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LEAN HEALTH CHECK FRAMEWORK

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ABSTRACT

Lean construction is an approach that prioritizes enhancing quality and value while minimizing waste. Lean management comprises of principles and concepts that must be observed to effectively implement Lean management and leverage its benefits. In line with Lean concepts and principles, appropriate behavior and culture must be properly implemented to achieve successful Lean management, hence necessitating the use of an established health check assessment to evaluate the level of Lean maturity. This study aims to introduce a health check assessment to ascertain the level of maturity of Lean behavior and culture in the construction industry. The health check assessment was formulated by identifying Lean success factors, which were further validated by Lean experts. The methodology employed to achieve the study objectives follows a Design Science Research (DSR) approach, which involves creating a health check framework and evaluating it through an expert panel interview among project parties in a real case study project. In addition to the Lean expert panel interview, other performance metrics, such as percent planned complete (PPC) and constraint information, were collected. The proposed framework was validated, and the results indicate that there may be a correlation between effective team communication and project performance.

KEYWORDS

Lean construction, Lean maturity level, framework, Lean health check.

INTRODUCTION

Planning plays an essential role in construction projects. It tackles uncertainties in a project and improves the efficiency of processes while providing a better understanding of project objectives (Chan et al. 2004). However, the construction industry faces several challenges in conducting reliable planning, scheduling, and budgeting, which leads to additional uncertainties and inefficiencies. To address these challenges, modern project management has been developed over the past forty years (Kerzner, 2017), including Lean project management, which focuses on delivering high-quality products while minimizing waste and maximizing value and quality (Ballard & Howell, 2003). The delivery process of Lean management is characterized with clearer objectives where the product and process can be designed simultaneously, and the production control applies entirely during a project's life cycle (Howell, 1999). This is achieved within an environment of strong communication which is a fundamental aspect of Lean philosophy. Put simply, in the construction context, planning, project management, and communication are closely related and interconnected. Effective planning lays the foundation

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for successful project management, and clear communication is essential for both planning and project management to be successful.

The decision-making process in construction projects is influenced by communication between team members; thus, miscommunication and involved parties' behaviours throughout the process might lead to creating more new tasks (Hamzeh & Aridi, 2013). Put differently, since construction teams are multidisciplinary and temporary, having effective communication to exchange information and collaborate to reach the same goal is crucial. In addition to communication and collaboration, there are some other Lean success factors like transparency, safety, and waste minimization (Bayhan et al., 2019). As can be seen, some critical factors should be considered in Lean implementation to achieve the highest potential. Therefore, this research aims to provide a Lean health check framework to understand the Lean maturity level on a project. The framework consists of first identifying Lean success factors through extensive literature review, which are then validated by an expert panel and used to develop an expert panel interview. The interview is designed and distributed among the participants of a real project and the results are analyzed along with some last planner system (LPS) metrics. Finally, team performance is analyzed, and lessons learned are collected.

LITERATURE REVIEW

THE NEED FOR LEAN CONSTRUCTION

According to PMI's "*A guide to the Project Management Body of Knowledge*," project management is the application of knowledge, skills, tools, and techniques to project activities to meet project requirements. Project planning is essential for controlling project success as it provides the project parties with detailed information about execution dates and resources (Zwikael, 2009). Project management is accomplished through the appropriate application of five process groups, which are: initiating, planning, executing, monitoring and controlling, and closing. Managing a project goes further to include the management of integration, scope, time, cost, quality, human resources, communications, risks, and procurement (PMI 1996; Ballard, 2000).

In the 19th century, Bar and Gantt charts were used for planning and scheduling industrial and construction projects. Afterwards, the Critical Path Method (CPM) was established as a more developed version of the Gantt chart for production management, and it has been widely used since the late 1950's (Henrich & Koskela, 2006). CPM relies on creating construction schedules by breaking the project down into activities and assigning them to task leaders. The traditional project management methods work by delivering project objectives on the activity level through a transformational approach, and while disregarding flow and value generation. Therefore, when activities fall behind their schedule, specific measures must be taken to reduce the cost and duration of delays (Howell, 1999; Diekmann & Thrush, 1986). As a result of shortcomings in traditional project management methods, Ballard and Howell (1998) stated that there is a need to develop a new management system for making sound decisions when it comes to productivity and project progress.

Another reason for introducing a new management system was to reduce variability. A poor management system leads to unexpected conditions and renders objectives unstable and unachievable (Ballard, 2000; Thomas et al., 2002). Unstable conditions are mainly due to variability in performance; so, it is vital to have a new management system that could decrease such variability. Consequently, Lean construction was introduced as a production system that tackles variability and waste. Lean concepts originated in the manufacturing industry. According to Lean manufacturing principles, construction workflow variables are imped system performance (Howell, & Ballard, 1994; Tommelein, 1998).

Lean philosophy began with the Toyota Production System (TPS), and it was developed by Taiichi Ohno. TPS' main concepts include customer value identification, waste reduction by eliminating non-value-adding activities, creating a continuous flow, and seeking continuous improvement (Koskela, 1992; Howell, 1999). Additionally, Lean production focuses on managing a process through achieving value efficiency and providing helpful tools and methodologies for appropriate planning (Faniran et al., 1997).

LPS technique is an essential application of the Lean production system, which helps to control planning, and minimize uncertainties and complexities by involving subcontractors and lower-level management in the planning and control process (Hamzeh et al., 2019; Viana et al., 2017). Moreover, the LPS production planning and control system increases workflow reliability on construction projects (Ballard & Howell, 1998). Several metrics have been developed as part of LPS environment, and among these metrics, Percent Planned Completed (PPC) is the most common. PPC measures the reliability of weekly work planning and tracks the performance of reliable promising. It is calculated by dividing the number of planned activities completed at the end of a short period over the total number of activities promised to be completed at the beginning of that period.

LEAN CONSTRUCTION AND IMPLEMENTATION

Koskela and Ballard (2012) examined that developing new ways of thinking and integrating elements of production management and project management into a comprehensive system for construction is essential for the effective delivery of projects through Lean. Certainly, the transformation towards Lean construction will lead to changes in the culture and its people (Green et al., 2008), at both the temporary organization (project) and the management level (Ballard and Howell, 1998).

According to Hamouda et al. (2014), Lean behaviour is defined as a behaviour that adds or creates value, and this behaviour will impact Lean management. The authors also mentioned that behaviour change is the key factor to improve performance. Implementing sustainable Lean concept is required to change the culture by focusing on Lean behaviour. The authors examined that collecting and documenting the critical success factors of Lean implementation will help to change the culture and create more focus on Lean behaviour.

Bayhan et al. 2019 stated that there should be a clear strategy to implement the Lean culture effectively and enhance its potential. A clear strategy will also help decrease the waste in the system which is one of the main Lean principles. Therefore, the authors introduced a list of enablers and barriers to Lean implementation. In addition, other researchers introduced Lean success factors and barriers (Tayeh et al., 2018; Netland 2016; Salem et al., 2015). Thus, this research aims to implement a Lean health check framework as a clear strategy according to the Lean success factors which have been collected through the literature review and Lean experts' knowledge.

LEAN IMPLEMENTATION SUCCESS FACTORS

Many researchers addressed the critical success factors of Lean construction. For instance, Demirkesen and Bayhan (2020) proposed a success model for implementing Lean philosophy in the construction industry. The model uses Delphi method to administer data collected from a questionnaire conducted with eight experienced civil engineers. It targets identifying seven categories of success criteria and uses an analytical network process to reveal links between the success attributes. The study found that Lean training, availability of Lean tools and techniques, and market share were the most important success factors for Lean implementation.

In another study, Li et al. (2020) proposed a method for assessing the lean construction management performance (LCMP) using the analytic network process-fuzzy comprehensive evaluation (ANP-FCE) model. The LCMP evaluation index system was achieved through literature review and questionnaire surveys. The ANP and Super Decisions software were used to calculate the weights of the indices and the FCE was adopted to carry out a comprehensive evaluation of LCMP. The proposed method can help decision makers identify the strengths and weaknesses of LC management of the evaluated project.

Watfa and Sawalha (2021) identified critical factors necessary for successful implementation of Lean Construction and developed a conceptual framework for adopting it. The authors conducted a literature review and a survey of local construction companies to identify 13 Critical Success Factors (CSFs) categorized into four main constructs: Managerial, Organizational, Structural, and External Factors. The study proposes a preliminary roadmap to guide construction companies in adopting Lean techniques.

Another study by Shaqour (2022) focused on the challenges faced by the construction sector and suggested that the adoption of lean construction approaches can help in reducing waste and enhancing performance. Data was collected from 162 construction professionals, and the study found that the adoption of lean tools positively affects time, cost, quality, safety, environment, and relationships. However, the study also found that while construction professionals apply lean tools in construction sites, their knowledge level of lean concepts is less than the adoption level.

METHODOLOGY

According to Van Aken (2004), scientific disciplines can be classified into formal sciences, explanatory sciences, and design sciences depending on the mode of producing scientific knowledge. In design sciences, knowledge is created through the implementation of a solution that is able to employ or alter a particular occurrence (Vaishnavi and Kuechler, 2007). Therefore, according to Alsehaimi et al. (2012), design science (or constructive research) can assist in developing and implementing innovative managerial tools and tackling different managerial construction problems. Therefore, this approach seems to be appropriate for conducting research in construction management. March and Smith (1995) state that the design science research (DSR) process has two fundamental parts: creating artifacts that can address real-world issues and evaluating their performance in use.

According to Hevner (2007), DSR contains three primary cycles, which are:

5. The relevance cycle: it involves the development of an artifact to resolve a relevant problem identified in a specific environment.
6. The design cycle: it facilitates iterations in the design and assessment of the artifact until a satisfying product is obtained.
7. The rigour cycle: it uses existing past knowledge, skills, and artifacts in the application area to ensure innovation beyond the known.

This research implements the DSR methodology to develop a framework for LPS and social health checks. Three main stages of the research approach are shown in Figure 1, which are: the need for a framework, framework development, and testing of the framework.

Figure 1: Research Methodology Steps

DEVELOPING THE FRAMEWORK

According to the literature review, it was found that there is a need to develop a framework to assess the Lean maturity level of a project. After realizing the need for such a framework, literature review has been conducted to collect the Lean success factors which have been further validated by Lean experts. The collected factors are then used to design questions and create an interview to be run on a real project. The Lean expert panel interview will help to understand the Lean implementation level of the project.

In addition to the interview results, some performance metrics are needed to compare the interview results and Lean project performance. Lean project performance indicators like PPC and constraint information can be used as data-driven decision-making approach to understand the team performance, identify their strengths and weakness, and summarize lessons learned from the project. Since project performance and Lean implementation are time-related, the above-mentioned steps should be done every month to have a clear idea about the strengths and weaknesses. Figure 2 illustrates the health check framework and the steps in detail.

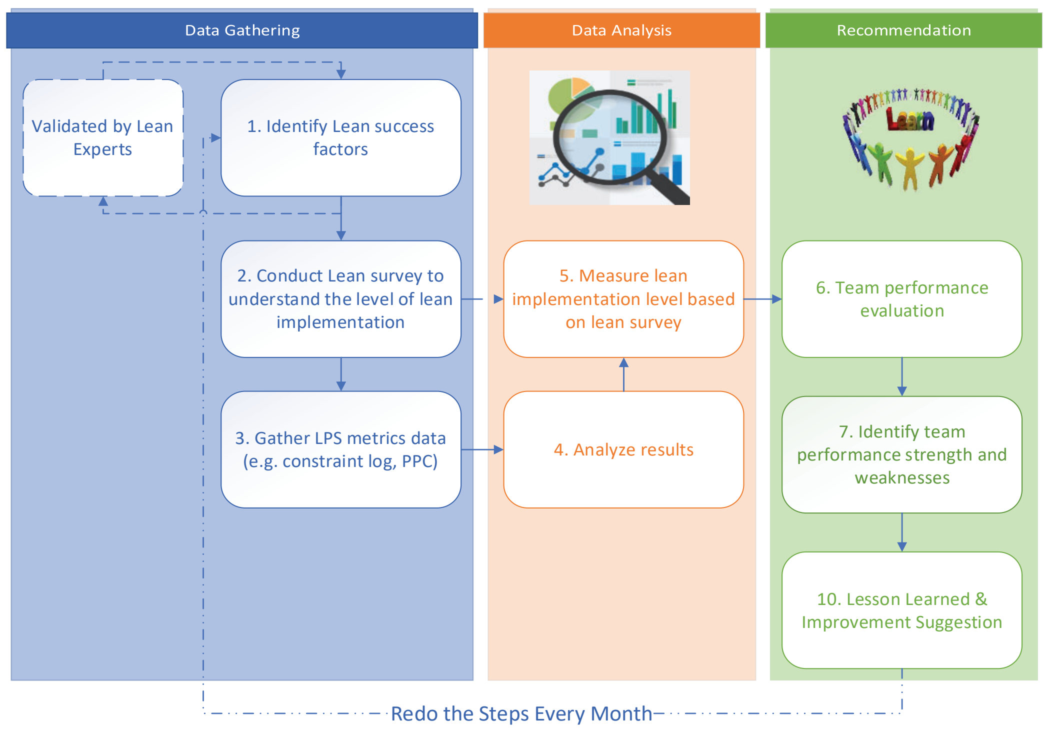

Figure 2: Lean Health Check Framework

DESIGNING THE INTERVIEW

The Lean expert panel interview has been designed to understand the level of Lean implementation in projects based on the Lean success factors collected through literature review (Bayhan et al., 2019; Castillo et al. 2018; Kallassy and Hamzeh 2021; Power et al. 2021; Simmons et al. 2020; Zheng et al. 2020). At first stage, around 90 factors have been collected, which were then reduced based on the research goal pertaining to focusing on the effect of communication on Lean maturity level. The process of reducing the factors and designing the questions has been validated by the Lean experts and finalized as shown in Table 1. After finalizing the factors and questions, the Lean expert panel interview is conducted to understand the Lean implementation level. Table 1 summarizes the factors and questions which have been finalized by Lean experts and project managers and implemented on real projects.

Table 1: Lean Success Factors and Interview Questions

Categories	Interview Questions to Rate Each Factors
Respect for people	"Communication is formalized and communicated when required. "
Teamwork	"The company is flexible in communicating with trades during the execution phase and whenever needed without waiting for RFI."
	"The company trusts the word given by the trade partners and provides an opportunity to the trade partners for decision making."
Communication & Collaboration	"There is a knowledge-sharing culture in the company."
	"The company creates the handover structure and schedule of deliverables."
	"The company cooperates with trades to build trust and commitments
Transparency	"The information on which tasks will be performed during the week is transparent and available to the trades."
Safety	"The company prompts employees about safety in the workplace every day during the daily huddles."
Problem Solving-Learning	"The company is using problem-solving techniques to determine the reasons for variance are identified and discussed during the weekly trades meetings."
Consistency and Standardization	" The company standardizes the best practices and defines certain rules for the trades."
Waste minimization/consciousness	"Handoff quality is good, and no need to rework."
	Work activities and tasks are planned in such a way to minimize the DOWNTIME."
Innovation	"There is continuous support from the top management."
Continuous improvement–Quality	" The company continually reports the project status and updates the progress."
	" The company has meetings to discuss lessons learned in the middle of the project."
	"There is an ongoing effort to teach the Lean concepts and further specialization."
LPS	"The information on which tasks will be performed during the week is transparent and available to all workers of the construction."
	" The company provides the information regarding what task should be done, when, and by whom.
	" The company keeps a record of the lessons learned on-site for future projects."
	"There is a systematic update of the master plan when it is necessary."
	"Trades are involved in constraint identification and providing solutions."

TABLE TESTING THE FRAMEWORK

The proposed Lean health check framework and dashboard have been tested in one real project as a case study. The case study is a school rehabilitation project in Vancouver, Canada. The project was selected because the Lean management system and the last planner system were used for production planning and control. This case study aims to examine Lean maturity and behaviour and find the gap to improve the weakness. To do so, first, the Lean expert panel interview has been conducted to understand the level of Lean implementation in the project. Second, the performance indicators like PPC and constraint information have been collected from the software that the company was using as their planning software. After collecting all the information, the dashboard has been created to have a current project performance and Lean maturity indicators. The proposed framework suggests that the process should be repetitive every month to understand the process improvement, however, we were able to collect the data to complete the process only one time because of time and data collection limitation.

RESULTS AND DISCUSSION

The interview was conducted on the LimeSurvey platform and was accessible for one month to collect the results. Each respondent was asked to rate the Lean success factors between 1 (low) and 5 (high). After getting all the answers, the average of the results was used to check the Lean maturity level for the project and the result was finalized by designing a radar chart, which can be seen in Figure 3. Figure 3 shows the categories of the success factors with the answers' averages. The interview results in **Error! Reference source not found.** show that communication and collaboration are the lowest and transparency and LPS are the highest among other factors.

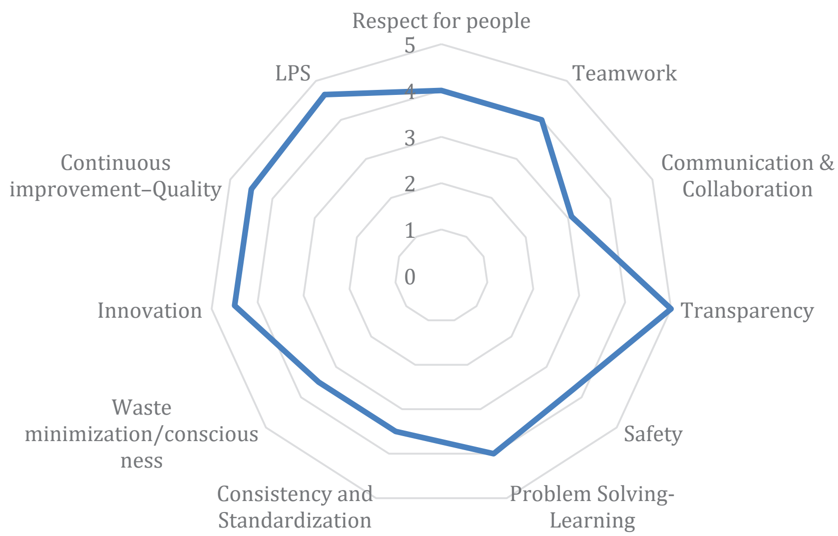

Figure 3: Lean Maturity Level

In addition to interview results, LPS-related metrics like PPC and constraint information were collected from the software used by the company to compare the actual results to parties' opinions. The average PPC was 65% during the study, which is shown in Figure 4. The PPC result shows that the company was struggling to complete the planned tasks and as a result, the PPC rate was not high enough. At the same time, the interview results show that the company has a high LPS implementation rate, and the actual LPS-related metrics show through the questionnaires that there is optimism around LPS implementation.

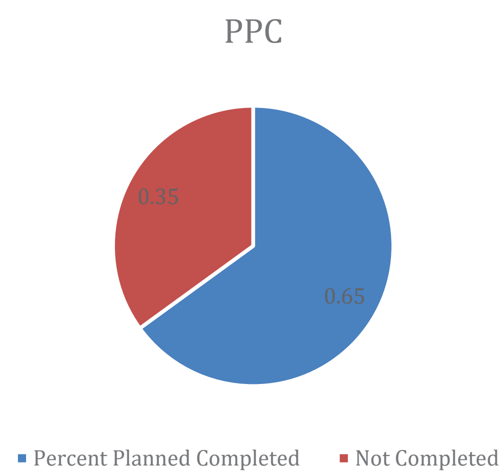

Figure 4: Actual Percent Plan Completed

In addition, the constraint log information has been collected to uncover the reasons for having lower PPC. The constraint information log shows that 135 constraints had to be removed to execute specific tasks, and among the 135 constraints, only 25 were removed on time and 21 were removed ahead of time. During the study period, 40 constraints had not been removed yet, and they were behind in removing 46 constraints. The behind tasks were divided into two sections which are behind by more than 50 days and behind by less than 50 days. The results show that 22 tasks were behind by more than 50 days. Figure 5shows the results in more detail.

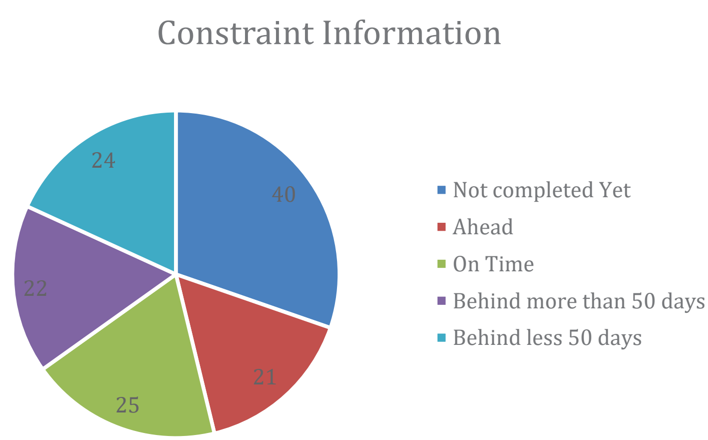

Figure 5: Constraint Log Information

Performance dashboard

After collecting all the required information, a dashboard was created to have a clear understanding of the current project's performance. It contains visualized Lean expert panel interview results, actual PPC, goal, and constraint logs. On the top of the dashboard, the user will see the interview results and the middle of the dashboard shows the average and the standard deviation of the interview results which help in visualizing the variability. At the bottom of the dashboard, the user will see all the LPS metrics information that has been collected from the planning software, which can be seen in Figure 6.

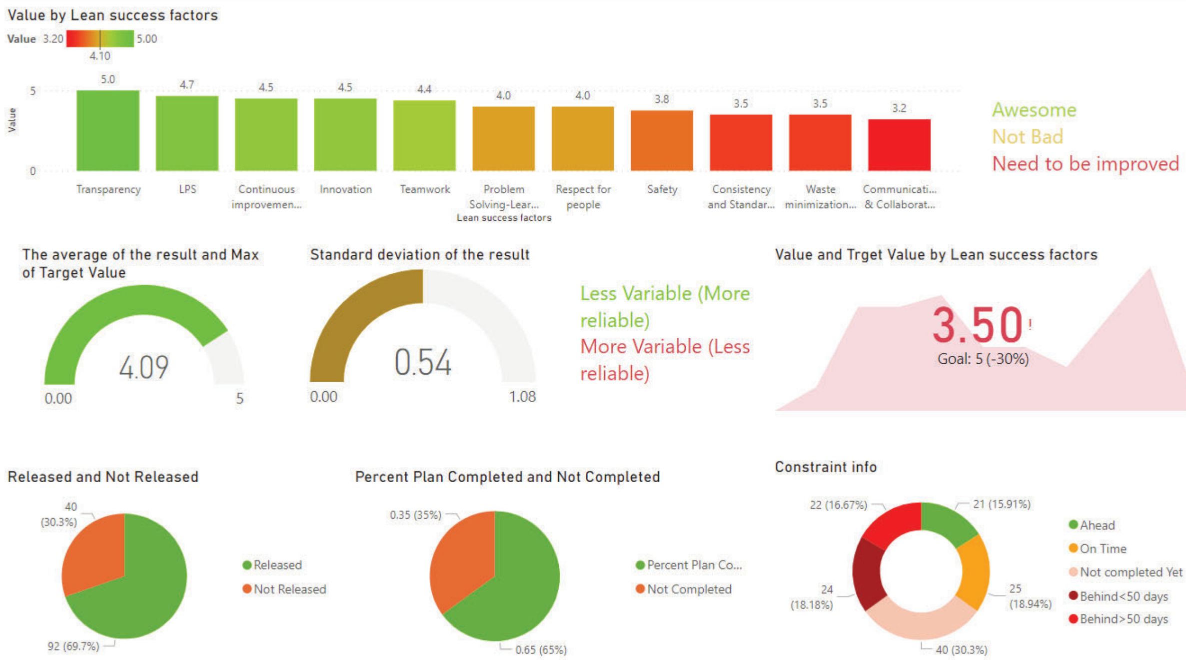

Figure 6: Performance Dashboard

The dashboard for the project adopted as a case study is generated. As can be seen in Figure 6, the interview results show that the company has a high rate of transparency and a low rate of communication and collaboration. In addition to the interview results and LPS-related metrics, the dashboard shows that the company is 30% behind its goal. Therefore, the framework and the dashboard will help reveal the weaknesses and strengths and find room for improvement of Lean implementation.

CONCLUSION

Lean project management is part of modern project management because it focuses on increasing quality and value while decreasing waste. Even though Lean is widely used worldwide, it is still new to many construction professionals, and partial implementation of Lean and LPS will limit its potential. Implementing Lean not only improves production control, but also helps build relationships among construction teams and strengthen social networks; accomplishing an effective Lean environment requires effective communication to collaborate and exchange information. Therefore, increasing the level of communication and collaboration will help individuals and companies implement a more mature Lean system in their projects. Accordingly, this research introduces a Lean health check framework to understand the level of Lean implementation on a project and it also helps to find room for improvements.

The proposed framework has been tested on a real project and the interview results show that the team was optimistic about how they are implementing LPS; however, the data shows that they are struggling with constraint identification and removal, which can directly affect LPS proper implementation (Perez & Ghosh, 2018; Hamzeh et al., 2015; Hamzeh, Zankoul, & Rouhana, 2015; Ballard, 2000). The interview results also show that the level of communication and collaboration is low and needs to be improved. According to Alarcón and Calderón (2003), the communication-transparency factor is one of the main factors that can directly impact PPC results. Thus, more involvement and training would be valuable to increase the Lean maturity level. The authors also noticed that PPC is higher on projects with a collaborative approach. Therefore, by considering the mixed method approach, which is a combination of interview results and data-driven decision-making, there could be a relationship between LPS implementation and the parties' interaction. As a result, there is a need to study such relationship in future research. In addition, some limitations of this study should be addressed in future research such as testing the framework on multiple projects and considering additional factors like project nature and complexity.

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