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IMPACT OF LEAN PRACTICES IN THE PLANNING OF DESIGN TASKS: EVIDENCE FROM TWO PROJECTS IN FRANCE

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ABSTRACT

Lean construction, through its different tools, has enriched the construction industry with several ways to present reliable planning for the construction process. Nevertheless, the focus on planning design tasks is still incomparable to that devoted to the construction tasks. Additionally, lean construction and its planning tools and principles are still not routinely practiced in many areas of the world. This article tries to contribute to the existing efforts and shows the integration of lean construction with digital tools to improve the reliability of planning activities for design tasks in two projects in France in time of the COVID-19 pandemic. The article results show that the use of lean practices helped avoid delays in design, better consider the client's expectations, and improve the collaboration between the participants in the design phase. The current study brings new insights into the applicability of lean practices in improving design management in the Architecture, Engineering, and Construction (AEC) industry.

KEYWORDS

Lean construction, Last Planner® System (LPS), lean design, planning, Key Performance Indicators (KPIs).

INTRODUCTION

One of the most essential keys to achieving success in construction projects is having reliable planning (Rizk et al., 2017). Reliable planning allocates the resources properly, defines the criteria and needs to achieve the objectives of the project, and helps to anticipate the risks early enough to be properly managed and mitigated (Aziz & Hafez, 2013). Thus, it is not surprising that some construction managers invest more than one-third of their time in planning activities (Daniel et al., 2020; Mustapha & Langford, 1990).

Design is the first process in construction projects when the objectives are defined and customer's requirements are translated into solutions (Koskela, 2000). Similar to construction, design is also a complex process as it requires a proper translation of the client's needs and requirements and includes decisions that affect all measures in the projects (Rosas, 2013). It is evident that although design includes the lowest expenditures, it has the greatest influence on the project cost among all the project phases due to the

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decisions made in this phase (Yang & Wei, 2010). Improper design is also considered one of the most popular reasons behind delays and poor quality in construction projects (Sweis et al., 2008; Zidane & Andersen, 2018). Nevertheless, design in construction still includes high levels of variability in workflow due to poor planning of design activities (Bolviken et al., 2010; Hamzeh et al., 2009; Khan & Tzortzopoulos, 2015).

The traditional planning for construction design is usually based between the upper management and the client who regularly meet to define the objectives and deliverables without matching what should and what can be done and without considering if the designers can achieve these deliverables. Usually, the planning is done based on a master schedule and due dates. Meeting these dates through the definition of activities' duration is left to each design department to decide, which confirms the levels of fragmentation and the lack of collaboration in design. Moreover, performance measurement, in most cases, is neglected (Khan & Tzortzopoulos, 2015; Koskela et al., 1997).

Reduction of variability in planning, improving workflow, waste reduction, and value creation have been always seen as the principles of lean construction (Ballard, 2000; Koskela, 2000). Therefore, massive efforts have been done to improve the reliability of the planning and workflow in several phases of the construction projects by lean researchers and practitioners; and the best example here is the Last Planner® System (LPS) that was presented by Glenn Ballard (Ballard, 2000) and was successfully implemented in the planning for construction processes (Hamzeh et al., 2009; Koskenvesa & Koskela, 2012). Nevertheless, despite the importance of the design, the efforts to integrate lean practices in the planning for design are incomparable to those made in the construction phase.

USE OF LEAN TOOLS IN PLANNING FOR DESIGN

The above-mentioned problems that face traditional planning for design are similar to those cited by Ballard (2000) when he introduced LPS to improve planning and control of construction processes (i.e. Planning is understood based on the skills and talents of planners rather than being understood as a system, neglection of crew level planning and focusing only on a schedule, lack of constraints removal and matching between "should" and "can", and lack of performance indicators and learning process). Therefore, following the success of LPS and due to having similar problems in planning for construction and planning for the design, it is worthy to shed the light on the possible ways to integrate lean tools and LPS to improve the planning for design.

Hamzeh et al (2009) investigated the applicability of LPS in the design phase and presented the adjustments that can be presented to LPS to better suit the design activities. Kerosuo et al (2012) presented a case study about the use of LPS in the design of renovation in a school. The study showed that the design was completed on time and the communications were improved between the team due to the implementation of LPS. Rosas (2013) investigated the impact of the integration between design structure matrix (DSM) and LPS in design management. The study showed that this integration can improve the reliability of the planning and the identification of corrective actions by the team. Fundli and Dervland (2014) introduced an LPS-based method that is usable during the planning for the design activities and is called Collaborative Design Management (CDM). The presented method was helpful to improve communication, collaboration, understanding, and commitment in the design phase. Khan and Tzortzopoulos (2015) showed how weekly work planning was effective to improve workflow, reliability of

planning, and collaboration during the design of two building projects. Fosse and Ballard (2016) stated that LPS can help to improve quality and reduce design time and cost.

RESEARCH OBJECTIVES

The impact of lean tools on the planning of design activities is still overlooked in comparison to the efforts devoted to construction activities. Additionally, the last pandemic of COVID-19 affected the implementation of lean practices in general and planning activities and the last planner systems in particular. This is due to the measures that were taken to limit the spread of the virus, including social distancing, traveling reduction, and reducing the opportunities to organize meetings between the different projects' stakeholders. As a result, digital tools are more needed to connect different parties and stakeholders to achieve proper planning. The use of these tools while implementing lean construction can mitigate the impact of fragmentation, disseminate the lean culture, integrate different partners in the project, and decrease workload related to sticky notes management during the implementation of LPS (Hua & Schwartz, 2021; McHugh et al., 2021; Pedó et al., 2020; Salhab et al., 2021). Nevertheless, digitizing lean construction is still in its infancy and its acceptance of it still needs further investigation.

The current study, and through a presentation of two case studies that were conducted in France where lean construction is still not routinely practiced; especially in the design phase (Dakhli et al., 2017), aims to: Investigate the impact of lean tools adoption with support of digital tools to improve the planning for design activities.

RESEARCH METHODOLOGY

The study was based on three main phases: the first phase was conducting a preliminary survey that aimed to evaluate the current challenges and difficulties faced in the French construction sector based on the perspectives of different stakeholders in the sector. The second phase followed the analysis of the results of the preliminary survey and aimed to implement lean tools and practices in two projects in France, while the third phase aimed to investigate the perspectives of the participants in the two cases about the implemented tools and practices through a second survey. This section shows the development of the preliminary survey and its results as they were the guide for the discussions in the two cases, then it describes the two cases and the implementation of lean tools, and then it presents the second survey, whose results will be shown in the results section.

PRELIMINARY SURVEY

The first phase consists of the realization of a preliminary survey that was conducted as market research and developed to make a general understanding of the difficulties that face the different actors in the French construction industry. The development of the survey was using Google Forms and the survey was distributed by email to a list of 1,750 practitioners in the French construction industry representing different types of companies (contractors, owners, design and engineering offices, suppliers…etc.). The survey was developed to include six main parts with 23 questions. The questions covered the demographic profile of the participants, client's requirements and involvement, cost-related issues, time-related issues, methods of working, and current managerial practices.

The total number of participants in the survey was 260 participants; 29% of them were from general contracting companies, 25% were from project management offices, 13% were owner representatives, and 10% were from engineering studies offices. The

participants were working on different types of projects including real estate, residential, hotels, industrial, and commercial projects.

The key findings of the preliminary survey are as follows:

1. More than half of the participants believe that the clients' requirements and inputs are incomplete and these requirements and inputs are not stable and keep changing.
2. 35% of the participants believe that the client is not sufficiently involved in the development of the project.
3. 88% of the participants believe that sharing knowledge between project partners would contribute to problem-solving and 39% believe that it can increase profitability.
4. Around two-thirds of the participants believe that sharing success and financial gains between the partners of the project is difficult.
5. To face the different challenges facing the management of construction projects starting from the design phase, participants believe that the most effective measures are the use of a shared software or a platform between the partners (reported by 82% of the participants) and establishing a collaborative and integrated unit between different companies (reported by 77% of the participants).

The results of the preliminary survey confirmed that although collaboration between project stakeholders and client involvement is considered very important, especially in the design phase, participants considered this collaboration not easy to do. Accordingly, lean tools and LPS were adopted as it is evident that these tools are very useful to focus on client's needs and satisfaction and improve collaboration in projects (Al balkhy et al., 2021; Albalkhy & Sweis, 2021, 2022; Fundli & Drevland, 2014; Hamzeh et al., 2009). Additionally, as the majority of the participants believe that a shared platform in a way of software is a possible solution to improve collaboration, the decision to use digital tools to improve lean adoption was taken.

CASE STUDIES

Following the analysis of the results from the preliminary survey, the work focused on presenting lean practices in two case studies. The two cases were selected based on having similarities in the design duration and teams. In both cases, the client, main contractor, specific sub-contractors, architect, and engineering consultants were involved during the design phase. Therefore, it was possible to implement the same tools in both cases.

Case study 1-

The first case was an aquatic complex project built as part of the Paris 2024 Olympic games. This aquatic center offers a total surface area of 1588m², including a sports pool 21m wide and 33m long, an activity pool of 150m² free forms, a 70 m² free-form awareness pool, and a wellness area. The project met solid environmental requirements to reduce water and electricity consumption and reduce the carbon footprint in the construction and maintenance phases. The construction contract was a Build-operate-transfer (BOT) contract. BOT is a contractual relationship between a public owner and a contracting company that is responsible for providing the design, constructing the facility, and then operating it for some time before transferring the operations to the owner. The intervention to introduce lean practices in the project was between February 2021 and October 2021. Lean practices were implemented to improve the design management starting from the beginning of the conceptual design phase, then the preliminary design phase, until the detailed design phase.

Case study 2-

The second case study was 40 000m² office and business campus on 11 levels. The project is schematically constituted by three parallel buildings in the direction of the slope, drawing sloping valleys, like "scarifications" on the hillside. The project includes the following activities: Labor code building for the office areas, business center, common areas, parking, technical premises, one arena located on the ground floor, four shops located on the ground floor, one fitness area, and one wellness area, and one crèche. The project had to meet ambitions in terms of sustainable development facing future users and local partners. The project would also respond to local efforts led by the public authorities, particularly the Greater Paris Climate Plan. The contract was a private contract of the Guaranteed Maximum Price type (GMP). This type of contract includes a maximum price that can be paid by the owner to the contractor (unless having a formal agreement on scope change). If the project costs less than the GMP, the owner retains the savings or may have an agreement to share them with the contractor. The intervention on the project was from January 2019 to August 2021, covering the preliminary and detailed design.

Implemented practices and tools in the case studies

Following analyzing the results of the first survey, a team seminar was presented for the design and construction stakeholders. This seminar aimed to raise awareness about lean management in the construction industry and covered the following topics: sharing the vision of the project by all the participants (clients, architects, design, studies, contractor), reviewing the conditions of satisfaction of the project by the client, risks and opportunities for each stakeholder, and initiate the collaborative planning using LPS.

LPS was implemented in the design phase by planning the whole deliverables and levels starting from the master schedule to the daily meetings. To do so, a series of meetings had to be done to reach all partners in the design phase as follows:

1. General study steering meeting: this is a remote meeting. It enables the progress of the design to be monitored (indicators, tasks to be carried out, blocking points, decisions, customer feedback).
2. Weekly organization meeting: 30-minute telephone meeting to confirm everyone's commitment to the tasks to be done, the agenda for the general meeting, and the topics to be covered during the week.
3. Owner's meeting: monthly meeting allowing to fix the reviews of the decisions to be taken by the owner, the thoughts on the evolutions and modifications of the project, and the reviews of the specific expectations of the owner.
4. Internal meeting between the project manager and the company: this meeting is used to deal with technical issues that do not require the presence of the whole team.

Measuring performance and progress between the planned and the actual work and identifying the root causes for the variance in the performance are among the essential differences between LPS and other traditional planning and control practices. Therefore, to support the implementation of LPS, Key Performance Indicators (KPIs), which are quantifiable measures that are used to assess the actual performance, were developed and used in the two cases. The list of KPIs included the following (as shown in Figure 1):

KPI 1: is a general key performance indicator for the whole project management in the design phase that shows the percent plan complete (PPC) for the project and was depicted as two curves; one is for the planned work and the other is for the actual finished work. **KPI 2**: was used to assess the involvement of partners in the meetings by presenting the present rates in each meeting. **KPI 3**: was to monitor the needed inputs from the client.

This KPI was digitally controlled by a vertical histogram bar showing the weekly number of client input data, and their status (to be received, late, received). **KPI 4**: was to track the completion of weekly tasks per stakeholders. It shows the status of the different number of tasks assigned for each stakeholder involved in this phase of the project (Architect, Company, Steering, Owner), the other status of each task shown in the bar of the histogram are: To do, in progress, late and done. **KPI 5**: was to show the overall number of tasks to be processed in the project design. **KPI 6**: This was used to show the consolidation number of changes and the sources of the changes. In addition, two other KPIs were used to show the progress in documentation production; one KPI was used to show PPC for the planned delivered documents by each employee involved in the studying phase in both projects. While the other shows the needed number of days required by each employee to deliver the remaining deliverables.

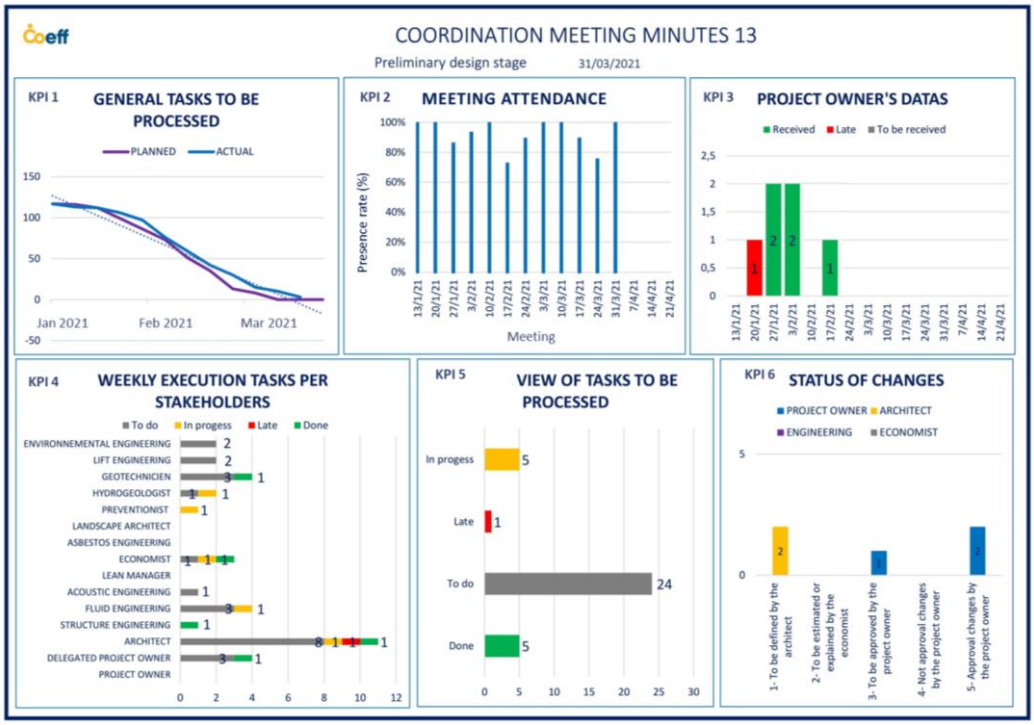

Figure 1. Key Performance Indicators (KPIs)

In addition to LPS, Visual Management (VM) and the KANBAN board were used in the two cases to manage and track the design of the two projects, visually present the progress of the work, and support the involvement of all employees in the work. VM is a lean tool that is based on the use of signs and posts, in a physical or virtual environment, to pass specific instructions to people in the project. In turn, KANBAN is one of the most important lean tools that is based on the use of inventory cards or signs to manage the flow of information (and materials on-site), monitor the progress, improve decision-making, and enhance communication and knowledge management and sharing in the project. Figure 2 shows the used digital KANBAN boards in the two cases. The Figure shows the classification of different tasks in the design phase to improve the monitoring of these tasks and the identification of actions to be taken.

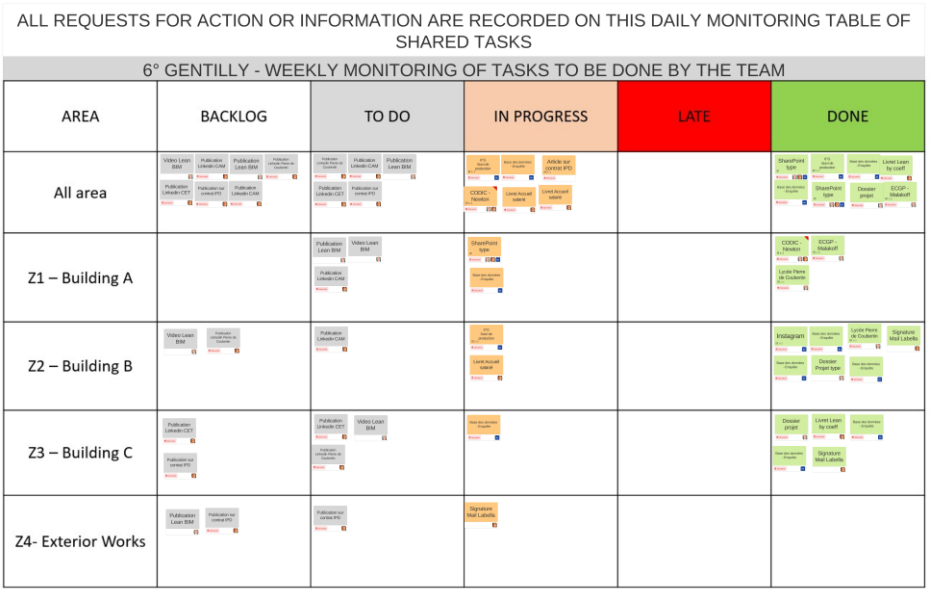

Figure 2. KANBAN Boards

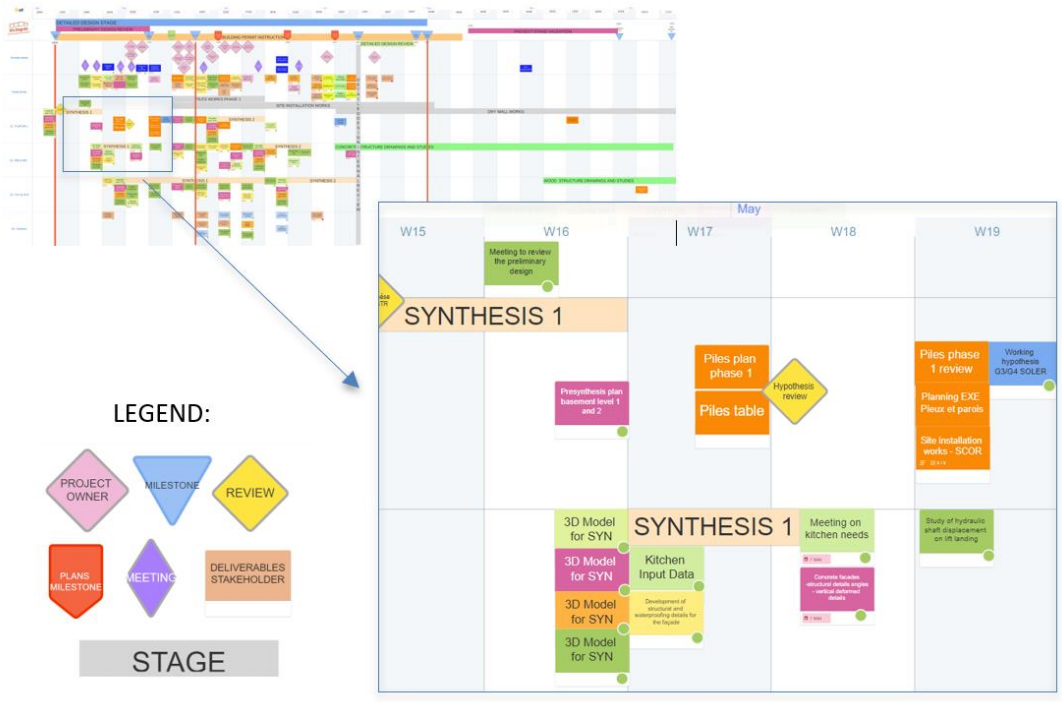

Figure 3. Use of digital tool "iObeya" to deliver the planning for design tasks

The integration of lean and digital tools was done through the whole design phase. In addition to the use of building information modeling (BIM) and digital meeting platforms to conduct online meetings between different partners, a digital space for sharing project information was established. This space served as a room for all managers, leaders, and employees to share their ideas, collaborate, and ask questions. This space was based on two main tools:

1. "iObeya": a virtual collaboration platform that is based on the Obeya method, which is based on establishing a room for project partners designed to improve communication, collaboration, and decision-making. The use of the Obeya method

is helpful to track the progress, discuss the design, and engage different stakeholders in the discussions. For the two studied cases, "iObeya" included panels for LPS and KANBAN. Figure 2 shows an example of the use of "iObeya" in the planning for the design tasks. The figure depicts how partners were able to use notes and stickers during the implementation of LPS.

2. "SharePoint", which is a collaborative document-sharing platform. In this platform, partners were able to access all project information including project information and organization, details about meetings, weekly tasks, progress toward KPIs and milestones, requests for order and information, and reports and drawings, in addition to links to emails, shared calendar, and "iObeya" room.

THE SECOND SURVEY

To assess the impact of lean implementation and the effectiveness of the used tools in the two cases, a second survey was developed. The survey was developed using Microsoft forms and distributed to the emails of 37 stakeholders who participated in the design phase of the projects. The survey included five main sections, which are:

1. The role of participants
2. The created impact in the two projects due to the implementation of lean practices in planning for the design tasks (four point-Likert scale: 1) strongly disagree, 2) disagree, 3) agree, 4) strongly agree)
3. The contribution of the tools used to improve the planning for design activities (yes/no questions)
4. The benefits of lean implementation in the design phase (yes/no questions)
5. Readiness to implement lean management again (yes/no question)

RESULTS AND ANALYSIS

The second survey was filled by 25 participants, representing a response rate of 68%. The participants were from engineering studies and design office (9 participants), architectural office (5 participants), owner representatives (5 participants), general contractor (3 participants), in addition to three participants who were working as BIM manager, landscape manager, an employee in the control office.

Table 1. Created Impact in the two projects due to lean implementation

Lean Implementation Impact	Overall	Case 1	Case 2
Better consideration of customer expectations	3,30	3,28	3,31
Better responsiveness to integrate project changes	3,25	3,00	3,37
Compliance with work costs	2,64	2,67	2,64
Compliance with study deadlines	3,48	3,22	3,64
Improved working and collaboration conditions	3,36	3,00	3,47
Improved design brief quality and consistency	3,36	3,37	3,36
Better preparation for the works phase	2,89	2,80	2,91

The analysis of the results revealed that participants in the study believe that the use of lean tools in the planning for design tasks helped to present different outcomes (as shown in Table 1). The highest impact was found on the compliance with the study deadline (mean= 3.48 out of 4.00), which was the second most challenge found in the first survey. While the lowest impact was on compliance with cost, which was the most difficult challenge found in the first survey. Nevertheless, the rate is still acceptable as the mean equals 2.64 out of 4.00 (66%). Participants also give high and approximately

similar rankings to improved design brief quality and consistency improved working and collaboration conditions (mean= 3.36), Improved design brief quality and consistency (mean= 3.33), better consideration of customer expectations (mean=3.30), and better responsiveness to integrate project changes (mean= 3.25). In comparison between the perspectives of the participants from the two projects regarding the impact of lean implementation, the analysis showed similar rankings for most statements with slightly higher ratings in the second case for the responsiveness to integrate project changes, compliance with the deadline, and improved working and collaboration conditions.

Regarding the benefits of lean implementation in the planning for the design phase. Figure 4 shows that most participants agreed that lean can help to organize the design smoothly, improve the efficiency of the planning, understand and share the objectives and expectations of the client, improve the collaborative environment between all stakeholders, and improve the decision-making process and validate the study effectively.

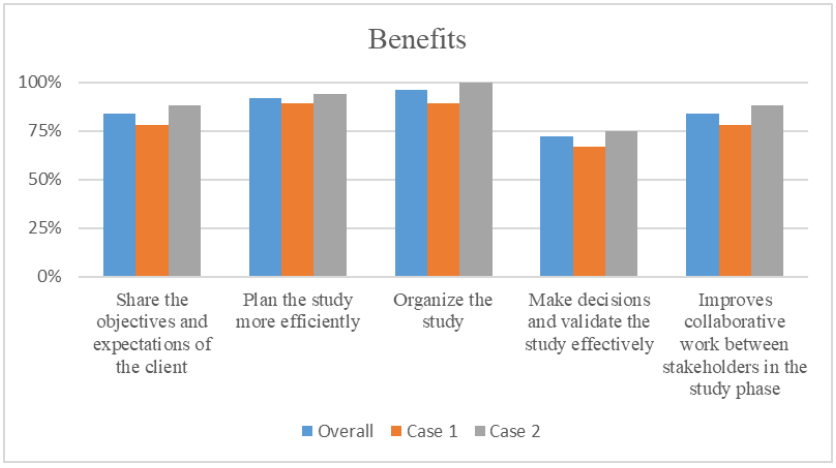

Figure 4. Perspectives about the benefits of lean implementation in the design phase

Regarding the contribution of the tools used to improve the efficiency of the planning for the design, the highest-ranking was for the meetings organized to conduct the planning; all the participants in the survey stated that these meetings were effective to improve the planning for the design. The meetings with the owner and phase planning that was done during the seminar received the second-highest rating (88% and 86% respectively). The implementation of digital tools (Sharepoint – iObeya) was considered effective to improve the planning efficiency by 16 participants (64%). While the lowest ranking was surprisingly for scheduling delivery of BIM models based on studies (48%) and establishment of production indicators (52%).

DISCUSSION

The purpose of this study is to investigate the impact of the use of lean tools during the planning of design activities. The main used tools in the cases are LPS, KANBAN boards, and visual management. The results showed that most participants in this study believed that the adoption of these tools is helpful to deliver the design on time, meet customers' expectations, improve the quality of the design, and achieving better collaboration between the team members. The results of this study are consistent with the studies about the applicability of lean tools in design management (Fosse & Ballard, 2016; Fundli & Drevland, 2014; Hamzeh et al., 2009; Kerosuo et al., 2012; Khan & Tzortzopoulos, 2015; Rosas, 2013). Additionally, it was noticed that the use of KANBAN boards improved

the knowledge sharing, transparency, and decision-making during the design phase as it helps to improve information flow, focus on the priorities and pull the design to be consistent with the needs instead of pushing the design to finish based on predetermined deadlines. This result supports the finding of Modrich and Cousins (2017) who stated the combination of LPS and KANBAN is necessary to improve the design management. This combination was supported in the two cases by visual management, which helped to ensure better workflow and knowledge sharing among the partners.

Moreover, the results of the study showed that digitizing the used lean tools was effective in the design phase. The used digital tools helped to keep the partners connected with each other's and improved the collaboration environment, communication, and transparency between the partner. Additionally, these tools served as an easily-accessible reference that included information about the plans and progress in the projects. This was very helpful especially during the times of the lockdown due to the COVID-19 pandemic. The ranking for these tools was even higher than that given to BIM. This might be because the partners had already some knowledge about BIM, while lean and digital tools were newly presented to them.

Finally, during the analysis of the results, a slightly higher ranking for the impact and benefits of lean was given in the second case study. While this difference was not investigated during the conduction of the study, the authors believe that the duration of the intervention might be the reason for the difference. This is due to two reasons; firstly, the needed time to build a culture of lean and see the impact of lean adoption (Albalkhy and Sweis, 2021), and secondly, the impact of COVID-19 as in this project, participants were able to be exposed to the use of lean before and after the pandemic and noticed how lean can improve managing the design during uncertainty times.

CONCLUSION

Design is the first phase in construction projects. The deliverables of this phase should clearly and accurately reflect the client's needs and requirements to ensure that these needs are met along the whole project life cycle. Therefore, the planning for design to ensure the success of this phase is essential as it defines the objective, deliverables, and success criteria and the steps that are needed to achieve success. This study shows that lean implementation can be a key to the success of the design due to its role in improving the planning for the activities in this phase.

The current study was conducted during the time of the COVID-19 pandemic, which has affected all practices in all industries. Nevertheless, during the work in this study, all measures were followed and the levels of digitization increased to adapt to the new situation. Therefore, this study does not only serve as a good example of the applicability of lean tools in construction design management but also contributes to the provided solution about lean digitization and lean implementation during times of uncertainty. Moreover, this study used quantitative data collected from participants in two case studies to show the impact of lean and digital tools on the planning process; future studies can use other types of data collection methods such as interviews or focus groups. In addition, future studies can use thorough and detailed indices to assess some variables such as trust, communication, decision-making process, knowledge sharing, and other variables. Moreover, future studies can cover the integration of lean and other digital practices and tools in design management such as cloud computing, artificial intelligence, and big data analytics.

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