Naser A. (2025). Integrating advanced work packaging and value stream mapping into last planner system: an operational framework. In O. Seppänen, L. Koskela, & K. Murata (Eds.), *Proceedings of the 33rd Annual Conference of the International Group for Lean Construction* (IGLC33) (pp. 563–574). https://doi.org/10.24928/2025/0159

INTEGRATING ADVANCED WORK PACKAGING AND VALUE STREAM MAPPING INTO LAST PLANNER SYSTEM: AN OPERATIONAL FRAMEWORK

Ayman Naser[1]

ABSTRACT

This paper examines the escalating challenges in the implementation of Lean Construction (LC) concerning project delivery within temporal and financial limitations. It suggests an operational framework that incorporates Advanced Work Packaging (AWP), Value Stream Mapping (VSM), and the Last Planner System (LPS) to improve project performance. The study reveals constraints in the execution of LPS, notwithstanding its extensive utilization as a lean construction approach. The study examines the synergistic integration of VSM and AWP with LPS to rectify these deficiencies through an extensive literature review. The proposed framework seeks to augment collaboration among project stakeholders, enhance visualization of project workflows, and enable more efficient risk assessment and analysis. This research aims to furnish contractors with a systematic method for incorporating lean tools to enhance project outcomes, reduce waste, and elevate overall efficiency across various phases of construction projects. The study concludes by highlighting the necessity for empirical validation of the framework to evaluate its practicality and efficacy.

KEYWORDS

Advanced work packaging (AWP), last planner system (LPS), value stream mapping (VSM), project control, operational framework.

INTRODUCTION

In recent decades, the construction industry has faced increasing challenges in delivering projects on time, within budget, and to a high standard. This has led to a paradigm shift towards viewing construction as a production system, which emphasizes the need for systematic approaches to enhance project outcomes. Farghaly and Soman (2021) highlight that traditional project management methodologies have often fallen short in addressing the complexities and dynamic nature of construction projects. The adoption of a production system perspective allows for a more structured approach to managing construction processes, focusing on efficiency, quality, and client satisfaction (Babalola et al., 2019).

LC, along with its related methodologies and applications, including the Last Planner System (LPS), Integrated Project Delivery (IPD), and more recently, Advanced Work Packaging (AWP), exemplifies principles that facilitate the management and oversight of construction production systems (Farghaly & Soman, 2021). The global implementation of lean construction practices has evidenced improvements across multiple dimensions, including cost efficiency, shortened project timelines, heightened safety consciousness, diminished accident

1 Assistant Professor, Engineering Management Department, College of Engineering, Qatar University, Doha, Qatar, an1401569@qu.edu.qa, orcid.org/0000-0002-0670-9200

rates, enhanced sustainability, reduced errors and rework, minimised waste, improved inventory management, increased predictability of work, superior labour productivity, and heightened customer satisfaction (Albalkhy & Sweis, 2021). While AWP is relatively new compared to lean construction, it exhibits promising potential in enhancing construction project performance. For instance, a study involving 20 construction projects in the United States and Canada indicated that AWP implementation led to enhanced predictability, productivity, cost efficiency, safety, and quality (Rebai et al., 2023). Some estimates suggest that AWP can result in approximately a 25% increase in productivity and a 10% reduction in installation costs (CII & COAA, 2013; Rebai et al., 2023). As a result, there is an increasing prevalence of research and interest in AWP. AWP is a structured approach to project planning and execution that emphasizes the pre-packaging of work into manageable units, known as Integrated Work Packages (IWPs) (Halala & Fayek, 2019). This method aims to improve project delivery by ensuring that all necessary resources, information, and materials are available at the right time and place, thereby minimizing delays and inefficiencies. On the other hand, Lean Construction is rooted in the principles of Lean Manufacturing, focusing on waste reduction, continuous improvement, and maximizing value for the client (Rebai et al., 2023). Both methodologies share a common goal of enhancing productivity, yet they approach this goal from different angles. AWP emphasizes the organization and sequencing of work, while Lean Construction focuses on eliminating waste and improving workflow. The integration of AWP and Lean Construction (LC) such as LPS presents a promising avenue for enhancing productivity and efficiency in the construction industry. For instance, while some studies have highlighted the potential for AWP to adopt Lean principles, such as Just-In-Time (JIT) delivery and continuous flow, there is a lack of empirical research demonstrating how these methodologies can be systematically integrated (Sepúlveda, 2023). Furthermore, the integration of AWP into LPS as a tool to visualize and analyze the flow of materials and information in Lean Construction contexts has not been thoroughly investigated. The integration is a vital Lean practice, providing insights into process efficiencies and inefficiencies, yet its role in AWP remains ambiguous (Heravi et al., 2019). The literature suggests that while AWP and Lean Construction share foundational principles, their operationalization can lead to conflicting practices (Rebai et al., 2024). For example, AWP's emphasis on detailed planning and pre-packaging may inadvertently lead to increased inventory levels, which contradicts Lean's focus on minimizing waste (Rebai et al., 2023). This tension highlights a critical gap in understanding how to reconcile these differences to create a cohesive framework that leverages the strengths of both methodologies.

Additionally, the construction industry's fragmented nature complicates the adoption of integrated approaches, as different stakeholders may have varying levels of commitment to Lean and AWP practices (Tamošaitienė & Starta, 2019). This fragmentation can lead to misalignment in project goals and hinder the effective implementation of integrated methodologies. Furthermore, the existing literature often fails to provide a comprehensive framework for integrating AWP, VSM into LPS. While some studies have explored the individual components of these methodologies, there is a lack of cohesive models that illustrate how they can work together synergistically (Rebai et al., 2023). For instance, the integration of VSM into the AWP process could provide valuable insights into workflow efficiencies, yet this potential has not been fully realized in practice. The absence of such frameworks limits the ability of practitioners to implement integrated approaches effectively. However, despite their potential synergies, the academic literature reveals significant gaps in understanding how these methodologies can be effectively combined to maximize project outcomes. Hence, this paper aims to develop an operational framework for linking of AWP and VSM into LPS for enhancing overall project performance in the construction industry.

LITERATURE REVIEW

LAST PLANNER SYSTEM

Last Planner System (LPS) is a production planning and control methodology rooted in lean construction principles, designed to enhance planning reliability and project performance in the construction industry. Developed in the 1990s by Glenn Ballard and Greg Howell, LPS emphasizes the importance of collaboration among project stakeholders and focuses on the role of the "last planner," typically the foreman or supervisor, who is closest to the execution of tasks (Daniel et al., 2017). This system aims to reduce variability in workflow and improve the reliability of project schedules by ensuring that commitments made during planning are realistic and achievable (Vieira et al., 2024; Power et al., 2024). LPS primarily comprises five stages: Master Production Schedule (MPS), Phase Schedule, Lookahead Plan, Weekly Work Plan, and Lesson Learnt (Ballard 2000). LPS enhances the planning and execution of construction operations through the "pull" system (Heigermoser et al. 2019). Heigermoser et al. (2019) discovered that augmenting the reliability of planning through LPS improves project performance.

VALUE STREAM MAPPING

VSM is a lean management tool that visually represents the flow of materials and information required to bring a product or service from conception to delivery. It identifies both value-added and non-value-added activities, enabling organizations to pinpoint inefficiencies and areas for improvement in their processes (Gunduz & Naser, 2019; Gunduz & Naser, 2017; Naser et al., 2023). VSM is particularly beneficial in the construction industry, where it can be employed to analyze workflows, reduce waste, and enhance productivity. The application of VSM in the construction sector has been shown to significantly impact project efficiency and waste reduction. Studies indicate that VSM can effectively identify and minimize material and time waste, which are prevalent in construction project. By mapping out the current state of operations, construction managers can visualize bottlenecks and redundancies, leading to targeted interventions that streamline processes (Gunduz & Naser, 2019; Gunduz & Naser, 2017; Naser, 2023). This systematic approach not only enhances productivity but also contributes to cost savings, as resources are utilized more effectively (Hamaidi et al., 2024).

ADVANCED WORK PACKING

AWP is a project management methodology that has gained traction in the construction industry, particularly in industrial projects. Defined by the Construction Industry Institute (CII), AWP is a structured approach that organizes project planning and execution into manageable work packages, enhancing coordination and efficiency throughout the project lifecycle (Halala & Fayek, 2019; Rocha, 2023). The primary objective of AWP is to mitigate common challenges such as cost overruns and scheduling delays, which have historically plagued construction projects (Rebai et al., 2024). The implementation of AWP has been shown to yield significant benefits for the construction industry. For instance, studies indicate that AWP can lead to a reduction in total installation costs by as much as 10% and an enhancement in labour productivity by approximately 25% (Rebai et al., 2024; Sepúlveda et al., 2023). These improvements are attributed to better alignment of engineering, procurement, and construction activities, allowing for more effective planning and execution (Sepúlveda et al., 2023; Musarat et al., 2024). Moreover, AWP's structured approach allows for enhanced project visibility and control, enabling teams to identify potential risks and bottlenecks early in the process (Rocha, 2023; Sepúlveda et al., 2023).

INTEGRATION OF LEAN TOOLS: RESEARCH GAP AND POINT OF DEPARTURE

LPS is a lean construction methodology developed to enhance project management by promoting reliable workflow, minimizing waste, and improving collaboration among stakeholders. Despite its widespread adoption, significant deficiencies in implementation persist across various construction projects, undermining its intended benefits. This literature review explores the primary deficiencies associated with LPS and highlights how VSM and AWP can be employed to address these shortcomings and augment construction performance. Fernandez-Solis et al. (2013) identified obstacles to the successful implementation of LPS at both organizational and technical levels but did not provide recommendations for addressing these challenges. Lagos et al. (2019) endorsed the execution of LPS through information technology (IT); however, the application of IT in overseeing lookahead/weekly planning by alleviating constraints and implementing corrective strategies has been insufficiently studied. El-Sabek and McCabe (2018) established a framework for the implementation of Last Planner System (LPS) in large-scale projects by identifying 31 challenges associated with LPS implementation and subsequently proposing a framework for its successful execution. This framework addresses the comprehensive application of the LPS at a macro level; however, it does not elaborate on the staged implementation of LPS at a micro level, such as reverse phase planning and look-ahead/weekly planning. Micro-level implementation strategies elucidating each LPS stage will facilitate new LPS users in executing projects effectively. Khanh and Kim 92016) endeavored to prioritize the strategies for the effective implementation of LPS but were confined to examining only look-ahead planning, team workshops, and weekly work plans. To establish a framework for the effective implementation of LPS in Egypt, Aboseif and Khallaf (2020) proposed nine strategies addressing five identified challenges; however, they did not provide methodologies for integrating these strategies into a comprehensive LPS model. Additionally, other researchers identified critical barriers and success factors to enhance the efficiency of LPS. Ebbs et al. (2017) attempted to implement the LPS path clearing approach (PCA) by focusing on "shallow and wide" organizational dimensions instead of the conventional "narrow and deep" project methodology. The authors assert that the 15-step action plan formulated during the study can successfully address barriers to LPS implementation. This implementation strategy prioritizes addressing organizational challenges while minimizing the impact on technical and project-related issues.

In conclusion, researchers have devised advanced frameworks and strategies to eradicate inefficiencies in the LPS model to facilitate implementation. Regrettably, a connection between strategies and implementation challenges could not be established. In certain instances, challenges associated with LPS implementation are recognized but remain unaddressed. Identifying the shortcomings and barriers of LPS, along with implementation strategies, complicates the implementation process. Most LPS implementation frameworks emphasize macro aspects of the project, whereas LPS operational strategies are infrequently addressed. This study seeks to formulate implementation strategies by identifying existing challenges in LPS and offering micro-level approaches for executing various stages of LPS. LPS can enhance its system to accommodate the construction environment and significantly improve construction performance. Lean practitioners have recognized numerous tools to mitigate the limitations of LPS. To develop the most efficient last planner tool, it is essential to analyse all tools, techniques, and specific areas of focus. The challenges of LPS can be remedied by evaluating the operational capabilities of each tool and their adaptability to LPS. This research combines the LPS with additional lean construction methodologies to enhance its challenges. This will enable the integration of each tool's advantages for optimal system efficiency. The developed operational framework subsequently provides owners, consultants, and contractors with a logical pathway to success. Contractors seeking to transition to LC will significantly benefit from the research by implementing a strategy that optimizes profits in this competitive sector. The primary objectives of this research are as follows:

- Recognizing the limitations in implementing the LPS.
- Address these limitations by integration with VSM and AWP.
- Developing an efficient operational framework that optimizes performance through the integration, and offering directives for the execution of diverse construction project phases.

METHODOLOGY

An extensive literature review was conducted to fulfil the objectives of this study. The Scopus databases including rapture journals and conferences in lean construction (i.e., the Lean Construction Journal (LCJ), American Society of Civil Engineers Online (ASCE), Science Direct, and the International Group for Lean Construction (IGLC)) served as the foundation for selecting research papers to assess the objectives of this study. The research was structured into three phases according to the study's objectives. In the initial stage, implementation challenges of LPS identified by researchers in the literature since 2000 are extracted and summarized. In the second stage, the VSM and AWP tools are recognized and classified according to their efficacy in addressing the deficiencies identified in the LPS. In stage three, an operational framework is formulated by incorporating VSM and AWP into its various stages. Keywords were identified corresponding to each objective of this research paper and employed as the primary method for locating the necessary research papers for the respective tools. The identification of necessary documents was conducted in three stages. In the initial step, all pertinent papers were cataloged solely based on keywords, without delving into the specifics of the documents. In the second step, the introduction and conclusion serve as the foundation for the retention of the documents. Finally, step three involves the definitive selection of the papers based on the comprehensive context. Figure 1 provides a comprehensive schematic elucidation of the entire methodology. This study primarily aims to develop an efficient lean construction methodology based solely on its operational processes. The primary and essential factors necessary for improving the implementation of the current LPS have been addressed, and the framework is prepared to undergo optimal execution.

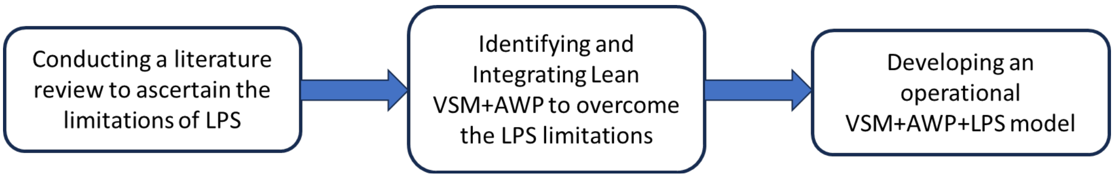

Figure 1: Research Methodology

RESULTS

LPS is recognized as the most robust and comprehensive methodology for executing lean construction. Nonetheless, it has been elucidated both theoretically and through case studies that LPS possesses intrinsic deficiencies that must be rectified for its optimal utilization.

One of the fundamental deficiencies identified in the LPS is the inconsistent application of processes among project stakeholders. Research shows that while the LPS promotes collaborative planning practices, discrepancies in how different stakeholders interpret and apply these practices lead to variances in workflow reliability (Daniel et al., 2017; Ravi, 2018). Furthermore, Daniel et al. (2019) emphasize that while LPS should ideally foster a collaborative environment, the reality often sees poor engagement and commitment from team members due to varying levels of understanding and acceptance of the system. Inconsistent application also manifests in the measurement of performance metrics. Many projects predominantly use Percent Planned Complete (PPC) as a metric to gauge LPS effectiveness, neglecting other vital performance indicators that could provide a more holistic view of project health and workflow reliability (Abusalem, 2022; Samad et al., 2017). This oversimplification limits the ability to identify specific areas requiring improvement and fails to capture the complexities of team dynamics and project conditions, which are crucial for successful implementation (Gunduz et al., 2023; Samad et al., 2017). Moreover, the contextual factors influencing LPS adoption cannot be overlooked. Various case studies have reported discrepancies in project performance attributed to a lack of alignment between LPS practices and specific project conditions, such as project size, complexity, or unique stakeholder dynamics (Boton et al., 2020). These factors often exacerbate existing challenges in maintaining a consistent application of the system. As reported by Abusalem (2022), a lack of adequate training and commitment among team members further compounds these deficiencies and results in a fragmented understanding of the LPS principles.

Power et al. (2024) examined the effects of LPS and identified multiple operational deficiencies, such as inadequate look-ahead planning execution, insufficient motivation for ongoing enhancement, and limited visualization capabilities. Dave et al. (2015) identified inadequate look-ahead planning, insufficient motivation for ongoing improvement, and deficiencies in root cause analysis and collaborative elements as primary challenges in LPS. Bortolazza and Formoso (2006) identified the ineffective execution of look-ahead planning and the absence of constraint analysis as significant deficiencies in LPS. Fernandez-Solis et al. (2013) emphasized that the exclusion of employees and subcontractors is a significant factor contributing to the ineffective execution of look-ahead planning. Babalola et al. (2022) identified the discordance between procurement methods and LPS as a significant barrier to the implementation of LPS. Hamaidi et al. (2024) proposed integrated project delivery (IPD) as a remedy for issues arising from the entire team operating as a cohesive unit with collective responsibilities. Boton et al. (2021) identified insufficient material availability as the primary cause of incomplete assignments following the implementation of LPS, alongside challenges in labor management, rework, incomplete designs, and adverse weather conditions. The authors determined that deficiencies in material management, design visualization during construction, and risk assessment capabilities of LPS at the execution stage require further clarification. Ensuring continuous flow is a fundamental aspect of Koskela's tripartite framework of lean construction (transformation, flow, and value). Lindhard and Wandahl (2016) conducted a comprehensive analysis of the LPS, concentrating exclusively on flow considerations at the lookahead level when various activities must be prepared for construction. Table 1 summarizes the LPS limitations.

DEVELOPMENT OF AN OPERATIONAL AWP+VSM+LPS FRAMEWORK

The primary challenge for lean practitioners is to amalgamate VSM and AWP across the various phases of LPS. Each LPS phase has been designed to strategize and implement tasks throughout different stages of construction. The master and phase schedules must be meticulously developed prior to the commencement of construction to ascertain the critical milestones that should be organized through reverse planning. Lookahead plans are formulated during construction to eliminate potential constraints and ensure work readiness.

Table 1: Limitations of Implementing LPS

No.	LPS Constraint	References
1	Lack of effective implementation of lookahead planning	Dave et al. (2015) , Bortolazza & Formoso (2006), Lindhard & Wandahl (2013), Daniel et al. (2017), Ravi (2018), Power et al. (2024), Bortolazza and Formoso (2006)
2	Failure to execute constraint analysis	Bortolazza & Formoso (2006), Daniel et al. (2017) Abusalem, (2022), Samad et al. (2017), Bortolazza and Formoso (2006)
3	Lack of visualization	Gunduz et al. (2023), Naser et al. (2023), Lindhard & Wandahl (2013)
4	Lack of communication	Lindhard & Wandahl (2013), Ravi (2018), Daniel et al. (2019)
5	Failing to take into account all flows	Lindhard & Wandahl (2013), Daniel et al. (2019)
6	Lack of training	Fernandez-Solis et al (2013), Abusalem (2022), Boton et al. (2020)
7	Insufficient integration of the supply chain	Dave et al. (2015) , Bortolazza & Formoso (2006), Lindhard & Wandahl (2013)
8	Lack of collaboration (Subcontractors/Suppliers)	Fernandez-Solis et al (2013), Ebbs et al. (2018), Daniel et al. (2019), Boton et al. (2020)
9	Lack of conducting root cause analysis and apply corrective action	Fernandez-Solis et al (2013), Ebbs et al. (2018)

Only activities devoid of constraints are retained for construction. Weekly schedules are formulated to synchronize the planned tasks for seamless execution. Ultimately, the construction process is overseen and perpetually refined to attain the requisite efficiency. Each phase possesses unique functions and outcomes that require individual management. The diversity within LPS necessitates that users manage each phase independently. The issue occurs when LPS is addressed and managed as a singular entity, thereby overlooking the distinctiveness of each LPS stage. To address the limitations of the current LPS, lean practitioners must independently manage each stage of the LPS by implementing measures that enhance the efficiency of every phase. The application of VSM and AWP throughout the various stages of LPS can effectively facilitate LPS management. As previously elucidated, lean tools possess distinct objectives and functionalities that can only operate synergistically with each LPS stage, provided they are compatible and complementary. For instance, while VSM can serve as an effective instrument in the planning and management of supply chain activities during the look-ahead phase, its application during the master schedule may prove to be less efficacious. Likewise, the AWP can be employed to eliminate limitations during anticipatory planning. A schematic model, illustrated in Figure 2, is an operational model is developed according to the objectives and functionalities of VSM and AWP that can effectively mitigate the shortcomings of LPS at various stages.

ENHANCING THE COLLABORATION

Collaboration has to be maintained throughout all phases of LPS, and the level of collaboration will determine the effectiveness of LPS implementation. Increased collaboration among project participants will enhance the performance of LPS. Engagement of key stakeholders in the initial phases and inclusion of all team members, including subcontractors, in subsequent planning will eliminate coordination issues among the project teams.

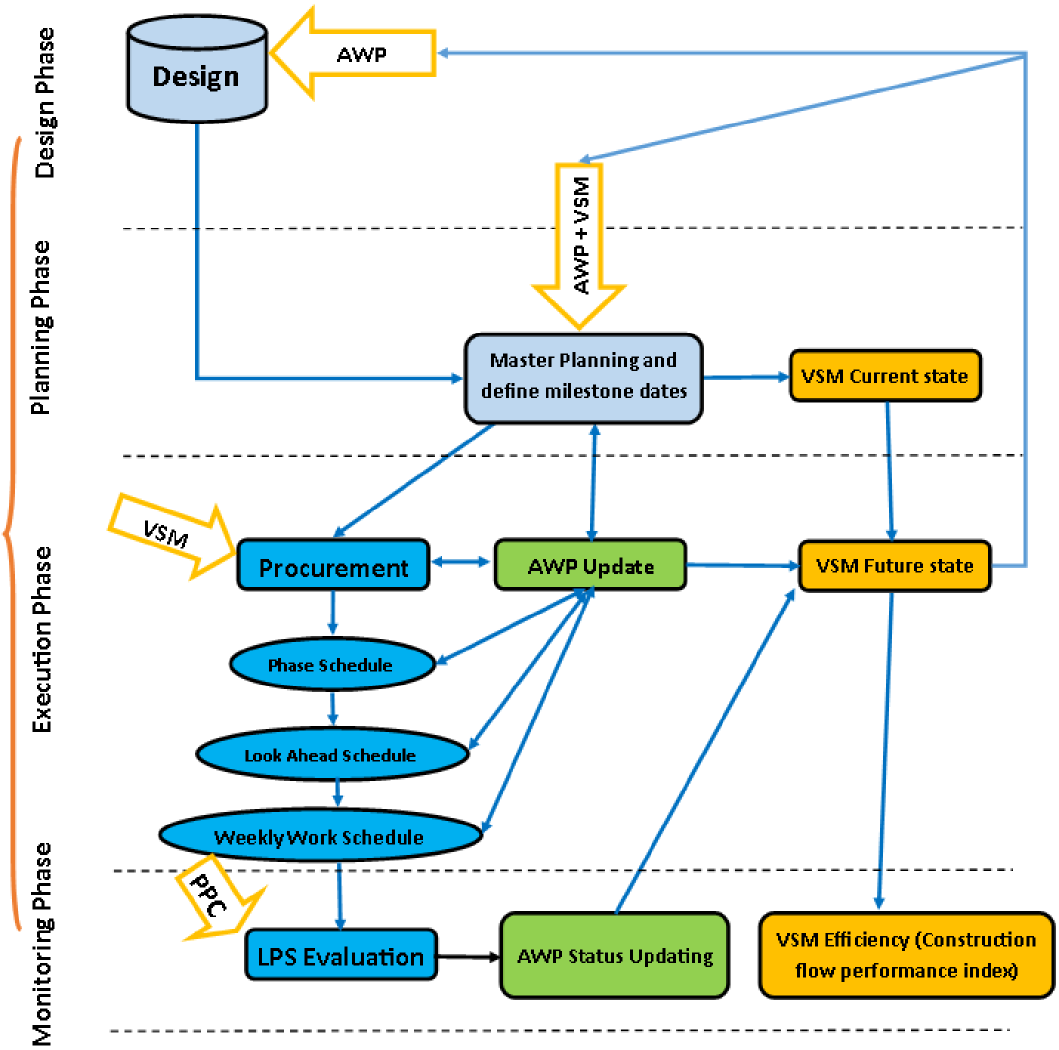

Figure 2: Operational framework (AWP + VSM + LPS)

ENHANCING THE VISUALIZATION

AWP, as the most potent tool, should be employed for visualizing construction and integrated into all planning phases of LPS (master, reverse phase, lookahead, and weekly). In the design phase, the incorporation of AWP into LPS will eliminate all subsequent design and construction conflicts while enhancing workflow efficiency. In conjunction with VSM, it will enhance the project by integrating all design and cost alternatives while eliminating or reducing non-value-adding activities. Utilizing AWP during master planning will facilitate the identification of milestones and enhance project visualization. Efforts must ensure that the design and master plan are realistic and constructive to minimize subsequent changes in design and schedule.

ENHANCED COMMUNICATION

The execution of the AWP+VSM+LPS model will promote collaboration, foster confidence and trust among stakeholders, and ensure the implementation of measures beneficial to all project participants.

RISK ASSESSMENT AND ANALYSIS

Backward phase scheduling utilizes the pull technique, wherein the subsequent activity determines the delivery date of the preceding activity. Assessing potential risks during this phase will eliminate uncertainties in planning. Furthermore, the utilization of the AWP to optimize implementation processes will enhance the teams' task performance and prepare them for upcoming assignments. To assess external risks, risk analysis must be conducted post-completion of master planning or scheduling, with appropriate attention during the reverse phase scheduling, utilizing tools such as root cause analysis. VSM will further enhance activities according to their value-adding potential. Upon conducting the risk analysis and optimizing the implementation process, the tasks eligible for execution will be identified and preserved for future planning.

IMPROVING LOOKAHEAD PLANNING

The absence of constraints management and the analysis of root causes are significant challenges for look-ahead planning. The backward phased schedule can be further examined through constraint analysis to determine the final tasks prepared for execution. AWP and VSM can be employed to evaluate potential constraints and determine the suggested strategies for their removal. Working sequences must be redefined following the elimination of constraints through AWP and VSM, incorporating downstream participants, subcontractors, and suppliers. Their participation will facilitate the modification of on-site tasks. This will efficiently assist in addressing issues pertaining to supply chain and material management. Material management must be intentionally strategized and synchronized during look-ahead and weekly planning.

ENHANCING THE WEEKLY PLANNING

Planning is conducted on a weekly basis for all construction activities. The schedule shall be refined and coordinated with the extensive involvement of downstream players and subcontractors/suppliers in order to ascertain their readiness and to provide input. AWP can offer an exceptional platform for the final alignment and coordination of all teams in their respective tasks. VSM can be employed to enhance one's abilities and familiarize oneself with novel or uncommon activities. The timely delivery of materials from suppliers can be guaranteed through the use of VSM. If necessary, storage locations are further reconciled in accordance with the site's specifications, and modifications are implemented. The issuing procedure can be streamlined and site safety can be guaranteed by organizing worker's tools accordingly. The project will commence following the weekly planning phase and will be evaluated on a regular basis during the look-ahead and weekly planning stages to ensure continuous improvement. Additionally, reviewing the AWP on daily basis offers a critical platform that facilitates the collaboration of cross-functional teams in order to address the issues in a coordinated manner. In order to optimize the advantages of LPS, it is necessary to execute the entire cycle on a regular basis.

MAINTAINING CONTINUOUS IMPROVEMENT

Performance measurement tools will be evaluated to sustain optimal performance and enable further enhancements. LPS utilizes weekly PPC as an effective measure for evaluating construction productivity. Alongside PPC, the number of defects identified and corrected in weekly assignments must be recorded and subsequently analyzed to ensure the quality of construction tasks. The construction flow index via VSM can improve zonal delivery. The analysis and results of both measurements will be employed to enhance processes by correcting malfunctions, ultimately resulting in the creation of a system that evolves through ongoing learning.

CONCLUSIONS

The construction sector necessitates initiatives that improve productivity and control time and cost overruns. LC has been established to tackle performance-related issues in the construction industry. LPS has served as a mechanism for the past 30 years to achieve the goals of LC. Although researchers have quantified the improved performances attributed to the implementation of LPS, the full benefits remain to be explored due to inherent challenges associated with LPS. This study aims to tackle the elements of LPS that hinder its effective implementation by combining the existing LPS model with AWP and VSM tools. This study formulates an operational AWP+VSM+LPS by pinpointing the shortcomings of the LPS and rectifying them through optimal operation. This study seeks to augment the existing knowledge by clarifying the fundamental functions and methods relevant to the effective execution of LC. This will augment the capacity for optimizing the use of the LC tools via integration. This study will provide contractors with a framework to implement the LC effectively, resulting in optimal outcomes and improved performance. To enhance this initial operational framework, the model's effectiveness must be evaluated in real-world contexts to determine its feasibility and validity. The concepts of this study may provide a foundation for researchers to further explore the integration of LPS with other lean tools and to improve implementation in construction projects. The framework will be validated through experiments with construction practitioners in an environment designed according to the proposed framework. Additionally, the operational framework must include performance metrics to assess the efficacy of the integrated approach. Key performance indicators pertaining to productivity, waste minimization, and stakeholder contentment can yield significant insights into the efficacy of the framework.

REFERENCES

Abusalem, O. (2022). Valuation: a new approach to measure the performance of last planner system. *American Journal of Engineering and Technology Management*, *7*(1), 1-7. https://doi.org/10.11648/j.ajetm.20220701.11

Albalkhy, W., & Sweis, R. (2021). Barriers to adopting lean construction in the construction industry: a literature review. *International Journal of Lean Six Sigma*, *12*(2), 210–236. https://doi-org.qulib.idm.oclc.org/10.1108/IJLSS-12-2018-0144

Aboseif, E., & Khallaf, R. (2020). A framework for last planner system implementation in Egypt. In *CIGOS 2019, Innovation for Sustainable Infrastructure: Proceedings of the 5th International Conference on Geotechnics, Civil Engineering Works and Structures* (pp. 1019-1024). Springer Singapore. https://doi.org/10.1007/978-981-15-0802-8_163

Babalola, O., Ibem, E. O., & Ezema, I. C. (2019). Implementation of lean practices in the construction industry: A systematic review. *Building and environment*, *148*, 34-43. https://doi.org/10.1016/j.buildenv.2018.10.051

Babalola, O., Ibem, E. O., Ezema, I. C., & Sharon, A. (2022). Barriers to the Adoption of Lean Practices (LPs) in the Nigerian Building Industry. *Tropical Journal of the Built Environment (TJOBE)*, *3*(2). https://jabu.edu.ng/wp-content/uploads/2023/09/1-Barriers-to-the-Adoption-of-Lean-Practices-in-the-Nigerian-Building-Industry.pdf

Ballard, H. G. (2000). *The last planner system of production control* (Doctoral dissertation, University of Birmingham). https://etheses.bham.ac.uk/id/eprint/4789/

Bortolazza, R. C., & Formoso, C. T. (2006). A quantitative analysis of data collected from the last planner system in Brazil. In *annual conference of the international group for Lean construction* (Vol. 14). https://iglc.net/Papers/Details/415

Boton, C., Pitti, Y., Forgues, D., & Iordanova, I. (2021). Investigating the challenges related to combining BIM and Last Planner System on construction sites. *Frontiers of Engineering Management*, *8*, 172-182. https://doi.org/10.1007/s42524-019-0086-4

CII, & COAA. (2013). Advanced Work Packaging Solution. CII, I. https://www.bentley.com/en/solutions/advanced-work-packaging

Daniel, E., Pasquire, C., Dickens, G., & Ballard, H. (2017). The relationship between the last planner® system and collaborative planning practice in UK construction. *Engineering Construction & Architectural Management, 24*(3), 407-425. doi.org/10.1108/ecam-07-2015-0109

Daniel, E., Pasquire, C., & Dickens, G. (2019). Development of approach to support construction stakeholders in implementation of the last planner system. *Journal of Management in Engineering, 35(5)*. doi.org/10.1061/(asce)me.1943-5479.0000699

Dave, B., Hämäläinen, J. P., & Koskela, L. (2015). Exploring the recurrent problems in the last planner implementation on construction projects. In: *Proceedings of the Indian Lean Construction Conference (ILCC 2015),* p 9. https://urn.fi/URN:NBN:fi:aalto-201503031948

Ebbs, P., Pasquire, C., & Daniel, E. I. (2018). The Last Planner® system path clearing approach in action: a case study. In *26th International Group for Lean Construction Conference, Chennai India*. https://doi.org/10.24928/2018/0433

El-Sabek, L. & McCabe, B. (2018). Framework for managing integration challenges of last planner system in IMPs. *J. Constr. Eng. Manag. 144(5):*04018022. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001468

El Samad, G., Hamzeh, F., & Emdanat, S. (2017, July). Last planner system—The need for new metrics. In *Proceedings of the 25th Annual Conference of the International Group for Lean Construction* (pp. 637-44). https://doi.org/10.24928/2017/0218

Farghaly, K., & Soman, R. K. (2021). Bridging the gap between Information Management and Advanced Work Packaging: AWP Ontology. In *Proceedings of the 38th International Conference of CIB W* (Vol. 78, pp. 11-15). https://itc.scix.net/pdfs/w78-2021-paper-086.pdf

Fernandez-Solis, J. L., Porwal, V., Lavy, S., Shafaat, A., Rybkowski, Z. K., Son, K., & Lagoo, N. (2013). Survey of motivations, benefits, and implementation challenges of last planner system users. *Journal of construction engineering and management*, *139*(4), 354-360. https://doi.org/10.1061/(ASCE)CO.1943-7862.0000606

Gunduz, M., & Naser, A. (2019). Value stream mapping as a lean tool for construction projects. *International Journal of Structural and Civil Engineering Research*, *8*(1), 69-74. https://www.ijscer.com/uploadfile/2018/1207/20181207050023870.pdf

Gunduz, M., & Fahmi Naser, A. (2017). Cost based Value Stream Mapping as a sustainable construction tool for undergraound pipeline construction projects. *Sustainability*, *9*(12), 2184. doi.org/10.3390/su9122184

Gunduz, M., Naji, K., & Naser, A. F. (2023). Duality of Lean Construction and Building Information Modeling into Digital Collaborative Scheduling in Qatar: A Conceptual Framework. *The 2nd International Conference on Civil Infrastructure and Construction (CIC 2023), Doha, Qatar*, 5-8, doi.org/10.29117/cic.2023.0013

Halala, Y. S., & Fayek, A. R. (2019). A framework to assess the costs and benefits of advanced work packaging in industrial construction. *Canadian Journal of Civil Engineering*, *46*(3), 216–229. doi.org/10.1139/cjce-2018-0072

Hamaidi, M. , Ghandour, N. , Hadi, M. A. & Naser, A. (2024). The Influence of Preconstruction Phase and Lean Construction Implementation on Project Performance, *Proceedings of the 32nd Annual Conference of the International Group for Lean Construction (IGLC 32)* , 353-364. doi.org/10.24928/2024/0133

Heigermoser, D., de Soto, B. G., Abbott, E. L. S., & Chua, D. K. H. (2019). BIM-based Last Planner System tool for improving construction project management. *Automation in Construction*, *104*, 246-254. https://doi.org/10.1016/j.autcon.2019.03.019

Heravi, G., Kebria, M.F. and Rostami, M. (2021). Integrating the production and the erection processes of pre-fabricated steel frames in building projects using phased lean management, *Engineering, Construction and Architectural Management, Vol*. 28 No. 1, pp. 174-195. doi.org/10.1108/ECAM-03-2019-0133

Khanh, H. and Kim, S. (2016). A survey on production planning system in construction projects based on last planner system. *KSCE J Civ Eng 20(1)*:1–11. https://doi.org/10.1007/s12205-015-1412-y

Lagos, C., Herrera, R. and Alarco´n, L. (2019). Assessing the impacts of an IT LPS support system on schedule accomplishment in construction projects. *J Constr Eng Manag 145*(10):04019055. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001691

Lindhard, S. and Wandahl, S. (2013). Looking for improvement in the last planner system: defining selection criteria. In: *ICCREM 2013: construction and operation in the context of sustainability*, pp 27–35. https://doi.org/10.1061/9780784413135.003

Musarat, M. A., Alaloul, W. S., Abdullah Sani, M. A. A. B., & Chong, N. W. (2024). Advanced Work Packaging (AWP): Implementation and Challenges in the Malaysian Oil and Gas Sector. *Sustainability (2071-1050)*, *16*(23). doi.org/10.3390/su162310234

Naser, A., Al-Sulaiti, J. E., & Dahmani, Z. (2023). Using Value-Stream Mapping to Enhance the Production Performance in Infrastructure Construction Projects in Qatar: A Case Study. In *Proceedings of the International Conference on Civil Infrastructure and Construction (CIC)* (pp. 189-196). doi.org/10.29117/cic.2023.0029

Power, W., Sinnott, D. & Lynch, P. (2024). Scrum's Distinct Role Definition Complementing LPS & Takt Implementation, *Proceedings of the 32nd Annual Conference of the International Group for Lean Construction (IGLC 32)* , 442-453. doi.org/10.24928/2024/0181

Ravi, R. (2018). *Last Planner System: Comparing Indian and Norwegian approaches* (Master's thesis, NTNU). http://hdl.handle.net/11250/2562312

Rebai, S., AlBalkhy, W., Hamdi, O. & Lafhaj, Z. (2023). Lean construction and AWP: similarities, differences, and opportunities. Proceedings of the 31st *Annual Conference of the International Group for Lean Construction (IGLC31)*, 1428–1439. doi.org/10.24928/2023/0258

Rebai, S., Sepúlveda, I., AlBalkhy, W., Hamdi, O., Lafhaj, Z., Alarcón, L. F., & Yim, P. (2024). Barriers to Adopting Advanced Work Packaging (AWP) in Construction. *Buildings*, *14*(4), 1032. doi.org/10.3390/buildings14041032

Rocha, A. (2023). Risk assessment in the implementation of advanced work packaging (AWP) in the oil and gas industry., *Proceedings of the 33rd European Safety and Reliability Conference (ESREL 2023)*, 2396-2404. doi.org/10.3850/978-981-18-8071-1_p075-cd

Sepúlveda, I., Alarcón, L. F. & Barkokebas, B. (2023). Can advanced work packaging become a lean method? *Proceedings of the 31st Annual Conference of the International Group for Lean Construction (IGLC31),* 1475–1486. doi.org/10.24928/2023/0129

Tamošaitienė, J. and Starta, T. (2019). Integration of lean last planner system in construction processes. *17th International Colloquium Sustainable Decisions in Built Environment*. doi.org/10.3846/colloquium.2019.007

Vieira, J. P. P. , Etges, B. M. B. S. , Vasconcelos, F. P. , Bellaver, G. B. & Nogueira, H. R. C. (2024). Synergy Between LPS and Slack: A Case Study in Brazilian Horizontal Housing Developments, *Proceedings of the 32nd Annual Conference of the International Group for Lean Construction (IGLC 32)*, 428-441. doi.org/10.24928/2024/0176