Rivera-Nalvarte, C. C., Villar-Vasquez, J. A., Morales-Gutierrez, Y. A., Garay-Ramos, D. B., & Erazo-Rondinel, A. A. (2025). A scoping review of pull planning: good practices, benefits and barriers. In O. Seppänen, L. Koskela, & K. Murata (Eds.), *Proceedings of the 33rd Annual Conference of the International Group for Lean Construction* (IGLC33) (pp. 483–493). https://doi.org/10.24928/2025/0211

A SCOPING REVIEW OF PULL PLANNING: GOOD PRACTICES, BENEFITS AND BARRIERS

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ABSTRACT

Pull planning is a key element within the Last Planner System (LPS) that promotes collaborative planning in construction projects due to its benefits, such as fostering collaborative planning. This article aims to identify the benefits, barriers, and good practices associated with implementing Pull Planning. The research began with an exhaustive literature review, analysing 124 studies, following the scoping review criteria. Subsequently, a list of good practices, benefits, and barriers was prepared and organized according to their frequency of appearance in the literature.

This analysis allowed us to identify nine good practices for implementing Pull Planning, 11 benefits highlighting its positive impact on the construction industry, and 10 barriers limiting its effective adoption. The results of this research offer practical guidance for professionals who wish to optimize the implementation of pull planning, and researchers interested in delving deeper into this approach.

KEYWORDS

Pull Planning, Lean Construction, benefits, barriers, good practices.

INTRODUCTION

The construction industry is a fundamental pillar of infrastructure development and global economic growth (Dave et al., 2013). Its impact extends to providing housing, transportation, essential services, and other key societal projects (Yabuki, 2010). However, this industry faces multiple challenges that affect the delivery of projects on time and within budget, including inefficiencies in planning and control, sustainability issues, and low project predictability (Ballard, 2000).

One of the main factors contributing to these problems is variability in planning processes caused by poor coordination, inaccurate forecasts, and disruptions in material supply chains (Babanagar et al., 2024). These difficulties lead to delays and cost overruns and compromise workflow reliability and the overall success of construction projects. To address these

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challenges, the construction industry has adopted innovative planning and management approaches, most notably Pull Planning, a scheduling technique that seeks to improve project coordination and efficiency. Pull planning allows teams to align activities with project milestones through collaborative planning, ensuring each task is ready before starting the next (Tsao et al., 2014). This methodology is a key component of the Last Planner System (LPS), which has proven effective in reducing variability and optimizing resources in construction (Ballard, 2000).

Although the LPS has been implemented in several countries, its adoption is still uneven. Studies have analyzed the implementation of LPS in different contexts, identifying that Pull Planning is one of the least adopted elements within this system (Daniel et al., 2017).

Despite the growing implementation of LPS, no consolidated review unifies the knowledge and experiences on its application, particularly regarding Pull Planning. Thus, it is important to identify the barriers that limit the implementation of Pull Planning to improve its adoption in the construction industry. The main obstacles are resistance to change, lack of training, and poor collaboration among project stakeholders (Antonini et al., 2023). At the same time, it is essential to analyze the benefits of this methodology and the good practices that can facilitate its implementation, allowing more efficient and sustainable planning in the management of construction projects.

Therefore, this research aims to identify the best practices needed to effectively implement Pull Planning in construction projects and analyze its benefits and barriers.

BACKGROUND

LAST PLANNER SYSTEM

The Last Planner System (LPS) is a production planning and control system designed to improve workflow reliability and reduce waste in construction projects (Ballard, 2000). It is based on the principles of the Toyota Production System (TPS), developed by Taiichi Ohno in the 1940s, which incorporates Just-in-Time (JIT), which promotes on-demand production, and Jidoka, which emphasizes quality at the source and allows production to be stopped in the event of defects (Ohno, 1988).

LPS translates these principles to the construction sector, fostering collaborative planning and optimizing constraint management. Its implementation has demonstrated benefits in improving project predictability, operational efficiency, and time and costs (Kalsaas et al., 2009). Furthermore, it facilitates short—and medium-term planning, allowing for better control over constraints and activities.

One of the key tools within LPS is the Percent Plan Complete (PPC), an indicator that measures schedule reliability and helps identify bottlenecks, prioritize activities, and adjust strategies to optimize workflow (Hamzeh & Aridi, 2013).

The success of LPS in the industry depends on its proper implementation, which requires team alignment, the development of collaborative planning skills, and the integration of tools that enable its practical application (Daniel et al., 2017). However, its adoption faces barriers such as resistance to change and difficulty integrating with traditional planning methods (Antonini et al., 2023).

PULL PLANNING

Pull planning, a Last Planner System (LPS) methodology, seeks to improve reliability and efficiency in construction projects through collaborative planning (LCI, 2025). Its main objective is to reduce variability, align teams, and ensure that activities are ready before execution, minimizing waste and optimizing available resources (Chandran et al., 2022). As Tvedt (2020) describes, pull planning increases productivity in the design phase. Its primary goal is to establish a reliable flow in designers' iterative work, encouraging collaborative engagement to formulate the optimal plan for this stage. This process, in turn, seeks to minimize waste (Tvedt, 2020).

Pull planning uses reverse planning, organizing activities from a final milestone to previous steps. This approach ensures that each task adds value and removes constraints early (Tsao et al., 2014). In addition, it encourages collaboration between teams and allows schedules to be adjusted according to actual needs, improving communication and monitoring with visual tools such as boards and diagrams (Skinnarland & Yndesdal, 2014).

However, its implementation faces barriers such as resistance to change, the use of traditional methods, and the lack of training in Lean tools. These barriers highlight the need for a cultural change that promotes collaboration and trust (Chandran et al., 2022). Its benefits include improved collaboration, reduced waste and downtime, and resource optimization, which increases overall project performance (Tsao et al., 2014).

METHODOLOGY

This research uses a scoping review approach, the purpose of which is to analyze how Lean Construction and emerging technologies that are revolutionizing the construction industry interact. This type of review was chosen due to its ability to integrate evidence from a general overview, maintaining the methodological rigor typical of systematic reviews (Mura et al., 2024). Scoping reviews are valuable tools for quickly mapping key concepts within a field of research, identifying the primary sources and types of evidence available, and addressing complex or underexplored issues with objectivity and clarity, according to (Arksey & O'Malley ,2005).

This choice is also based on methodological flexibility, maintaining the necessary rigor, which allows literature to be included (Lopez-Cortes et al., 2022). The review was organized into four main stages: 1) Design, purpose, and scope; 2) Search strategy; 3) Selection process; and 4) Results, which will be detailed in the following sections.

DESIGN, PURPOSE AND SCOPE

This study provides an overview of good practices, barriers, and benefits of implementing pull planning in construction. To this end, the following research questions delimit the scope of this review:

- What are the good practices, benefits, and barriers most frequently documented in the literature on implementing Pull Planning in construction projects?

SEARCH STRATEGY

Once the purpose of this review was established, the second stage focused on collecting the available evidence using a search strategy aligned with the research questions posed. For this, the IGLC and Scopus databases were selected. Scopus is the largest database of scientific literature in the world (Schotten et al., 2017), and IGLC hosts almost all Lean Construction publications worldwide (Daniel et al., 2015).

Subsequently, specific search terms were defined for both databases. The search equation included seven keywords: "lean construction," "last planner," "pull planning," "phase schedule," "phase planning," "phase scheduling," and "collaborative planning." This allowed the generation of 15 combinations of searches. These combinations were designed to cover a broad spectrum and ensure the identification of relevant literature regarding the implementation of Pull Planning in construction.

Keywords were systematically combined using Boolean operators (AND) to ensure the search was comprehensive and replicable. Each search equation was executed independently in the selected databases, and the results were recorded in a structured spreadsheet. The terms were selected based on their frequency in Lean Construction literature and their direct relevance to Pull Planning. Additionally, synonyms and related phrases (e.g., 'phase schedule' and 'phase planning') were included to broaden the search scope and avoid missing relevant studies due to terminological differences. This systematic approach enabled a robust body of literature aligned with the review's objectives.

Table 1: Search Equation (Own elaboration)

Database	Equation	amount	date
Scopus	("lean construction" AND "pull planning") = 16 results ("lean construction" AND "phase schedule") = 9 results ("lean construction" AND "phase planning") = 1 results ("lean construction" AND "phase scheduling") = 8 results ("lean construction" AND "collaborative planning") = 25 results ("last planner" AND "pull planning") = 14 results ("last planner" AND "phase schedule") = 14 results ("last planner" AND "phase planning") = 7 results ("last planner" AND "phase scheduling = 14 results ("last planner" AND "collaborative planning") = 23 results	131	22/12/2024
IGLC	("pull planning") = 22 results; ("phase schedule") = 10 results; ("phase planning") = 5 results; ("phase scheduling") = 16 results; ("collaborative planning") = 16 results	69	22/12/2024

SELECTION PROCESS

The process of selection and evaluation of publications is illustrated in Figure 1.

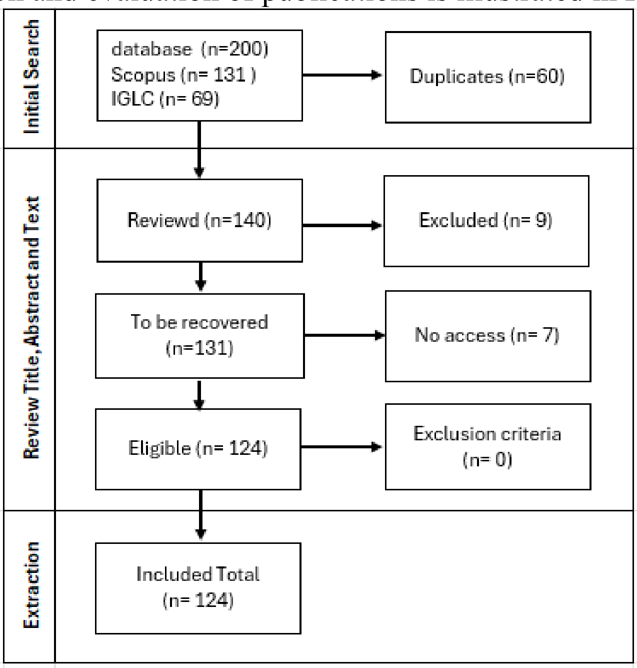

Figure 1: PRISMA declaration Flowchart (Own elaboration)

The article selection process was developed following the PRISMA statement, as detailed in Figure 1 (PRISMA flowchart). Initially, 200 documents were identified, with 131 from the

Scopus database and 69 from IGLC. In the first phase, 60 duplicate documents were removed, resulting in 140 unique records for initial screening.

Next, the titles and abstracts of these 140 articles were analyzed using predefined inclusion and exclusion criteria. Studies were included if they directly addressed Pull Planning within the construction sector, whether through theoretical discussion, empirical evidence, or case studies. Articles that did not mention Pull Planning as a central concept or focused exclusively on other components of the Last Planner System without direct relevance to reverse planning were excluded.

This screening resulted in 131 articles selected for full-text retrieval. Seven articles could not be accessed in the retrieval phase due to restricted availability, leaving 124 eligible articles. These 124 documents were reviewed in full, and none were excluded based on the established criteria. After this selection, the articles underwent manual review to extract relevant content related to good practices, benefits, and barriers in implementing Pull Planning. The extracted data were then grouped into thematic categories using a qualitative analysis approach, allowing us to identify recurring patterns and systematize the findings in a structured manner. Finally, 124 articles were included for analysis in the review. The complete list of articles analyzed is available for consultation in the following online repository: https://docs.google.com/spreadsheets/d/10-km2-aRd1eCEQshoWyzwELuusgBP7Za/edit?gid=876781428#gid=876781428

RESULTS AND DISCUSSION

GOOD PRACTICES

Figure 2 summarizes the leading good practices identified in the implementation of Pull Planning and their frequency of appearance in the reviewed literature. These practices represent key strategies to maximize efficiency in construction projects and ensure team collaboration. According to Skinnarland and Yndesdal (2014), implementing good practices in construction requires overcoming organizational barriers and fostering a continuous learning process to enhance efficiency and collaboration. In this context, good practices in Pull Planning help strengthen team communication, reduce waste, and improve workflow reliability.

Collaborative planning (BP1, 74 mentions, 59.68%) is the most cited best practice. It is recognized for its ability to actively engage all stakeholders in developing the master plan, enhancing schedule predictability, and minimizing conflicts during execution (Ballard, 2000). In a hospital project in Finland, this approach led to a 35% reduction in conflicts (Ballard, 2020). Similarly, on an underground metro line in Norway, collaborative planning between the client and contractors accelerated the construction process, delivering key milestones five months ahead of schedule (Prabhu et al., 2024).

Given that LPS is a sociotechnical system, its success relies on the active participation of all project stakeholders, making collaborative planning a key factor in achieving efficiency and coordination. Both cases demonstrate how this practice can reduce conflicts and improve project performance, consolidating over time as an effective tool within Lean principles, regardless of the project's scale.

Continuous monitoring and learning (BP2, 42 mentions, 33.87%) ensure project adaptability by constantly identifying and eliminating constraints, aligning with Lean principles (Hamzeh et al., 2016). In projects applying Percent Plan Complete (PPC), continuous monitoring improved schedule performance by 20% (Ezzeddine et al., 2019), reinforcing LPS's emphasis on systematic learning. Likewise, in a housing construction project in Quito (Ecuador), the PPC progressively increased from 41% to 70% in 21 weeks, thanks to the implementation of this practice (Fiallo & Revelo, 2002).

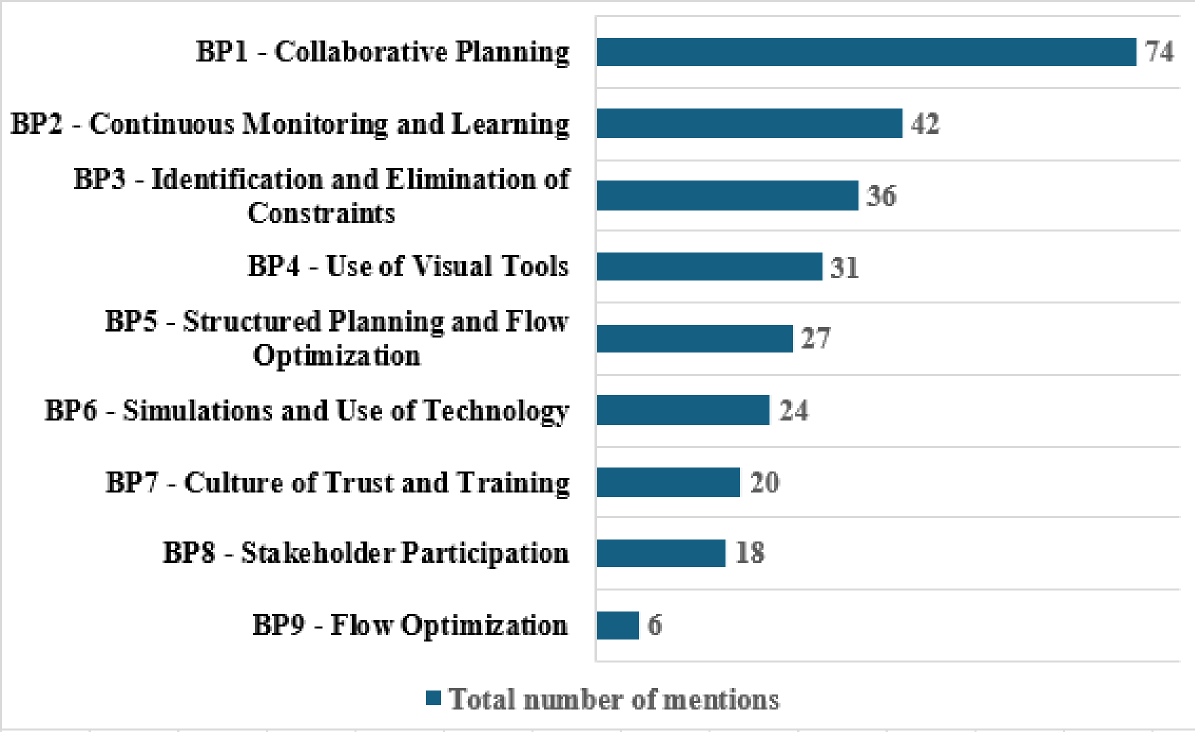

Figure 2: Good practices identified in the literature (Own elaboration)

In another case, on a highway project in Virginia (USA), continuous monitoring detected interruptions that were not visible using traditional methods, reducing downtime by 24% and improving overall project performance by 18% (Grau et al., 2019). These examples reinforce the systematic learning approach promoted by LPS, demonstrating that this practice improves plan adherence and optimizes processes.

In LPS, visual management reduces coordination issues by 40% and increases task reliability (Fosse & Ballard, 2016). More recently, (Farzad & Cameron, 2019) implemented Lean visual tools during the closeout phase of a large-scale project in Mexico, using a visual matrix for communication, tracking, and coordination. This strategy significantly reduced closeout time and improved communication, even overcoming cultural and methodological barriers. These cases reflect the importance of visual tools as a key element in strengthening communication, transparency, and efficiency in construction projects.

BENEFITS

The benefits of Pull Planning refer to the advantages gained by implementing this collaborative scheduling technique, which focuses on planning tasks from the end goal backward to ensure efficiency and workflow continuity. These benefits are commonly categorized into three main areas: efficiency, collaboration, and reliability (Silva et al., 2022; Tsao et al, 2014). Figure 3 presents the most notable ones in the literature.

The increased reliability and effective planning (B1, 74 mentions, 59.68%) ensures more accurate and reliable schedules. (Koskela, 1992) documented a 20% reduction in schedule deviations in an industrial project. In Malaysia, integrating Lean and BIM with Pull Planning significantly improved schedule accuracy (Ismail et al., 2023). This practice aligns with LPS, where improved schedule reliability leads to a 30% increase in workflow predictability (Ballard & Howell, 1998). The LPS operates through four main phases—Master Scheduling, Pull Planning, Lookahead Planning, and Weekly Planning—each designed to ensure coordination between actors and minimize waste (Pourrahimian et al., 2023).

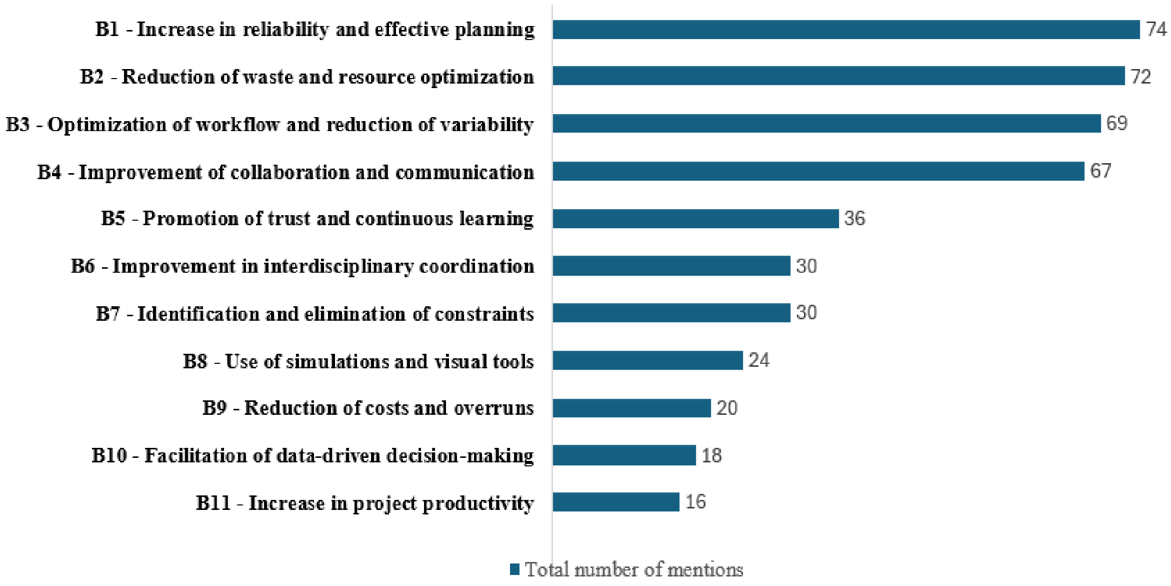

Figure 3: Benefits identified in the literature (Own elaboration)

Reducing waste and resource optimization (B2, 72 mentions, 58.06%) is linked to eliminating non-value-added activities. According to (Ghosh et al. 2017), Pull Planning generated significant material savings in infrastructure projects in the US, while a Japanese case reported a 15% reduction in surplus materials (Erazo et al. 2020). Lean Construction principles also emphasize waste minimization, achieving up to 40% material waste reduction (Hamzeh et al., 2016). Beyond operational efficiency, recent research such as that by (Alazmi et al. 2024) has begun to link Lean practices with environmental sustainability, integrating environmental management systems and Lean tools to address production waste and ecological impacts simultaneously. This perspective responds to an emerging need in the industry: to treat sustainability not as an isolated component, but as an integral part of project management.

The improvement in collaboration and communication (B4, 67 mentions, 54.03%) fosters a more cohesive and efficient work environment. (Alves et al. 2022) found that BIM and Pull Planning integration significantly improved interdisciplinary coordination. Similarly, in LPS, strong collaboration increases team alignment by 50% and reduces coordination conflicts by 35% (Kalsaas & Thorstensen, 2009). Pull Planning allows for transparent and flexible planning dynamics that reinforce active participation. Although its initial implementation may involve greater resource use due to the level of interaction required, experiences such as that of (Tiwari & Sarathy, 2012) show that, over time, a balance is achieved between the depth of the plan and the efficiency of the collaborative process.

Additionally, digitalization enhances these benefits. (Herrera, 2020) highlighted that integrating Lean and BIM improves real-time collaboration, data accuracy, and workflow efficiency. His findings show that digital platforms reduce scheduling uncertainty by 25%, supporting Pull Planning and aligning with Lean principles.

BARRIERS

The implementation of Pull Planning faces significant barriers that limit its adoption. Barriers refer to the obstacles or challenges that hinder the effective implementation of a methodology, often stemming from organizational, cultural, or technical limitations (Skinnarland & Yndesdal, 2014). In the context of Lean Construction, these barriers can reduce efficiency, limit collaboration, and prevent teams from fully realizing the benefits of Pull Planning and the Last Planner System. Figure 4 summarizes these barriers and their frequency.

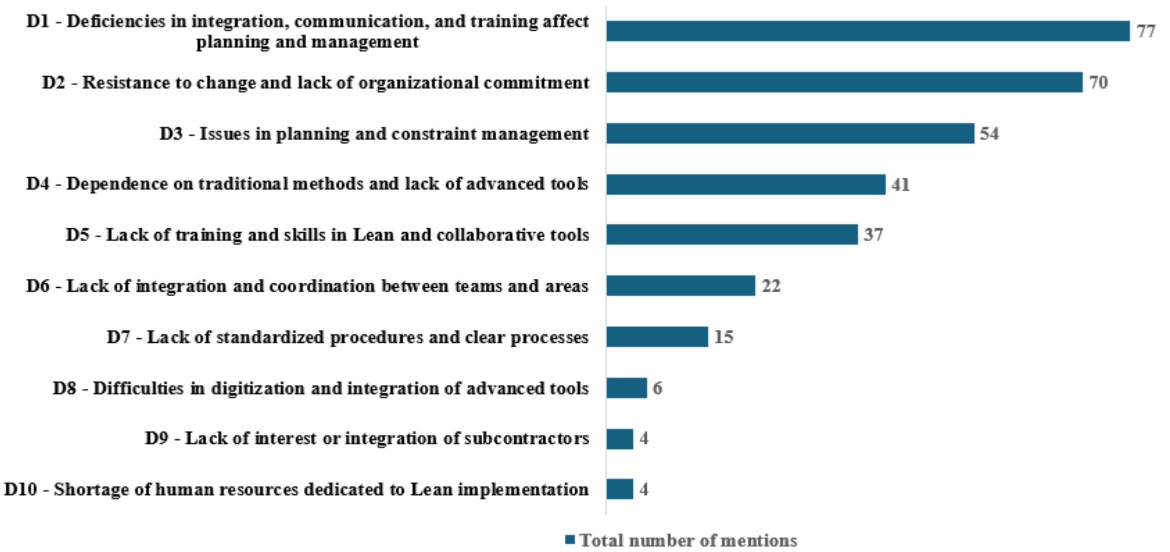

Figure 4: Barriers identified in the literature (Own elaboration)

Deficiencies in integration, communication, and training (D1, 77 mentions, 62.10%) represent one of the most critical barriers. The lack of coordination between teams and insufficient training in collaborative tools negatively impact planning reliability and constraint management. Similar challenges have been observed in Lean Construction, where insufficient interdisciplinary collaboration affects 60% of projects, reducing workflow efficiency (Hamzeh et al., 2008).

Resistance to change and lack of organizational commitment (D2, 70 mentions, 56.45%) hinder the transition from traditional methods to collaborative planning. A study in Morocco found that teams were reluctant to abandon conventional approaches despite the proven benefits of Pull Planning (Habchi & Mansouri, 2016). This resistance is also a significant challenge in LPS adoption, where approximately 55% of companies struggle with cultural inertia and reluctance to embrace Lean practices (Reginato & Alves, 2012).

Issues in planning and constraint management (D3, 54 mentions, 43.55%) reduce scheduling reliability. Research on LPS indicates that nearly 50% of planning failures stem from inadequate constraint management (Silva et al., 2022). The absence of proactive problem-solving mechanisms frequently leads to schedule disruptions, delaying project execution and reducing predictability.

Dependence on traditional methods and lack of advanced tools (D4, 41 mentions, 33.06%) remain significant barriers. Many construction companies still rely on conventional scheduling methods, resisting the adoption of BIM and Lean-related planning platforms. Studies indicate that 30% of Lean Construction projects experience inefficiencies due to the lack of digital tools, negatively impacting workflow integration (Karimi et al., 2024).

Difficulties in digitizing and integrating advanced tools (D8, six mentions, 4.84%) have been identified as key limitations in improving Lean workflows. (Herrera, 2020) highlights that digitalization enhances collaboration, real-time decision-making, and planning accuracy, reinforcing the benefits of Pull Planning and LPS. However, less than 10% of construction companies have successfully integrated digital Lean tools into their planning processes, mainly due to technological constraints and resistance to change (Herrera, 2020).

CONCLUSIONS

This research has allowed us to consolidate a comprehensive view of the implementation of Pull Planning in the construction industry, highlighting its best practices, benefits, and barriers.

Regarding the best practices identified, we have shown that collaborative planning, as well as continuous monitoring and learning, not only improves coordination among project stakeholders, but its application in the construction industry also strengthens reliability in project execution.

Furthermore, the benefits of Pull Planning, such as increasing planning reliability and effectiveness and improving collaboration and communication, demonstrate that it is a fundamental tool for improving competitiveness in the construction industry, based on cases in which these practices generated significant savings in material resources and time. However, barriers still hinder its implementation, and resistance to change remains the most significant challenge, especially in companies where traditional planning methods still predominate.

Beyond identifying these aspects, the aim was to critically examine how the findings obtained in our research can contribute to the development of the Lean Construction approach.

From a practical perspective, these findings reinforce the importance of developing specialized training programs, creating spaces where different professionals can collaborate, and promoting the use of Pull Planning in the industry. At an academic level, this study opens the door to new research that validates the effectiveness of these best practices in different types of construction projects.

Finally, Pull Planning represents an excellent opportunity to transform how projects are managed in construction. However, its success depends on technical aspects and the organization's ability to adapt and evolve. Integrating this approach will promote a more efficient, collaborative, and sustainable industry.

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