are used only when needed. This approach focuses on precisely producing what is required when it is required to reduce waste and avoid overproduction.

- **Flow:** it refers to the seamless progression of products or services through the value stream without delays, bottlenecks, or waste. By removing obstacles and inefficiencies, the process can run continuously and deliver value smoothly to the customer.

LC promotes accountability, teamwork, and clear communication among project participants, including suppliers and contractors. Lean methods like the Last Planner System, Kanban, and 5S improve scheduling and organization in construction. According to Abdullahi and Tembo (Abdullahi & Tembo, 2023), implementing Lean principles in construction reduces lead times, eliminates waste, and enhances resource use. This approach improves communication and teamwork, increasing project predictability while reducing delays and costs. Success requires commitment to cultural change, continuous improvement, and value creation with Lean tools. Standardizing processes boosts predictability and minimizes unpredictability.

PROPOSAL OF LC BARRIER MODEL

Figure 2 shows key factors influencing the successful adoption of LC in construction. Each element represents a barrier or enabler, highlighting the complex challenges involved. This research is based on an exhaustive review of the literature on LC, combined with the findings of Romo *et al.* (2024), who analyzed the barriers to applying LC. The study aims to understand the barriers to integrating LC in construction, focusing on those related to organizational culture.

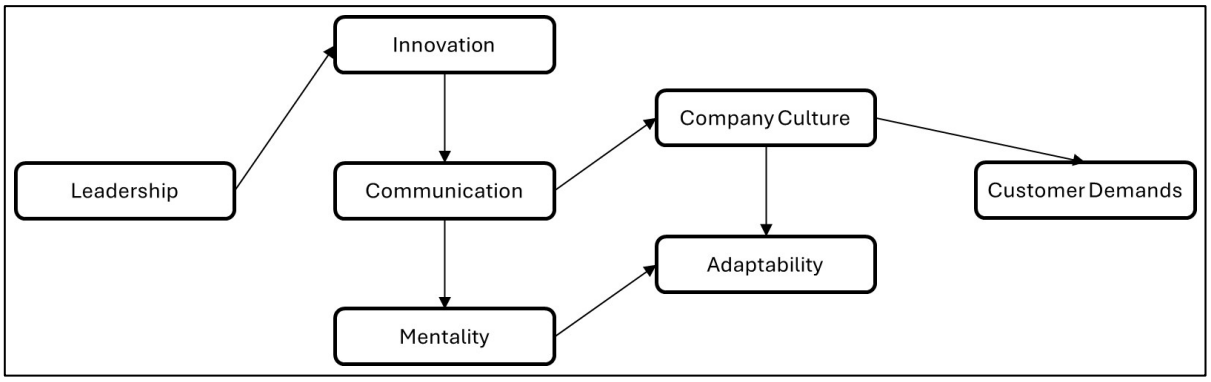

Figure 2. Proposal LC Barriers model.

The suggested Lean model stems from a literature review that highlights difficulties in its practical implementation, particularly in overcoming organizational culture hurdles. Key issues include adherence to conventional management, lack of leadership commitment, resistance to change, and inadequate training. Several studies have examined Lean matters in construction, including the difficulties in adopting the methodology in construction firms (Al Balkhy et al., 2021; Albalkhy & Sweis, 2021). The proposed model aims to create a flexible, cooperative, efficiency-driven workplace by addressing cultural barriers, expressed as following variables:

- **Leadership as a Central Node:** Leadership is vital for LC adoption, affecting innovation, culture, communication, and attitude. Leaders align vision with Lean principles, fostering collaboration and optimizing resources (Yang et al., 2022).
- **Mentality:** an organization's mindset and attitudes influence LC implementation success. This is closely tied to training, company culture, and adaptability. A positive attitude toward change fosters adaptation to new methodologies (Schein, 1985).
- **Company Culture:** the organizational culture is both a barrier and an enabler, depending on its alignment with Lean principles. Leadership, communication, mentality, and attitude shape it. A culture emphasizing collaboration, continuous improvement, and shared responsibility enhances process implementation (Cillo et al., 2022).

- **Communication:** effective communication underpins collaboration among teams and stakeholders. It ties into training, leadership, and adaptability, ensuring smooth information flow and minimizing misunderstandings (Hala Taleb et al., 2017).
- **Innovation:** addressing construction inefficiencies is vital. Leadership, resources, time, and customer demands affect the organization's adoption of Lean plans (Liu et al., 2023).
- **Adaptability:** this element shows the organization's ability to integrate Lean principles into operations, connecting Mentality, Attitude, Training, and Company Culture to highlight adaptability's importance in navigating industry challenges (Irfan et al., 2022).
- **Customer Demands:** adopting LC is impacted by external and internal constraints. Customer demands influence Lean practices' direction and urgency. Leadership balances these factors to align with organizational goals (Tunji-Olayeni et al., 2024).

The model emphasizes that adopting LC is not just a technical shift but a cultural transformation. Leadership is crucial, influencing all factors, while adaptability, innovation, and communication help overcome resistance. By addressing these barriers, organizations can effectively implement LC principles, achieving greater efficiency and sustainability.

ANALYSIS OF RESULTS

SAMPLE AND DATA COLLECTION

The assessment instrument included a questionnaire with closed-ended questions (using a Likert scale) addressing seven variables: Leadership, Mentality, Company Culture, Communication, Innovation, Adaptability, and Customer Demands. All methods followed the ethical guidelines of the university's scientific ethics committee.

The research focused on professionals in the Mexican construction sector, specifically architects and civil engineers practicing LC. A questionnaire was distributed to managers, directors, and owners of construction firms knowledgeable about their company's vision for process optimization, waste reduction, and continuous improvement. It was disseminated via LinkedIn and Mexican construction organizations using selective sampling based on experience, position, and LC expertise. A total of 100 construction enterprises responded, and their demographic information is shown in Table 2.

Table 2. Demographic summary of survey participants (N = 100).

Category		Sample size
Total sample size		100
Gender	Male	74
	Female	26
Education level	Primary school or below	
	Middle School	
	High school	
	College or University	100
Job position	Construction business owner	35
	Management personnel	41
	Director	24
Years of experience	0-10	23
	10-20	42
	20-30	35

The data collection revealed limited LC education among construction professionals in SMEs. Training and Lean resources are also scarce for companies outside major urban centers, reducing data representativeness. These constraints require cautious data interpretation, as results may not reflect the sector's complexities or readiness for LC integration.

MEASUREMENT AND STRUCTURAL MODEL

Evaluating the measurement model involves assessing item reliability, scale consistency, and validity. A PLS model determines item reliability by examining loadings (λ), or correlations, between indicators and constructs, which reflect relationships between latent and manifest variables. Reliability in a PLS model is assessed by reviewing these loadings and correlations.

According to Barroso Castro *et al.* (2007) and Carmines & Zeller (1979), an indicator must have a loading of at least 0.7 to be part of a construct, indicating stronger shared variance than error variance. Loadings indicate correlations; a value of 0.7 or higher means the construct explains over half the variance in the observed variable. Tables 2-5 later show that most variables in this study meet these criteria, confirming their reliability.

The Partial Least Squares (PLS) model illustrates relationships among latent variables in the conceptual framework. It mainly serves as a variance-based predictive model, generating accurate predictions of variable correlations. Thus, validating the PLS model assesses its ability to anticipate variations in observed data (Hair et al., 2011; Tenenhaus et al., 2004).

R^2 measures the predictive power of variables, indicating the variance explained by independent latent variables. It should be at least 0.1, as lower values offer limited insight, suggesting weak predictive capability for related hypotheses (Barroso Castro, Cepeda-Carrión, & Roldán Salgueiro, 2007). Internal consistency is assessed using reliability coefficients like Cronbach's alpha and Dillon-Goldstein rho. Cronbach's alpha measures the reliability and interrelation of survey items, with values from 0 to 1 —higher values indicate greater internal consistency. Generally, a value of 0.70 or above is suitable for research (Guenther et al., 2023).

ANALYSIS OF THE PROPOSED MODEL

After administering the questionnaire, we conducted a statistical analysis to assess employee perceptions of barriers. This identified relationships between variables and highlighted key indicators. Figure 3 illustrates the results and emphasizes the primary factors at play. The visual representation reveals correlations and significant indicators influencing barrier understanding, offering insights into organizational dynamics. This analysis clarifies the factors impacting employee perceptions and the significance of each barrier in organizational processes.

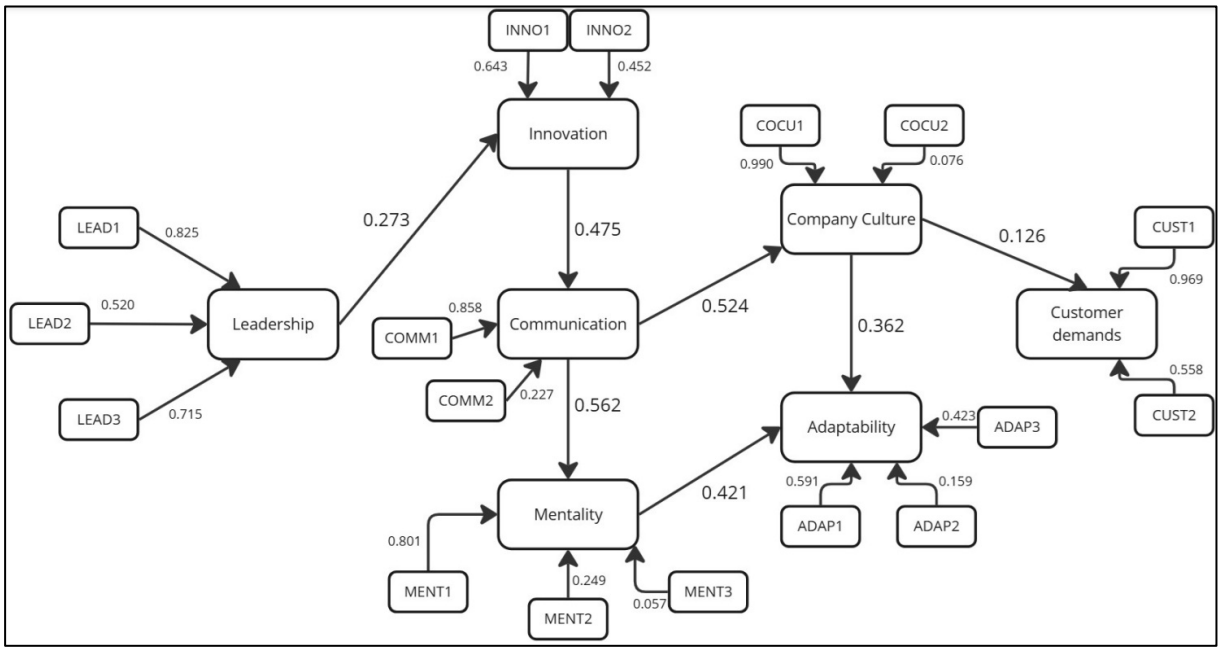

Figure 3. PLS Diagram for LC Barriers

Tables 2, 3, and 4 display the behavior of the loadings, path coefficients, and R^2 values. The Partial Least Squares (PLS) analysis offers valuable insights into the complex relationships among variables within the organizational context, particularly in adopting Lean principles.

Table 2. Loadings.

Variable	Outer loadings	Variable	Outer loadings
ADAP1 -> Adaptability	0.899	INNO1 -> Innovation	0.940
ADAP2 -> Adaptability	0.771	INNO2 -> Innovation	0.874
ADAP3 -> Adaptability	0.819	LEAD1 -> Leadership	0.837
COCU1 -> Company Culture	0.997	LEAD2 -> Leadership	0.018
COCU2 -> Company Culture	0.175	LEAD3 -> Leadership	0.445
COMM1 -> Communication	0.982	MENT1 -> Mentality	0.980
COMM2 -> Communication	0.693	MENT2 -> Mentality	0.794
CUST1 -> Customer demands	-0.840	MENT3 -> Mentality	0.318
CUST2 -> Customer demands	0.333		

Table 3, on the other hand, shows that barriers are not mutually correlated. Each barrier measures specific variables, indicating independence among factors.

Table 3. Path coefficients.

Variable	Path coefficients
Company Culture -> Adaptability	0.362
Company Culture -> Customer demands	0.126
Communication -> Company Culture	0.524
Communication -> Mentality	0.562
Innovation -> Communication	0.475
Leadership -> Innovation	0.273
Mentality -> Adaptability	0.421

The R^2 criterion suggests that a value greater than 0 indicates the model has predictive power, meaning it can explain some of the dependent variable variability, as seen in Table 4. If the R^2 value is greater than 0, it implies that the model accounts for a certain proportion of the variation in the dependent variable. An R^2 value close to 0 does not necessarily mean the model is unimportant or irrelevant. Instead, it indicates that the model cannot explain any of the variance in the dependent variable. Also, an R^2 value of 1 signifies that the model perfectly predicts the dependent variable based on the independent variable(s) (Chin, 1998; Wong & Cheung, 2005).

Table 4. Path coefficients R^2

Variable	R-square
Adaptability	0.647
Company Culture	0.575
Communication	0.525
Customer demands	0.716
Innovation	0.674
Mentality	0.616

Table 5 shows the internal consistency of the variables, indicating how survey items correlate within each variable. This metric is crucial for assessing the reliability of measurement

instruments, as it reflects the relationship of items measuring the same construct. The results indicate that all variables demonstrate high internal consistency, meaning the items align well and consistently measure the intended constructs. This enhances the reliability of the findings, boosting confidence in the accuracy and stability of the measurements used in the analysis.

Table 5. Cronbach's Alpha.

Variable	Cronbach's alpha	Variable	Cronbach's alpha
ADAP1 -> Adaptability	0.899	INNO1 -> Innovation	0.940
ADAP2 -> Adaptability	0.771	INNO2 -> Innovation	0.874
ADAP3 -> Adaptability	0.819	LEAD1 -> Leadership	0.837
COCU1 -> Company Culture	0.997	LEAD2 -> Leadership	0.618
COCU2 -> Company Culture	0.675	LEAD3 -> Leadership	0.745
COMM1 -> Communication	0.982	MENT1 -> Mentality	0.980
COMM2 -> Communication	0.693	MENT2 -> Mentality	0.794
CUST1 -> Customer demands	0.840	MENT3 -> Mentality	0.718
CUST2 -> Customer demands	0.333		

Based on the information provided in Figure 3 and Tables 2, 3, and 4, the structural modeling approach reveals the interdependencies that significantly influence organizational effectiveness. Below is a detailed exploration of these correlations, supported by specific effect sizes derived from the PLS model.

Employee Identification with Company Culture and Communication.
A correlation emerges between employee identification with company culture and employee communication, reflecting the critical role of shared values in fostering effective interaction within the workplace. The strength of this relationship underscores the importance of cultural alignment as a foundation for open and productive communication channels among employees.

Communication and Employee Mentality in Lean Methodology Adoption.
Communication has a significant influence on employees' acceptance of the Lean methodology, as reflected by a correlation of 0.562. This shows that transparent and frequent communication fosters a mindset open to process improvement. Clear messaging and consistent information sharing are crucial for reducing resistance and fostering a culture of continuous improvement.

Innovation and Communication.
Innovation is linked to communication, as revealed by an effect size of 0.475. This connection suggests that effective communication enables the exchange of ideas, collaboration, and creativity, which are essential for innovation. This finding might suggest that organizations that prioritize open communication are better positioned to generate and implement new ideas, thereby driving operational efficiency and competitive advantage.

Communication and Company Culture.
One of the most significant correlations is between communication and the company's culture, with an effect size of 0.524. This strong relationship emphasizes how communication serves as a bridge between organizational values and employee behavior. A robust cultural foundation supported by effective communication strategies facilitates alignment between individual and organizational goals, thereby enhancing overall performance.

Leadership and Innovation.
Leadership evidences a comparatively weaker effect on innovation, with an effect size of 0.273. This finding suggests that while leadership is important, other factors, such as communication and organizational culture, may play a more prominent role in driving innovation. Leaders may need to adopt more proactive strategies to foster creativity and research within their teams.

Company Culture and Customer Demand.
Company culture has a low effect on customer demand (effect size of 0.126). This modest correlation suggests that culture mostly influences internal dynamics rather than directly affecting customer needs. However, an indirect effect may arise from enhanced service quality and employee engagement, indicating a need for further exploration.

Company Culture and Employee Adaptability.
The relationship between company culture and employee adaptability is moderated, with an effect size of 0.362. A supportive and inclusive culture helps employees adapt to new working methods, which are essential for implementing the Lean methodology. Organizational adaptability is crucial for responding to market changes and maintaining competitiveness.

PLS analysis reveals the complex relationships within an organization, highlighting factors influencing Lean methodology adoption. Communication significantly affects innovation, mentality, and cultural alignment, while leadership and culture show weaker but important indirect contributions to success. These insights allow organizations to prioritize strategies that strengthen relationships and promote continuous improvement.

INTEGRATING THE LC PRINCIPLES AND THE ROLE OF ORGANIZATIONAL CULTURE

The Integrated LC Model shown in Figure 4 merges the foundational principles of Lean (Value, Value Stream Mapping, Perfection, Flow, and Pull) with the specific barriers faced in LC (Leadership, Innovation, Communication, Mentality, Company Culture, Adaptability, and Customer Demands). This comprehensive approach seeks to optimize construction processes while systematically overcoming industry-specific challenges. By integrating these core Lean principles with the barriers unique to the construction industry, the model provides a holistic framework for enhancing operational efficiency, improving stakeholder engagement, and fostering a culture of continuous improvement. This dual approach addresses both the technical aspects of process optimization and the human and organizational factors that often hinder successful implementation in construction projects.

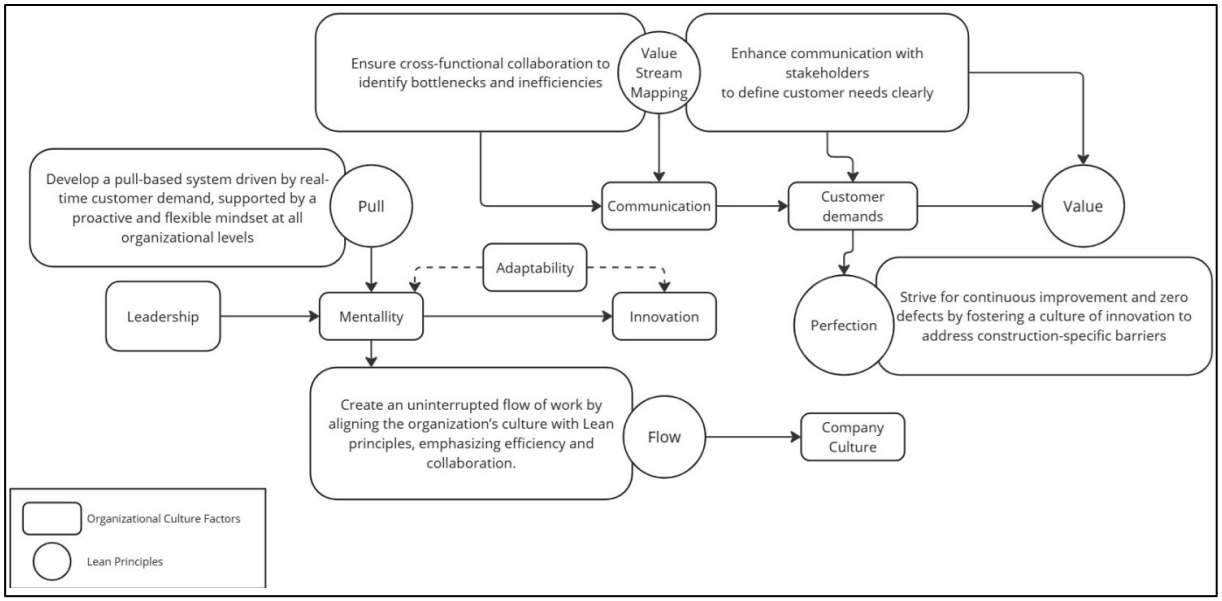

Figure 4. Integrated Lean model

This model advocates for a balanced integration where operational strategies are aligned with leadership development, innovative practices, and adaptive organizational structures. It emphasizes the importance of effective communication, a proactive mentality, and a company

culture that supports continuous learning and responsiveness to customer needs. This alignment ensures that process improvements are sustainable and the organization can swiftly adapt to evolving industry demands.

Integrating organizational culture within the framework of LC requires a cultural transformation. Resistance to change, often seen in the construction industry, can be overcome by promoting organizational values that prioritize continuous learning, flexibility, and cooperation. Strong leadership is essential for communicating the vision and aligning teams toward common goals. Additionally, a culture that promotes employee satisfaction and commitment can increase the adoption of advanced technologies. For instance, training in digital tools enhances productivity and motivates teams to actively participate in organizational transformation.

THE IMPACT ON PRACTITIONERS

Integrating technologies like AI, IoT, and BIM can greatly enhance LC in Industry 4.0. However, without a supportive organizational culture that fosters technology adoption and continuous learning, digital transformation may be seen as a threat. For maximum efficiency and minimal waste in building operations, organizational culture must align with digital technologies. The study's conclusions primarily benefit construction organizations aiming to improve operational effectiveness through LC. Its relevance may be limited in industries with labor structures that diverge from Lean principles, highly hierarchical organizations, or those uninterested in digitization.

The synergy between LC and a strong organizational culture can revolutionize the construction sector. Companies must invest in cultivating a culture that fosters innovation and collaboration to lead in a competitive industry. Organizational culture in construction is crucial for implementing innovative methodologies like LC. Traditionally artisanal and linear, the industry faces challenges such as resistance to change, team fragmentation, and project complexity. Overcoming these barriers needs a cultural transformation prioritizing values like continuous learning, cooperation, flexibility, and innovation.

CONCLUSIONS

The successful implementation of LC and organizational culture in the construction industry hinges on a dual focus: adopting advanced technologies and fostering a supportive organizational culture. Lean principles, which emphasize waste reduction and value maximization, can be significantly enhanced by the advanced tools provided by an adequate organizational culture. In other words, without a culture that champions continuous learning, collaboration, and adaptability, the full potential of these methodologies and technologies cannot be realized. A culture that embraces innovation and flexibility is essential for overcoming resistance to change, improving team coordination, and driving sustainable outcomes in construction projects. Additionally, as highlighted by recent research, measuring the success of Lean initiatives through key performance indicators aligned with strategic goals can further enhance the effectiveness of LC. Such metrics provide actionable insights and reinforce a culture of continuous improvement and accountability. This integrated approach addresses current challenges and positions construction firms at the forefront of an evolving industry, prepared to tackle future demands with greater efficiency and resilience.

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