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CAN ADVANCED WORK PACKAGING BECOME A LEAN METHOD?

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ABSTRACT

Advanced Work Packaging (AWP) is rapidly becoming a popular methodology to improve efficiency in construction projects. It is an innovative approach to project management that focuses on the planning, organization, and control of construction tasks on the job site is based on the idea that by organizing work effectively and reducing lead times, it is possible to maximize efficiency and productivity in construction. Nevertheless, Lean Construction (LC) practitioners identified significant shortcomings in AWP such as the lack of attention to buffers while arguing that this methodology is not effective in a practical setting. In this context, this research presents a literature review identifying the criticism of LC practitioners to AWP while identifying similarities and possible synergies where both approaches can complement each other to render better results during the delivery of construction projects. This research identifies the implementation of the Last Planner System® (LPS®) as means to address significant AWP shortcomings identified by LC practitioners while taking advantage of AWP's structured approach to better apply LC concepts. Therefore, the identified synergies and combination of both approaches will contribute to more efficient processes and improvement of construction practices.

KEYWORDS

Advanced Work Packaging, Workface Planning, Lean construction, Integration, Collaboration.

INTRODUCTION

Construction projects have the primary objective of meeting construction deadlines, however, we constantly observe cases where this is not met as a result of productivity loss in the industry (Sanni-Anibire et al., 2022). Low productivity has an impact on a country's Gross Domestic Product (GDP), as it accounts for 3% to 8% of its GDP (Hasan et al., 2018). In fact, the construction industry has been struggling to meet increasing productivity demands (Bock, 2015). The Construction Industry Institute (CII) and the Construction Owners Association of Alberta (COAA) proposed AWP as a methodology to increase on-site productivity (Farghaly & Soman, 2021). According to the CII (CII, 2013), AWP methodology is a comprehensive project management approach primarily employed in the construction and engineering industries. Its main objective is to enhance project efficiency, predictability, and productivity. AWP achieves this by effectively planning and organizing work from the project's conception to completion. It involves breaking down projects into manageable work packages and coordinating design, procurement, and construction activities. AWP involves a series of steps

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that are aimed at defining the project's objectives and scope, and at organizing the construction process in a structured and efficient way. These steps typically include planning the construction sequence and identifying the necessary work areas and resources, breaking down the work into manageable units, coordinating the engineering and procurement activities, and preparing the installation and commissioning plans. By following this methodology, project teams can improve their productivity, reduce rework and delays, and enhance the quality and safety of the construction process. These several steps aim to align engineering, procurement, and construction through the creation of specific work packages for each of these activities, which allows for consistent and effective planning throughout the project (Guerra & Leite, 2020).

Koskela (2002) proposed the concept of LC as a new approach to construction, based on the principles of the Toyota production system. LC's main premise is to reduce waste while adding value to the client. Unlike AWP, LC emphasizes a culture that supports workers and continuously improves the production system (Court et al., 2022).

LC provides a range of benefits for construction projects. First, the elimination of waste in construction processes reduces costs and optimizes resource usage. Second, by increasing worker productivity through waste elimination and process improvement, LC leads to greater efficiency and effectiveness in project management. Third, the reduction of delivery times through waste elimination and process optimization decreases indirect costs. Fourth, the continuous improvement of processes in LC leads to a better quality final product, which reduces indirect costs and increases customer satisfaction. Fifth, LC places a strong emphasis on workplace safety, helping to identify risks and reduce workplace accidents. Finally, by promoting collaboration and effective communication among work teams, LC aids in identifying waste and optimizing processes, leading to increased customer satisfaction through cost reduction, quality improvement, and delivery time reduction.

Both LC and AWP differ in terms of their methods and development contexts. However, LC focus on waste reduction and value creation, coupled with its emphasis on a culture that supports workers and continuously improves the production system, makes it a powerful approach for achieving successful and profitable construction projects.; while AWP optimizes the planning and execution of work activities in construction projects to improve project outcomes and deliver projects more efficiently and effectively (Court et al., 2022). Despite these differences, researchers state that AWP and LC have significant similarities between them. Indeed, Mao et al. (2022) argue that AWP has its roots based on LC. An important production system in LC, the LPS® focuses on creating a reliable and predictable workflow between different stakeholders of a project with the last responsible person to perform the work in mind (i.e., the LPS®) (Lean Construction Institute, 2023). As such, AWP can support LPS® by providing the participation of the last planner during planning sessions of work packages(Hood et al., 2021). As a result, the gap between the planning and execution phases can be minimized.

The authors believe that, besides differences between LC and AWP, methods in both approaches can complement each other thus resulting in an improved project development and execution. Therefore, this article aims to discuss the complementarity between LC and AWP, considering their common objectives, differences, and possible synergy between them.

RESEARCH METHOD

The present study is a preliminary exploratory search conducted to identify possible critiques in the application of the AWP methodology. Sources of information related to construction and project management were searched, including indexed journals, technical documents, and conferences. The methodology used is depicted in Figure 1.

Once possible critiques of the AWP methodology were identified, information on LC principles that could be applied to enhance and complement the AWP methodology was sought. The search also focused on similar sources of information.

Overall, the exploratory search aimed to discover relevant and valuable information to address the research question of whether AWP could become a Lean method. The investigation was not conducted exhaustively but focused on discovering new ideas and perspectives that could enrich the discussion.

The methodology utilized in this research involved conducting an exploratory search, which revealed that Workface Planning (WFP) is a crucial component of the AWP approach. WFP is a methodology used for detailed planning and efficient execution of work in the field, which enables early identification of issues and challenges in work execution, allowing for informed decision-making and early risk mitigation. Combining WFP and AWP maximizes efficiency in the construction process, reduces waste, and ensures project quality and safety by providing a structured approach to work management from planning to final delivery.

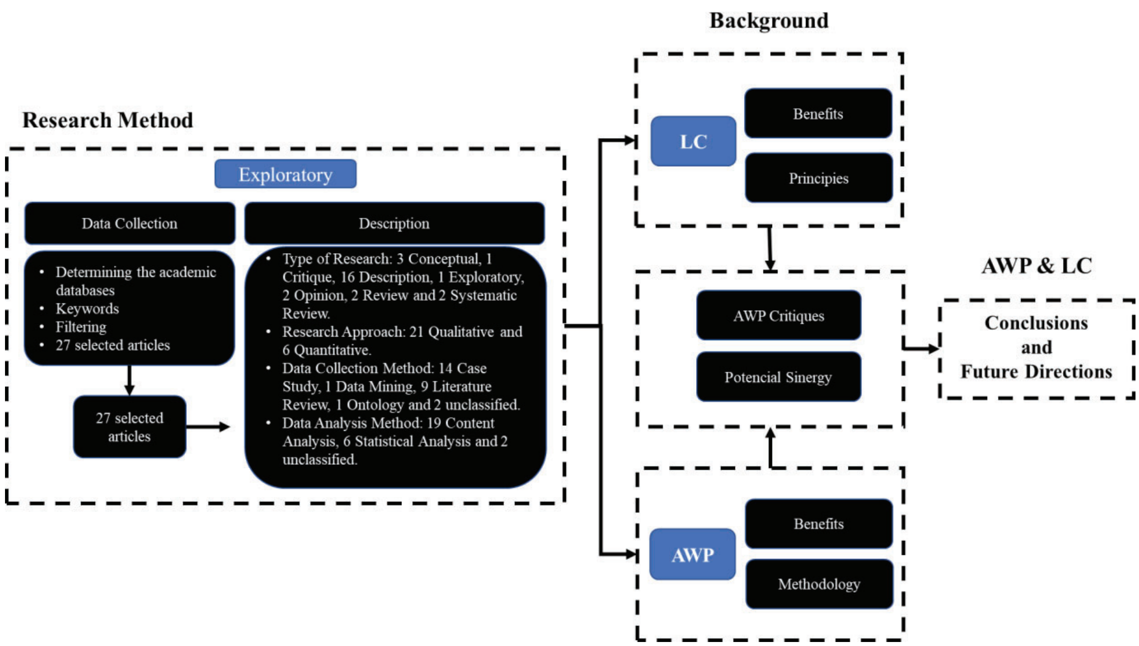

Figure 1: Research method

RESULTS AND DISCUSSION

The research included 25 articles on AWP and its interactions with LC. WFP. Figure 2 shows the volume of publications using these keywords indicating a low number of studies around this topic over the past years.

Through the exploratory search, the researchers found that Workface Planning (WFP) is a critical element of the AWP approach, as it allows for efficient execution and informed decision-making, early risk mitigation, and overall project efficiency, thus providing valuable information that can inform the discussion on whether AWP could become a Lean method. WFP is a fundamental component of the AWP approach, used for detailed planning and efficient execution of work in the field. WFP is a methodology that focuses on managing work packages in the field, allowing work teams to concentrate on effective execution, while AWP is a methodology for managing work across the project, from planning to final delivery. By enabling early identification of issues and challenges in work execution, WFP allows for informed decision-making and early risk mitigation, which contributes to overall project efficiency. When combined, WFP and AWP are tools that maximize efficiency in the construction process and reduce waste, while ensuring project quality and safety. Together, they allow for more efficient and effective management of work in the field, from planning to final delivery.

It is possible that the growing interest in the AWP and WFP methodologies can be attributed to several factors. In 2016, there may have been a greater dissemination of information and experiences regarding the application of AWP and WFP in construction projects, which may have generated interest in the methodology among researchers, professionals, and companies seeking innovative solutions to improve efficiency and quality in project management. Furthermore, the increasing complexity and cost of construction projects may have also contributed to the growing interest in AWP and WFP, as these methodologies can offer a promising approach to addressing these challenges.

In 2022, the interest in the AWP methodology may have been driven by the increasing demand for more efficient and sustainable solutions in the construction sector. The COVID-19 pandemic may have accelerated the need to adopt more advanced practices and methodologies for project management, which may have led to a greater interest in the AWP and WFP methodology. The pandemic has highlighted the importance of flexibility, adaptability, and resilience in project management, which are key principles of the AWP and WFP methodologies. Therefore, it is possible that the growing interest in these methodologies will continue as the construction industry seeks to improve project outcomes in an increasingly complex and uncertain environment.

Year	Publications
1991	1
2010	1
2011	2
2012	1
2013	2
2014	1
2015	2
2016	7
2017	1
2018	1
2019	4
2020	1
2021	4
2022	5

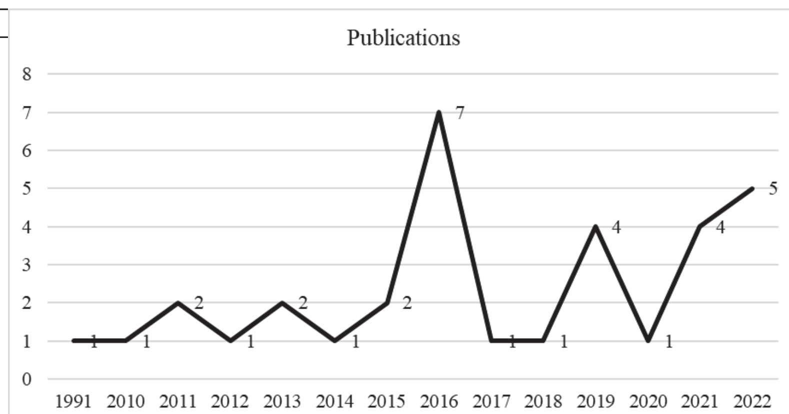

Figure 2: Past publications on AWP by year

BACKGROUND ON AWP

Driven by its recognition in the industry, the CII developed several studies to investigate improvements to the WFP methodology. As a result, CII proposed AWP as an improved version of WFP by providing several case studies and maturity models to identify its benefits (Hamdi, 2013; Ponticelli et al., 2015). The literature identifies benefits in several areas associated with the use of AWP as demonstrated in Table 1. According to Table 1, cost and productivity are commonly improved areas by AWP while benefits in quality and safety are only indicated by half of the authors. Farghaly & Soman (2021) applied AWP on a case study to monitor and control project deliverables in which shorter durations as a result of improved installation sequences onsite. Furthermore, a comparison between traditional projects and other projects under AWP was carried out; in the investigated projects, AWP showed better results in terms of cost, schedule, quality, and safety (Ponticelli et al., 2015). Following the same line, the use of AWP reveals a 25% increase in productivity, a 10% cost decrease, safety improvements, and lesser construction rework compared to traditional projects (Simhadri et al., 2017).

The article by Guerra and Leite (2020), presents a case study on how engineering and construction 3D models can be integrated to support AWP implementation. The article, by

Ponticelli, O'Brien, and Leite (2015), presents case studies demonstrating the benefits of AWP in industrial construction. The article, by Simhadri, Srivastava, and Warren (2017), discusses a case study on how AWP can enhance project control. Finally, the article, by Farghaly and Soman (2021), presents a case study on the development of an ontology to support information management and AWP integration. All four case studies involve the implementation of AWP in various project types, such as petrochemical plants, power plants, gas processing plants, and large-scale oil and gas projects. The case studies highlight the advantages of AWP, including reducing rework, improving communication and collaboration between project stakeholders, increasing productivity, and providing a structured approach to planning and execution.

Table 1: Identified benefits of using AWP.

Benefit	(Ponticelli et al., 2015)	(Simhadri et al., 2017)	(Guerra & Leite, 2020)	(Farghaly & Soman, 2021)
Cost	X	X		X
Planning	X	X	X	
Quality	X	X		
Safety	X	X		
Productivity	X	X		X

The use of AWP on a project requires the creation of several work packages. The owner's team is responsible to organize these packages according to the various contracts involved in the project. To do so, AWP establishes a workflow based on early integration in which work packages are defined based on requirements from field personnel. Hence, AWP is a construction-driven approach that adopts the fundamental philosophy of "start with the end in mind". Field personnel will execute these work packages as defined in the first stage. Figure 3 depicts the AWP methodology.

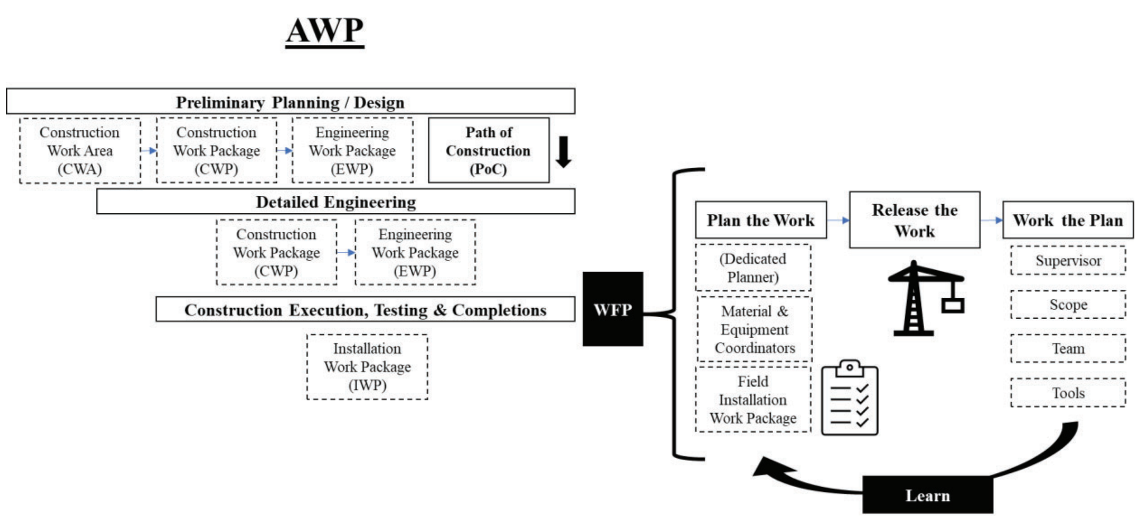

Figure 3: AWP methodology.

As noted in Figure 3, a key requirement in this process is collaboration between construction and engineering during the planning phase to create a constraint-free work environment on the field. This collaboration ensures the project is designed following a sequence that supports construction and its supply chain is organized by breaking down the project scope into work packages (CII, 2020).

AWP IN THE CONTEXT OF LC

The field of application for AWP and LC can be identified by examining relevant literature. According to the CII (CII) (2020), AWP is most used in industrial construction projects, such as those in the energy, chemical, and petrochemical industries. AWP is also applied in projects that require high levels of coordination and collaboration among different stakeholders. On the other hand, Koskela et al. (2002) describe LC as a new theory-based approach to construction, and its main premise is to reduce waste while adding value to the client. LC has been applied in a variety of construction projects, including healthcare, education, commercial, and residential buildings, as well as infrastructure projects. In summary, while AWP is mainly applied in industrial construction and projects requiring high coordination, LC is applied more broadly in a variety of construction projects.

Despite being lauded as an efficient methodology, AWP has gathered critics among the LC community. Ballard and Tommelein (2015) argue AWP is not effective since it focuses its efforts on the creation of work package documentation while not paying attention to production inventories and the creation of a push system as result. Moreover, they recommend the use of discrete event simulation to test the performance of AWP. Moreover, Tommelein (2016) argues that AWP results in large size of work crews, uncertain in schedules, and conflicting transformation processes from systems to product components and locations. Furthermore, Tommelein (2016) claims that supply chains in AWP are not considered as a challenge, which provides an additional complexity to any engineering project. Another critical point is the protection of the production system with a high inventory. As in the previous case, the use of discrete event simulation modelling is proposed to test the performance of AWP. Aligned with this, other studies sharing similar criticism are demonstrated in Table 2.

Table 2: AWP Critiques and Observations

Category	Criticisms/Observations	(Ballard & Tommelein, 2015)	(Tommelein, 2016)	(Fischer, 2021)	(Arbulu, 2019)
Planning	• Focus on document creation and packetization.	X			
	• Lack of synchronization between procurement, equipment, and deliveries.	X	X		X
	• Construction Work Package (CWP) are not made explicit in good form.	X			
	• Forced (Engineering Work Package (EWP) and Purchase Work Package (PWP).			X	
	• Planners are positioned as the ones who will do the thinking for the crews.			X	
Installation Work Package (IWP)	• Installation Work Package (IWP) focused on hours and not on performance.	X	X		
	• Installation Work Package (IWP) decoupled from the constructive logic of a work breakdown structure.			X	
	• Performance protection only protected by high inventory.	X	X	X	X
Production System	• Lack of vision of Balanced Production System.	X	X		X
	• Lack of concepts such as: Buffer, Flux, Push vs Pull, Lead time, and throughput.			X	
Resources	• Underloaded field resources.		X		
Trade Capability	• It is believed that the trade is incapable of effectively planning its own work.			X	

Arbulu (2019) defines AWP as a strategy to place large inventory stocks of materials and information to protect the production system despite not considering the predecessor work-in-process management, capacity, and process variability. Furthermore, Arbulu, (2019) argues that larger buffers generated by AWP will incur to higher project cost despite buffers being estimated by a combination of capacity, time, and inventory. Similarly, Fischer (2021) criticizes AWP pointing out errors in the planning process and the lack of knowledge of construction sequences from planners, which generates disassociation between the AWP packages and the actual work breakdown performed on construction sites due to the logic of construction processes. Indeed, when using AWP, three types of constraints are identified: engineering, supply chain, and site. These are the constraints that must be managed properly to ensure that the construction crew can develop their work as planned (Farghaly & Soman, 2021). Wang et al. (2016) provides a framework for constraint management applicable to both AWP and LPS®. One of the primary objectives in LC is to minimize the inventory and stablish a pull system while developing a culture based on value, mutual trust, and respect to support production. On the other hand, AWP is based on a structured approach (Court et al., 2022). Despite the criticisms presented in this section, the present work identifies potential synergies between LC and AWP as described in the following sections.

POTENTIAL SYNERGY BETWEEN LC AND AWP

Despite the identified differences, AWP and LC share the objective of improving efficiency and quality, constraint management, and stakeholder integration. Court et al. (2022) establishes the main difference between these approaches, Lean is a culture based on values of trust and mutual respect. Indeed, one of LC's main premises is the importance of achieving the project objectives under an environment of collaboration and integration that is enhanced (Alarcón et al., 2013). Table 3 presents a summary of the similarities and differences between AWP and LC.

Table 3: Comparing AWP and LC: Similarities and Differences

Similarities	Differences
Both AWP and LC aim to improve efficiency and quality, constraint management, and stakeholder integration.	LC is based on a culture of trust and mutual respect, while AWP is a methodology focused on work packaging.
Both methodologies focus on early planning, and AWP uses Interactive Planning Sessions while LC employs the Big Room.	LC emphasizes the importance of achieving project objectives in a collaborative and integrated environment.
Constraint management is a key aspect of both AWP and LC, with AWP using Workface Planning and LC using Last Planner System® (LPS®).	AWP focuses on work packaging, while LC focuses on creating a culture of continuous improvement.
The technology applied to implement AWP or LPS® is important for the success of both approaches, with both benefiting from the use of Building Information Modeling (BIM).	LC and AWP differ in their approach to planning and executing work.
Incorporating LC concepts or techniques into the AWP structure can potentially remediate criticisms of AWP and enhance its continuous improvement process.	AWP and LC have different structures and cultural focuses.

The similarities and differences between AWP and LC can be better illustrated through Figure 4. Initially, the focus on early planning is identified in both methodologies. LC considers the Big Room as a key element to meet all the needs of the stakeholders. Big Room seeks to help better coordination of complex engineering projects (Nascimento et al., 2018). Similarly, AWP uses Interactive Planning Sessions to define an integrated plan for project execution from design, construction, commissioning, and delivery to the customer despite no evidence of any specific techniques applied during the session. Hence, LC can contribute to AWP to motivate collaborative work and, consequently, improve how the work is performed while taking advantage from the structured work packages from AWP, when structured work packages are taken in AWP, it provides several benefits. It allows for the optimization of resources, reduces rework, increases productivity, and improves communication and collaboration among the project team. Structured work packages provide a clear understanding of the work to be performed, the required resources, and the expected outcome, facilitating effective planning, scheduling, and execution. Additionally, the structured approach ensures that work is completed in a logical and systematic order, which helps prevent delays and errors. Overall, taking structured work packages in AWP helps to improve project efficiency and effectiveness. Another similarity between both approaches is the execution phase. In AWP, constraint management is based on WFP. Both the LPS® and AWP are gaining more attention in the recent years because they consider richer information related to project constraints, which infers better quality decisions (Mao et al., 2022).

The technology applied to implement AWP or LPS® is also a fundamental aspect in order to achieve success in either AWP or LPS®. Figure 4 shows the similarities between the technology pertaining to AWP and LC. The work environment in AWP achieves a better development with the incorporation of technologies such as Building Information Modeling (BIM) contributing to an important support to the AWP methodology, as also LC. BIM is defined as a set of methodologies, technologies, and standards that allow designing, constructing, and operating a building or infrastructure collaboratively in a virtual space (Succar et al., 2012). Therefore, BIM offers a reduction of fragmentation in the supply chain and a better platform for construction management (Wu et al., 2021). In terms of linkage with AWP, BIM methodology is presented as an AWP modernization (Tixier et al., 2017). Similarly, the petrochemical industry values the complementarity between AWP and BIM (Guerra & Leite, 2020) as it strengthens the value stream of the project, allows efficient, and aligned engineering. Therefore, the use of BIM methodology is aligned with both AWP and Lean objectives.

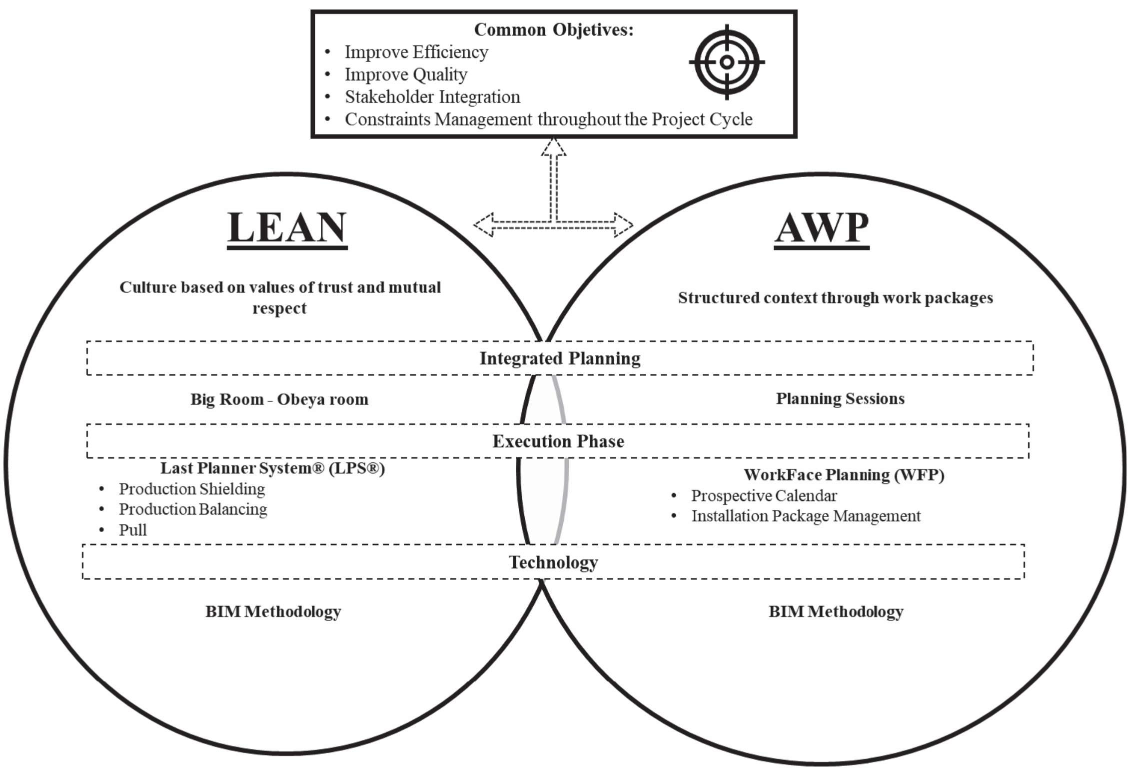

Figure 4: Agreement between Lean and AWP

Finally, aiming to present possible synergies between LC and AWP, Figure 5 shows which elements should be taken from LC and AWP to conform the proposal. The identified synergies rescue the work structure proposed in AWP while considering that each event or decision is supported by LC concepts or techniques. This paper acknowledges the criticisms of AWP which can be remedied by incorporating the DNA of LC in the AWP structure. Both WFP and LPS® are planning systems, seek that the work is executed in a fluid manner, prioritizing a construction rhythm, that allows to benefit the master planning. Figure 5 shows direct feedback to the work planning phase in AWP as in LPS® planning, this feedback process harbours a learning opportunity from the project constraints. In WFP the installation packages are established in a descending way which turns continuously improvement achieved from the information of constraints that is obtained from the field a more challenge and complex process. On the other hand, in LPS® the lessons learned from a project constraint is collected from the field personnel that executed the work and thus facilitating the assimilation of improvements in a continuous manner. As such, AWP can benefit from LPS® by incorporating this approach for continuous improvement in its methodology.

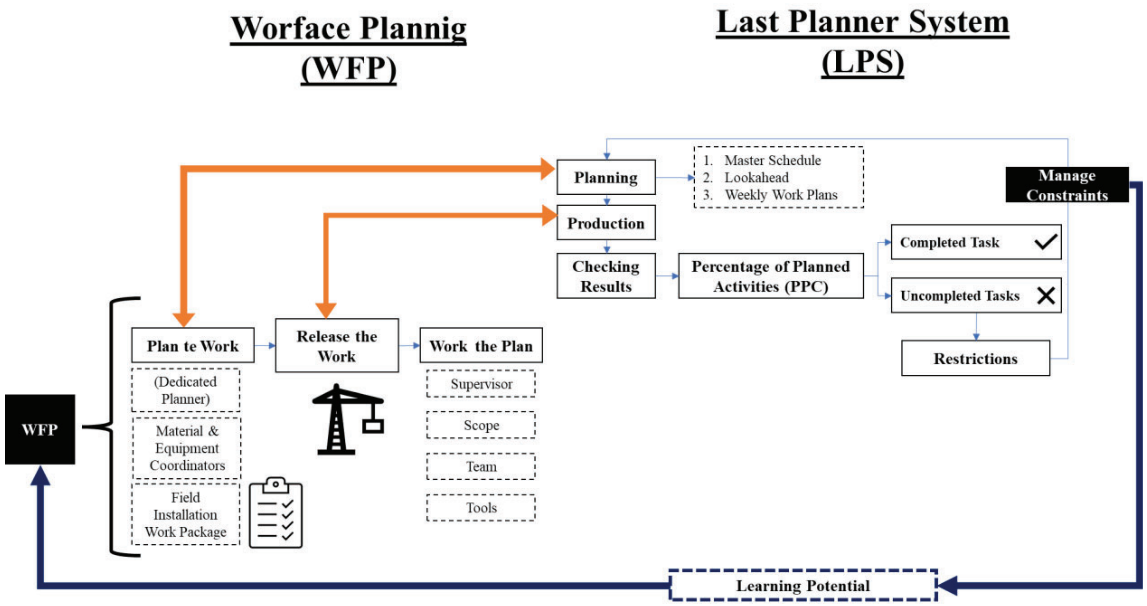

Figure 5: Comparison between Last Planner System® and Worface Planning.

The literature presents some criticism towards the Advanced Work Packaging (AWP) approach, particularly from the perspective of Professor Glenn Ballard and Irisi Tommelein. Despite this, there is evidence of learning opportunities for both Lean Construction (LC) and AWP methodologies. The interaction between these methodologies is worth exploring to identify the possibilities of improving AWP with contributions from LC, while also evaluating the possibilities of implementing the identified synergies. The low volume of publications related to AWP presents an opportunity to carry out academic work and strengthen this approach. For example, Halala and Fayek (2019) propose a framework to assess the costs and benefits of AWP in industrial construction. Additionally, Hood et al. (2021) provide evidence of the linkage between AWP and the LPS®. The incorporation of the identified synergies into AWP will open a field of research possibilities, which complement those already established in the literature.

CONCLUSIONS

Despite studies considering LC and AWP opposite approaches to construction, there is also evidence in the literature of learning opportunities on both ends. Taking this into account, the possibilities of improving AWP with contributions from LC holds a significant potential for its future development while maintaining the possibility to learn from other production planning approaches as well. The low volume of publications related to AWP presents an opportunity to carry out academic work and strengthen this approach. It is necessary to promote case studies that allow quantifying the promised benefits of AWP, as well as evaluating the possibilities of implementing the identified synergies. Before adopting LC concepts into AWP, it is necessary to take into account what factors are modified in the AWP approach when using LC techniques and what is the balance between an AWP and LC methodology. The incorporation of the identified synergies into AWP will open a field of research possibilities, which complement those already established in the literature such as the evaluation of multiple aspects of AWP implementation to quantify both its costs and benefits (Halala & Fayek, 2019).

The potential synergies between AWP and LC can significantly enhance the future development of AWP, as both approaches share similar objectives of improving efficiency and quality, constraint management, and stakeholder integration. LC emphasizes the importance of achieving project objectives under a collaborative and integrated environment, while AWP provides a framework for effective planning and execution of construction projects. By incorporating LC concepts into AWP, such as the balanced production system and synchronized procurement, equipment, and deliveries, AWP can benefit from increased performance and productivity. The bidirectional learning between AWP and Lean could also enable achieving a competitive level for Industrialized Construction, where people, process, technology, and culture are critical factors to consider. Therefore, it is necessary to evaluate the possibilities of implementing the identified synergies and promoting case studies that allow quantifying the promised benefits of AWP.

There is a clear opportunity to evaluate the interaction between LC and AWP methodologies, as there is already evidence on record where the linkage with the LPS® (Hood et al., 2021). A potential avenue for future research involves exploring the application of AWP to other project types. The literature proposes utilizing AWP for modular construction due to the high number of disciplines involved within a limited space. Thus, although AWP is essential, further research is needed to deepen its application in other areas. Furthermore, it is crucial to emphasize that bidirectional learning between AWP and Lean could enable achieving a competitive level for Industrialized Construction by taking into account critical factors such as people, process, technology, and culture.

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