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Enhancing Construction Efficiency through Last Planner System: A Study of Cultural Integration and Team Feedback Dynamics

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Abstract **-** The management of construction site production and the operation of industrialized construction often align with modern production methodologies, promising faster overall delivery. While this holds some truth, it has also ushered in a shift from traditional construction teams to specialized teams, escalating the coordination costs associated with intricate assembly, installation, and construction workflows. This paper aims to present an overview of collaborative coordination, planning, and review tools as a solution to cultural challenges. We evaluate the potential impact of the Last Planner on organizational culture, with a focus on team feedback. The objective is to facilitate shorter delivery times and improved project performance. This becomes particularly significant in the context of adopting new digital technologies for coordination and communication, aligning closely with customer value, meeting reduction targets, addressing sustainability, and enhancing overall performance in the construction sector. The Last Planner System (LPS) emerges as a valuable tool to enhance the interface between management and construction teams, promoting improved performance. By leveraging the Last Planner System, workflow reliability can be heightened, leading to reduced project duration and costs. Effective collaborative planning, high-quality team feedback, and a culture of continuous improvement hinge significantly on the development of trust and a commitment to engaging in constructive team feedback. Establishing such relationships requires proactive involvement from both managers and team members to reinforce the desired learning culture. This paper explores how these elements collectively contribute to optimizing construction processes and fostering a culture of continuous improvement.

Keywords**:** Team feedback; Lean Construction; Culture; Construction site management

1. Introduction

The challenge of managing site teams effectively and efficiently while incentivizing productivity and performance improvement is a complex issue in today's construction industry. Howard, et al. [1] points out that a key component in addressing this challenge is the implementation of effective team feedback mechanisms. This approach emphasizes the importance of communication and feedback in team management, suggesting that regular, constructive feedback can lead to significant improvements in team performance. By fostering an environment of open communication, teams can identify areas for improvement, develop strategies to address challenges, and recognize achievements, all of which contribute to enhanced productivity and a more harmonious work environment. Lean construction (LC), as proposed by Aslam, et al. [2], offers a robust framework for tackling the productivity and waste challenges in the construction industry. The philosophy of LC revolves around the principles of minimizing waste and maximizing value, which directly aligns with the objectives of efficient team management. Lean construction emphasizes streamlining processes, reducing unnecessary tasks, and improving the overall flow of construction activities. By adopting lean principles, site teams can focus on value-adding activities, reduce delays and redundancies, and enhance overall project performance. This approach not only improves efficiency but also contributes to creating a more structured and predictable work environment, which is crucial for team morale and productivity.

Lean construction (1993) was introduced by Ballard [3] as a management philosophy that aims to reduce waste, regulate variation, preserve flow, generate value, and increase safety and quality of construction products, offers a comprehensive strategy for improving team management in construction. This philosophy advocates for a systematic approach to construction management, focusing on continuous improvement and efficiency. By implementing lean construction principles, site managers can develop more effective strategies for team management, ensuring that each team member's efforts are aligned with the project's overall goals. This alignment not only enhances individual performance but also ensures

that the team as a whole works cohesively towards common objectives, ultimately leading to higher quality outcomes and improved safety standards on construction sites. The Last Planner System (LPS) is a significant approach in lean construction, emphasizing collaborative planning and team commitment. This system moves away from conventional top-down planning methods, focusing instead on collaboration and collective agreement from delivery teams. Such an approach not only enhances collaborative knowledge and control over tasks and issues but also fosters trustful relationships among project participants. Howell and Ballard [4] recognized LPS as a powerful tool in improving conventional production systems by reducing waste, increasing employee participation, and promoting pull flow production and continuous improvement philosophies.

Ballard [5] and Hamzeh [6] emphasize the role of LPS as a production planning and control system crucial for increasing workflow reliability in modern construction projects. LPS guides organizations to continually enhance their operations by consistently generating customer value and eliminating non-value-adding activities, as discussed by Mann [7] and El Masri and Matkó [8]. Supporting this view, Maru [9] in a case study analysis of the UT Arlington College Park construction, demonstrated the tangible benefits of implementing the Last Planner System, noting a significant increase in the Planned Percent Complete (PPC) values post-implementation, suggesting enhanced efficiency and productivity in construction projects. Further, Zhang, et al. [10] introduced the integration of the Earned Value Management (EVM) in LPS to evaluate project performance at different levels, enhancing the overall efficiency of construction management. This integration highlights the importance of complementing LPS with other management tools for a more comprehensive approach to project control and productivity improvement. Together, these studies and applications of LPS in various contexts underline its effectiveness in improving construction project management, affirming its role as a key component in the lean construction framework.

In the realm of construction management, the performance of teams is significantly enhanced when there is a clear understanding of expectations and regular feedback. Teizer [11] underscores this by highlighting the importance of feedback mechanisms for guiding team members and correcting any issues that might impede team performance. In construction sites, where multiple teams work on different work packages, effective team feedback becomes crucial for coordinating activities and ensuring seamless on-site work progression. This system of feedback and coordination is not only vital for task alignment but also for maintaining a harmonious and efficient work environment where every team member is aware of their role and its impact on the overall project. The LPS, while effective, encounters challenges that necessitate a focus on cultivating a lean culture and enhancing team feedback. Lühr and Bosch-Rekveldt [12] delve into this by exploring how to measure project team culture in projects utilizing LPS, suggesting that aligning the team's culture with ideal lean culture conditions is key to successful LPS implementation. Similarly, Schimanski, et al. [13] demonstrate the benefits of integrating LPS with Building Information Modelling (BIM) to improve efficiency and coordination, ultimately enhancing team performance on construction sites. This integration highlights the importance of leveraging technology in conjunction with lean principles to bolster team dynamics and project outcomes.

Reinbold, et al. [14] emphasize the significance of communication and transparency in construction processes, identifying these as critical factors for improving situation awareness on construction sites. The application of LPS in fostering an environment where feedback is timely and relevant is crucial for this. Moreover, Power, et al. [15] examine the role of a dedicated LPS facilitator in enhancing construction productivity, underscoring the importance of knowledgeable guidance in implementing LPS effectively. This approach ensures that the principles of lean construction and the benefits of enhanced team feedback are fully realized, leading to improved construction site performance. Together, these studies underscore the integral role of effective team management and lean culture in optimizing construction processes and outcomes. Current research work primarily contributes to the field of construction management by investigating the effective integration of the Last Planner System (LPS) into construction practices. It underscores the importance of aligning organizational culture with lean principles through LPS, emphasizing how this alignment can significantly improve workflow reliability, reduce costs, and cultivate a continuous improvement mindset within construction projects. The paper also highlights potential future research directions, particularly the integration of LPS with advanced digital technologies like Building Information Modeling (BIM) and Artificial Intelligence (AI), to further enhance construction management efficiency.

2. Literature Review

The critical role of the site manager in construction projects encompasses not only process management but also people people management, problem-solving, and rapid decision-making. Mäki and Kerosuo [16] emphasize the multifaceted nature nature of this role, highlighting the site manager's responsibility for linking planned activities to on-site execution and ensuring that projects are delivered within their constraints. Zhao, et al. [17] support this view, underlining the significance significance of construction management tasks in the timely delivery of projects. An explores the relationship between site managers' decision-making participation and organizational commitment in construction projects, suggesting that effective decision-making by site managers has a profound impact on project performance. Additionally, Noorzai [18] develops a model to select the most appropriate lean technique for site management, emphasizing the crucial role of site managers in implementing these techniques to improve construction phase efficiency. The study reveals that "Daily Huddle Meetings" are the most effective lean technique to enhance site management, demonstrating the significant influence site managers have on the success of construction projects. These references collectively highlight the essential role of site managers in construction projects, not only in terms of process management but also in personnel management, decision-making, and the implementation of lean techniques.

The key differences between LC and traditional construction approaches are substantial and transformative. Locatelli, et al. [19] present a comparison in Table 1 of their study, illustrating these differences in approach and methodology. Lean Construction, as opposed to traditional methods, focuses on maximizing value while minimizing waste, thereby changing the fundamental approach to construction project management. Howell [20] emphasizes the need to redefine control in construction from merely monitoring results to actively making things happen. This approach is integral to Lean Construction, where the planning system's performance is continuously measured and enhanced. Ballard [5] further explain that planning and control in LC are complementary and variable processes maintained throughout the project. These processes are not static; they adapt as project needs change, requiring replanning and feedback for continuous improvement. In the context of LC, the LPS plays a crucial role. It is designed for collaborative planning and work allocation among teams and individuals, such as subcontractors and specialist contractors. LPS links design and planning to construction programming, enabling systematic coordination between the 'design & designed plan' and construction planning. Zhao, et al. [17] note that LPS was created to help project teams establish a network of commitments and ensure dependable workflows, emphasizing continuous learning and development, which are ideal for enhancing safety and quality on construction sites. The strategy of planning with the LPS included is shown in figure 1 [21].

Table 1 – Differences between Traditional and Lean Construction

Traditional Construction	***Lean Construction***
Uses the same activity centered approach used in mass production and project management	Defines a clear set of objectives for delivery process
Aims to optimize the project activity by activity and identifies customer value in design	Aims at maximizing performance to the customer at the project level
Breaks the project into pieces and puts them in a logical sequence focusing on each activity	Designs concurrently product and process
Considers control as monitoring each activity against its schedule and budget projections	Applies production control throughout the entire project life

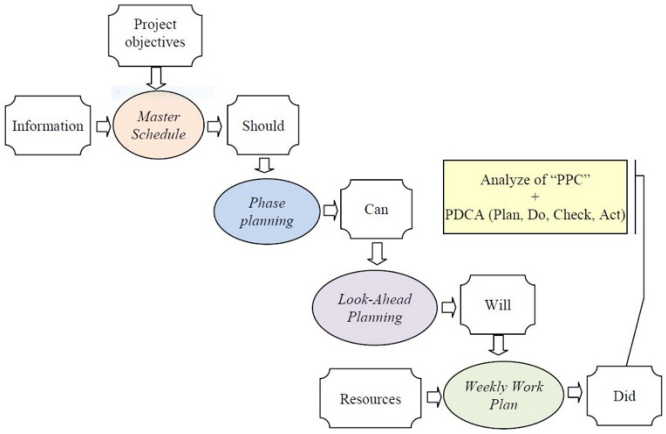

Fig 1. The strategy of planning with the LPS included.

The "Master Schedule" in Lean Construction is a fundamental tool for managing large-scale construction projects. It plays a pivotal role in establishing key characters, building sequences, and milestones that are essential during the phase planning stage. Each company, represented by a foreman, manages the schedule according to the tasks they are involved in. This concept is thoroughly explored in the study by Qi, et al. [22], which discusses Lean Planning and Controlling of Large-Scale Construction Engineering Projects. The study proposes a lean plan system, including milestone schedule, master schedule, sub-master schedule, look-ahead plan, and implementing plan, and analyzes the rule and process of lean planning. In the context of "Look-Ahead Planning," which is a two- to eight-week timetable, the focus is on identifying constraints that must be considered to avoid deadline overruns. This involves all organizations and subcontractors verifying the availability of necessary resources and conditions to complete scheduled tasks properly. Ballard [23] emphasizes the importance of verifying seven crucial aspects: prerequisites, work readiness, surface readiness, labor availability, plan availability, equipment availability, material availability, and favorable external conditions.

Furthermore, "Weekly Work Plan" and PPC (Percentage of Promises Completed) are integral components of Lean Construction. PPC is a production indicator measuring the completion rate of scheduled activities. Bajjou, et al. [21] delve into this by discussing the application of the PDCA (Plan, Do, Check, Act) approach to measure the disparity between intended outcomes and actual achievements. The LPS enhances reliability in construction projects through various mechanisms. According to Ballard [5], 'lookahead planning' and the 'make-ready' process play crucial roles, ensuring that materials, information, and equipment are available for tasks. This involves filtering scheduled tasks through the weekly work planning method, guaranteeing completion of prior activities and engaging work team leaders to commit meaningfully and trustworthily. Ballard and Howell [24] also emphasize the quality aspects of weekly work plans in LPS, focusing on selecting the right work sequence and amount, and ensuring specified work can be completed. LPS is recognized in the literature as a production control strategy that stabilizes and introduces advanced lean concepts in construction. This approach aims to minimize variation in construction operations, improve project planning and scheduling, and reduce uncertainty levels. Additionally, study by Priven and Sacks [25] further illustrates LPS's impact on improving construction workflow, emphasizing enhanced coordination among subcontractors and integration with Building Information Modelling (BIM) for more efficient project management. These insights collectively highlight LPS's multifaceted impact on construction projects, underscoring its role in improving workflow, enhancing coordination, and reducing variability in construction processes. Implementing the LPS in construction projects results in greater transparency, especially when combined with new digital tools like reality capture and automated activity recognition. This implementation necessitates a re-evaluation of the underlying cultural norms within the construction industry. Schein [26] defines culture as a pattern of shared basic assumptions, highlighting the importance of these assumptions in guiding how individuals perceive, think, and feel about various problems. The construction industry,

traditionally reliant on contract forms that focus on set performances and deliveries of work packages, often lacks incentives to consider the broader project context. Open feedback, as noted by Johansson, et al. [27], was frequently avoided due to the perceived vulnerability to claims it could create. However, LPS's emphasis on information sharing and documentation can make mistakes more visible, providing opportunities for root cause analysis and continuous improvement, but also raising concerns about blame assignment.

A balanced whole-system approach that focuses on the people providing value to customers is necessary. According to Stehn and Höök [28], when adopting lean principles and establishing a lean culture, involvement, personal focus, and motivation are critical. Lean principles and practices are seen as facilitators for both individual and organizational performance. In this context, LPS can be a transformative tool, but its success hinges on the organization's willingness to embrace a lean culture, focusing on transparency, collaboration, and continuous improvement. The shift to a lean culture requires not just the adoption of new tools and processes but also a change in mindset and attitudes towards work and collaboration within the construction industry. The distinction in behaviors and methodologies between traditional construction practices and those guided by lean construction principles is striking and transformative. Lean construction, as articulated by Lander and Liker [29], is an amalgamation of concepts and practices focused on discerning customer value, minimizing waste, fostering continual improvement, and adopting a long-term perspective. This philosophy significantly alters how tasks are approached and executed on construction sites. Central to lean construction is Koskela [30] 'TFV' theory of production, which reimagines production through the lenses of Transformation (T), Flow (F), and Value (V). Transformation relates to converting inputs into outputs, Flow pertains to the movement of materials and information, and Value focuses on what is beneficial for the customer. Emphasizing these aspects is crucial to elevating productivity and optimizing output in construction processes. The implementation of these principles requires a cultural shift, especially in terms of information sharing and management expectations. As Freeman and Seppänen [31] highlight, this shift can reveal underlying issues previously unaddressed by traditional management approaches. It necessitates building trust and modifying team motivations and business models to accommodate this new way of working.

2.1. Feedback in Construction Team

The concept of feedback, as defined by Cleland [32], underscores the importance of a two-way communication process. Effective teamwork in a lean construction environment heavily relies on continuous and constructive feedback, as supported by research from Kermanshachi [33]. This approach to feedback is integral to nurturing a collaborative and improvement-oriented work culture, distinguishing lean construction from its traditional counterpart. In the dynamic environment of team settings, feedback plays a pivotal role. It is defined as the transmission of information among team members or to the entire team, concerning their actions, events, processes, or behaviors in relation to task completion or effective teamwork [34]. This exchange of feedback is integral to the ongoing process of refining strategies and approaches to meet collective goals. Senescu, et al. [35] further emphasize the importance of communication, defining it as a critical factor in the relationship and collaborative interactions both within and between project teams. Coordination of feedback within team's manifests in two primary ways: through team design and communication. Team design refers to the strategic organization of activities and the implementation of necessary tools to enhance coordination. Meanwhile, communication involves various methods such as face-to-face meetings, email, file exchanges, and other forms of interaction that enable teams to accomplish tasks. These communication methods are vital for negotiating goals, making decisions, and sharing task status information.

2.2. Performance in Construction Team

The concept of team performance is multifaceted. Koke and Moehler [36] define it as the degree to which a team achieves its output goals, encompassing aspects such as quality, safety, productivity, functionality, and reliability. Lynn and Kalay [37] expand on this by including the fulfilment of member expectations, and the meeting of cost and time objectives. Team performance is a critical element in the overall performance of a company, especially in sectors like construction where the flow of information is paramount. The construction industry, often characterized as "information-dependent," necessitates robust communication methods to ensure project quality. Thus, effective communication is a key element in data delivery and maintaining interoperability among contractors, subcontractors, and other parties in a construction project [38]. This interplay of feedback, communication, and team performance underscores the complex yet essential nature of team dynamics

in achieving success in construction projects. Effective management of these elements is crucial for navigating the challenges of the construction industry and achieving optimal project outcomes.

2.3. Communication & Collaboration in Construction Team

Communication and collaboration practices within construction sites profoundly influence the efficiency and effectiveness of project execution. Loganathan, et al. [39] highlight how communication issues between supervisors or foremen and workers, along with inappropriate coordination and cooperation among workers, can significantly impact on-site task completion. The working culture, teamwork dynamics, and the practice of prematurely moving workers off tasks all contribute to the overall performance of construction projects. In this context, team feedback emerges as a crucial element to coordinate activities on construction sites. The complexity of construction projects, as noted by Mäki and Kerosuo [16], involves a diverse array of stakeholders, including clients, users, designers, contractors, construction workers, material suppliers, and authorities. This diversity makes effective communication and collaboration essential for the successful completion of these prolonged and intricate processes. Traditionally, construction managers rely heavily on their personal work experience and the expertise of colleagues and peers within their network to interpret and complete designs. This approach reflects a community of practice among construction site managers where verbal communication and 'talking' play pivotal roles. The transfer of knowledge from one project to another is largely dependent on individual memory, experience, and storytelling skills. Site managers typically view unexpected events as normal elements of a project, approaching work as a form of improvisational problem-solving that requires quick decision-making and adaptation.

Dossick and Neff [40] point out that information exchange and learning in construction projects are predominantly verbal, with informal conversations and 'messy talk' being common. This underscores the need for the site team to explore alternative methods for project communication, considering the most effective tools and methodologies for managing team communication as suggested by Den Otter and Emmitt [38]. Moreover, as Dainty, et al. [41] assert, communication difficulties are often a primary factor when construction performance falls below expectations. The challenges in directly connecting with project team members can lead to unnecessary expenses and negatively impact the project's progress and quality, a concern echoed by Senaratne and Ruwanpura [42]. Therefore, addressing communication issues and improving collaboration methods are essential for enhancing the overall performance and success of construction projects.

3. Discussion

The LPS represents a paradigm shift in construction project management, moving towards a more collaborative and integrated approach. This evolution in planning and execution methodologies is not just a change in tools and processes, but it also represents a fundamental shift in the mindset and culture within the construction industry. By fostering a collaborative environment, LPS enhances trust and improves the quality of feedback between teams and management, which is essential for fostering a culture of continuous improvement and value-driven performance.

In practice, the implementation of LPS has been transformative in several real-world projects. The Norwegian construction project, as discussed by Ravi [43], is a testament to how LPS, combined with visual Lean planning, can enhance the synergy between planning and production. This integration leads to a more cohesive workflow, directly impacting the efficiency and effectiveness of project execution. Similarly, the adoption of LPS in Chinese construction firms, analyzed by Gao and Low [44], demonstrates its broad applicability and effectiveness in different cultural and organizational contexts. In these firms, LPS has been a key factor in enhancing workflow reliability and operational efficiency. The integration of LPS with digital technologies like BIM further exemplifies its adaptability and potential for enhancing construction management. The project studied by Heigermoser, et al. [45] illustrates how the combination of LPS and BIM can lead to significant improvements in coordination, efficiency, and overall project workflow. This synergy between lean construction principles and digital technologies is pivotal in modernizing construction practices and responding to the evolving demands of the industry. However, the transition to LPS and its integration with technologies like BIM is not devoid of challenges. The study by Boton, et al. [46] sheds light on the resistance to change

often encountered in the construction industry. This resistance highlights the need for comprehensive training and support systems to facilitate the adoption of new methodologies like LPS and BIM. Successful implementation requires not just the introduction of new tools but also a cultural and behavioral shift among all stakeholders involved.

An interesting insight into the practical application of LPS is provided by the Luxembourg project discussed by Hua and Hua and Schwartz [47], where the combination of physical and digital visual management tools was evaluated. This case study brings to the fore the importance of selecting the appropriate tools for LPS implementation, balancing the advantages of digitalization with the practicality and familiarity of traditional methods. Overall, the adoption of LPS in the construction industry signifies a move towards more integrated, efficient, and collaborative project management. Its success, however, hinges on the willingness of organizations to embrace change, invest in training, and adapt to new technologies and methodologies. As the construction industry continues to evolve, LPS stands as a beacon of modern, efficient, and collaborative project management practices.

4. Conclusions

This paper demonstrates the transformative impact of the Last Planner System (LPS) on construction management, emphasizing the importance of cultural integration and robust team feedback mechanisms in enhancing operational efficiency and project delivery. By aligning organizational culture with lean principles, LPS has proven to be a vital tool for improving workflow reliability, cost reduction, and fostering a continuous improvement mindset across construction projects.

Future research could delve deeper into the integration of LPS with emerging digital technologies such as Building Information Modeling (BIM) and Artificial Intelligence (AI) to explore further enhancements in construction management efficiency and the development of predictive analytics for risk assessment and management in construction projects.

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