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LEAN SUPPORTING A FRAMEWORK FOR THE CONSTRUCTION INNOVATION PROCESS

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ABSTRACT

The construction sector has gradually been restructuring to advance the use of digitalization and taking advantage of Industry 4.0. Recent studies in the IGLC Community have emphasized the need to connect Lean Construction with the innovative movement by promoting and advancing the use of Industry 4.0 technologies. However, it is well known that innovation approaches are successful when they achieve the goal of problem solving. Considering this context two questions are set: (a) Does the innovation process in construction sector understand how to capture pain-points of the industry and in how it organizes itself? (b) Does Lean Construction contribute by offering a conceptual basis for reaching a better understanding of innovation? This paper aims to develop a framework for analyzing and catching the pain-points as the starting point for the innovation process. As a result, a Problem-space-framework (PSF) was proposed and validated in a empirical study. The first question was tackled by conducting a qualitative analysis and holding a workshop, the outcome of which was that eight out of 98 pain-points identified were prioritized towards the solution design. The second question was also fully answered identifying that 89% of the participants understood that Lean Construction contributed to the PSF and most of Lean tools proposed were regarded as having high usability during the implementation phases.

KEYWORDS

Lean construction, innovation, pain-points, problem-space-framework

INTRODUCTION

Throughout history, humans have managed to innovate and evolve different industrial solutions, to improve their labor processes but also, and, to a greater extent, their wellbeing (Noueihed, K., Hamzeh, F., 2022). Considering that innovation is needed in industry to enable a better quality of life, we may also say that innovation in a business environment defines the organization's ability to create and achieve competitive advantages that can generate a range of sustainable opportunities (Aranha, 2016). According to Audy and Piqué (2016), society now has a strong base that is founded on the knowledge of highly qualified professionals and teams, in addition to which this is reinforced by new technologies having been developed and mastered. These factors give society a new characteristic which focuses on knowledge and innovation.

An analysis of the construction industry shows that it configures an important pillar of the economy in many countries since it contributes greatly to GDP and is a major employer. However, construction is perceived as a sector that lags behind other industries with regard to innovation (Wang et al., 2021). A plethora of studies regarding many countries acknowledges that construction falls behind other industrial sectors in relation to improving productivity

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(Vrijhoef and Koskela, 2000, Kapelko et al., 2015, Zhan et al., 2018). Productivity in the construction industry is still described as having scarcely evolved, being nearly stagnant in the last 20 years and there having been a low rate of investments in digitalization and innovation (Mckinsey, 2017). However, the characteristics of the ecosystem of construction can pose several obstacles to innovation. These include the temporary nature of the relationships in construction projects, which hampers the exchange of knowledge and building trust between different parties (Greco et al. 2021) or due to construction having special operational characteristics, namely it is project-based, resource-intense and risk-related (Wang et al. 2021).

Given the above context, the next section of the article will undertake a panoramic review of the literature, considering the characteristics and main positions of the innovation process in the construction industry and its interfaces with Lean Construction. A gap in the literature and in knowledge is identified with regard to there not having been, hitherto, a structured process for identifying pain-points in the construction sector for innovation processes integrated with Lean Construction concepts and tools.

Therefore, this paper identifies an opportunity for developing practical proposals for guiding and implementing the innovation process in the civil construction value chain. The general objective of this paper is to develop a framework to analyze and capture pain-points as the starting point for initiating an innovation process in construction companies. To do so, two questions are set: (a) Does the innovation process in the construction sector understand how to capture pain-points of the industry in principle, and also, in practice, within a given company? (b) Does Lean Construction contribute by offering a conceptual basis for understanding innovation?

LITERATURE REVIEW

Lindgren and Emmitt (2017) state that technological innovation in construction depends on and involves a broad and complex network of stakeholders, from customers to product manufacturers and designers, contractors and end users. In addition, there is the relationship with governments and direct action with society to be considered. Seeking to identify these multiple relationships between stakeholders, Xue et al. (2017) and Larsen (2015) view the relationships of the innovation process as collaborative relationship networks and highlight the key roles that some parties play in the innovation process. The decomposition of collaborative relationships together with network analysis allowed a better understanding of the innovation process in construction. In particular, this enabled the so-called “real problems” that support the definitions of greatest impact regarding innovation to be identified (Xue et al., 2017). Taylor et al. (2006) had already concluded that, only by having organized and interdependent processes would significant performance improvements in innovation be achieved in the construction industry.

On the other hand, the focus of innovation research has tended to concentrate largely on traditional and hierarchical industries. When project-based industries are included in innovation studies, analyses rarely explore the implications for the organizational structure nor the specific characteristics of these industries with regard to the spread of innovation. Hopkins et al. (2011) suggested that project-based organizations are inherently more open than other organizations, and their efficiency comes from economies of the system, rather than from economies of scale. Hence, the paucity of studies on project-based industries and the Innovation Process is surprising.

Multiple authors have studied innovation in construction in terms of the product, new materials, building systems and design tools (Azhar, 2011). Their studies show that most companies generate innovative products and processes; however, they have difficulty in carrying out continuous and structured innovations (Pellicer et al., 2017). Viewing innovation as an organizational process, some studies in recent years have focused on the interrelationship

between the various players and stakeholders. Network-based, inter-organizational arrangements emerged as new means to facilitate the development and spread of innovation within the construction industry (Keast; Hampson, 2007). According to Pellicer et al. (2017), innovation in companies in the construction sector needs to stop being a spontaneous act that only arises when the solution of a specific problem is found, and to become a systematized management process integrated with the development of knowledge. Larsen (2015) indicates the importance of building an integrated and flexible innovation network into a continuous process of developing solutions and knowledge where good practices can be used collaboratively (Pellicer et al., 2017, Larsen, 2015).

Recently, Hamzeh, et al. (2021) suggested an important topic considering innovation and technology. Even with the arrival of the "fourth industrial revolution" or Industry 4.0, the attempts of research to acknowledge the influence of Industry 4.0 on the architecture-engineering-construction (AEC) industry, have been primarily on technology. Some studies point out that Lean Construction has become a major tool for learning, collaboration and for sparking an environment of innovation. A survey developed by Trentim and Etges (2021) identified that 92.6% of their respondents understood that implementing Lean Construction supported the development of knowledge and critical analysis of problems and solutions. Christensen and Christensen (2010) Zhang and Chen (2016), Tyagi et al. (2015) and Skinnarland and Yndesdal (2012) have similarly demonstrated that projects that implement Lean Construction (LC) have huge potential for generating knowledge and are fertile areas for collaborating due to LC's characteristic of creating interdisciplinary and collaborative innovation. Taggart et al. (2014) argued that, when a collaborative and proactive environment is provided to supply chain partners, the root causes of defects are more likely to be identified leading to cost-effective solutions being proposed (Greco et al. 2021). Hamzeh et al. (2021) highlighted the need to connect LC with this new innovative movement by introducing Lean Construction 4.0 principles into established practices so as to keep pace with the advancing technologies of Industry 4.0.

In the current paper, we will seek to understand how "real problems" can connect with innovation in different construction phases, given a LC background, collaboration and technology (Hamzeh et al., 2021, Xue et al, 2017, Azhar, 2011, Taggart et al., 2014).

RESEARCH METHOD

The current paper is part of a broader research activity for a doctoral thesis by the first author. The stage described in this article covers the validation of the first construct within a broader methodological approach of Design Science Research (DSR). This paper was undertaken in 3 stages divided into two phases, as illustrated in Figure 1. The first phase took a broad view of the construction market in relation to innovation on the way to support the questions set. The second phase (which includes stages A and B) is a an empirical study developed in a construction company within the Brazilian real estate market.

The first phase consisted of determining how specialists in the sector understand the innovation process in the Brazilian construction sector. Hence, a qualitative study was engaged on which drew on the experiences and opinions of a group of professionals. The technique adopted was an open individual interview, using a semi-structured script. As to the method used, it took a qualitative approach. A group of professionals was invited to take part, in order to have additional opinions and content about the object of study. The distribution of interviews was planned in order to obtain a balance between the number of respondents in each segment of innovation, thereby seeking to ensure a diversity of responses, which is desirable in qualitative studies (VOSS et al., 2002).

Since this paper focuses on validating the first construct of a DSR, it is important to note that one limitation of the second phase is that it was conducted with a company that already has experience with Lean Construction methodologies. Based on the results obtained in Phase 1, Phase 2 aims to develop a model for implementing the innovation process in a civil construction company. Stage A of phase 2 seeks to develop a model for structuring the performance of the innovation process in order to allow for greater efficiency and to capture value due innovation. This step was based on the conceptual model of the Double Diamond (Design Council, 2016). The case study company has a corporate innovation strategy and has already been involved in a broad Lean Construction implementation project. Last year, it defined its objective as being to centralize its investments in improvements by strengthening the innovation process.

The Double Diamond model was proposed by the British Design Organization in 2005. The model emphasizes the analysis of a problem as the basis for building 4-phase solutions using two adjacent diamonds. The two diamonds are (i) the problem and (ii) solution spaces. In each space, a diverging phase that expands the space is followed by a converging phase that narrows the space (Zhang et al. 2019)

Finally, Stage B of Phase 2 seeks to understand if Lean Construction favors innovation. Thus, the third stage of the research aims to answer the second question by applying a questionnaire to those involved in Stage A, in order to capture perceptions and map possible benefits of or weaknesses in integrating Lean Construction into the innovation process.

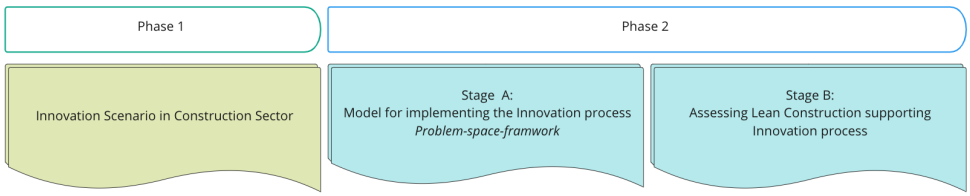

Figure 1: Structure of the Paper

RESULTS

IDENTIFICATION OF THE SCENARIO OF INNOVATION IN CIVIL CONSTRUCTION

The group of professionals chosen by the researcher was formed in order to elicit and add opinions and content about the object of study. Numerical representativeness is not the main focus, but it was considered important to have a diversity of respondents. By consisting of accelerator managers, innovation specialists and startup directors, the sample population is more likely to succeed in identifying gaps, generating insights and forming hypotheses. Thus, by adopting a qualitative approach, it is possible to explore the object of research in depth, because one can understand the cause-and-effect relationships and can seek ideas and new hypotheses (RIBEIRO and MILAN, 2004).

The interviewees were selected by the researcher who sought companies and professionals involved in the civil construction and engineering sectors, in innovation processes and who had taken part in founding startups in the sector. Eight interviewees were selected: (i) Two specialists in implementing innovation projects in engineering-based industries; (ii) Two managers of acceleration and open innovation programs, focused on the civil construction sector - the programs were selected considering that both had already concluded at least one complete cycle of acceleration; and (iii) Four Chief Executive Officers and founders of startups which have undergone at least one acceleration cycle and are already in the market operation phase. Choosing a startup was based on three criteria (a) it must be from the civil construction sector, (b) it already has a product, a Minimum Viable Product that has been validated, tested and is in the market phase, (c) it has undergone at least one full acceleration cycle.

The interviews were conducted, resulting in 6 hours of recordings. These recordings were transcribed into a text editor and compared to the notes of main topic notes made by the researcher during the interviews. After being transcribed, the interviews were prepared for analysis. Each of them was grouped according to the sequence of questions asked by the researcher using content analysis using the NVivo sotware

When questioning the interviewees about the perception of the innovation movement in Brazil, they all answered that it is a growing movement, but only one of the interviewees was openly optimistic: “I perceive that the movement has been gaining a lot of strength, but it seems to me that the people inserted (in startups, in companies and investors) are lost and so are the needs of the sector”. Five of the interviewees stated that it is up to companies and startups to better understand the pain-points of the sector to bring solutions that can add greater value to organizations: “The launch of a company as a result of a problem experienced, in my experience, is 50% of the success. Finding the problem is key to thinking about a solution.”

At the same time, six of the eight interviewees expressed apprehension regarding a certain trivialization of innovation and the loss of credibility of the proposed initiatives and solutions: “We are at a time when everyone has access to low-quality information, and therefore, there is much focus on "we need to innovate", "we need technology" without thinking about the real problem [...] There are solutions that generate zero value for the market. Not generating value compromises the fundamental objective of innovation processes. I fear the topic will become another "buzz-word" in the market. We must protect the innovation topic!”. Figure 2 shows the result collected from the content analysis of the interviews. All interviewees identify investments in innovation and the structuring of innovation processes in the construction sector are a growing movement, but they also associate the current situation with a certain pessimism. A large part of this sensation is due to the perception of the sector's difficulty in directing innovation actions and investments at the real problems and pain-points (six out of eight interviewees), which for also leads to the loss of credibility of innovation in the sector.

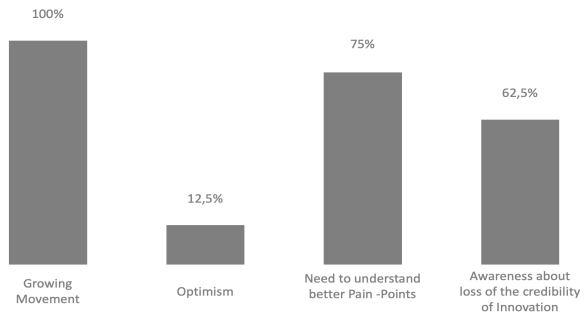

Figure 2: Perception of innovation in Brazil

Content analysis identified three main directions: (i) the movement towards innovation and access to new technologies is growing in the construction sector. However, (ii) there is a divergence between the interviewees about their perception of the value delivered by innovation initiatives and (iii) there is difficulty in measuring the results and impacts provided by implementing innovation in the construction sector.

Considering the above, two aspects can be raised that have an impact on the credibility and results of the solutions implemented in the proposed innovation processes analyzed. First, the gap in identifying the real pain-points or problems of the sector can make it difficult to understand what the innovation is (XUE et al., 2017, TAYLOR et al., 2006); second, the lack of definition of follow-up metrics and of a clear zero line distort, or make it impossible to understand, the result obtained.

MODEL TO IMPLEMENT THE INNOVATION PROCESS IN CONSTRUCTION SECTOR

The conceptual reference for the structure of the Workshop was that of the Double Diamond Framework. In the stage covered by this study, we are working on the first cycle of the diagram named Problem Space, seeking to Discover the problems and Define the actions. Figure 3 shows the association of the steps described with the Double Diamond Model.

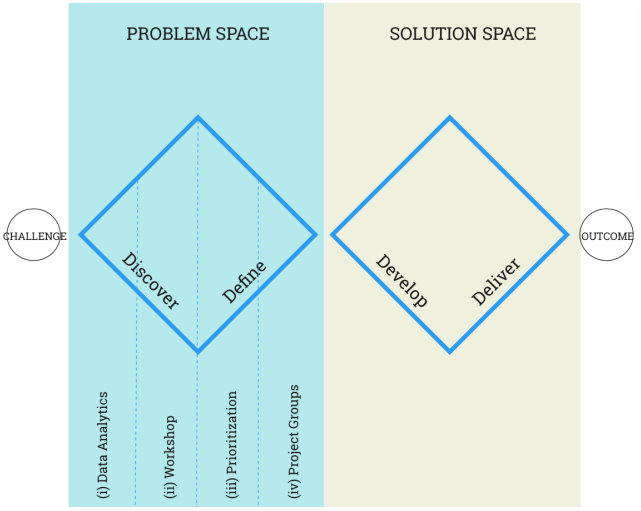

Figure 3: Double Diamond Framework adapted to the current research - Problem-space-framework (PSF)

Having obtained results from qualitative research conducted with specialists in the sector's innovation process, and having added these to the perception of a large-scale developer company in the Brazilian housing market, phase 2 of this study then set out to develop a model for guiding the innovation process of the company. To define this model, the current stage was divided into 4 sub-stages: (i) Preparation, carried out by collecting data and interviewing company representatives; (ii) Development and implementation of a model of a workshop on validating Pain-points; (iii) Prioritization of classification; and (iv) structuring of project teams to direct solutions to the Pain-points identified. For the first sub-stage, we made a comprehensive analysis of the company's budget, costs, and the performance of its supply chain. This involved a thorough examination of factors such as costs, savings, and construction terms. We also conducted open interviews with a group of site engineers and managers to gain a better understanding of the company's current situation.".

It should be noted that the company in the empirical study, which in this article is called Company A, has been investing for two years in a wide-ranging Lean Construction implementation project, a project that has already reached more than 150 construction sites. This consideration is important, as most of the leaders involved in this stage already participate in the Lean Construction project and are familiar with process design tools, how to identify causes and problem solving.

Company A has always held a prominent place in terms of innovation in the Brazilian Civil Construction market, featuring in important national awards (those given by the Brazilian sectorial journals); however, the team from the Innovation in Production sector has become aware of the difficulty of understanding, mapping and consolidating results of the multiple initiatives that were conducted. In addition, planning for the year 2023 required assertive investment planning in initiatives that addressed the company's real problems and pain-points. In numbers, the present situation covers 89 projects at some stage of implementation and with different levels of expected result and necessary investment, but without a clear governance to accompany them. Of this total of projects, 49 started from initiatives promoted by the Lean Construction project in the construction works. Nevertheless, their results have not been

managed nor have the results and lessons learned from acting on these initiatives been disseminated throughout the company.

Considering the context described, we first sought to understand the main problems of Company A based on data analysis (Data Analytics) and interactions with the company's Production team. It is important to mention that the company has a large source of consolidated information in Data Analytics and Business Intelligence in Microsoft Power BI and a specific sector that guides the business strategy and compiles and publishes indicators of the productive processes. At the same time, a questionnaire was sent via Google Forms to those involved in the production process. 42 responses were obtained, 6 from directors, 11 from managers, 5 from engineers, 3 from Backoffice consultants and 17 from Lean Construction project consultants. As a way to ensure more managers listen to what kinds of problem occur during production, two online workshops were held attended by 15 engineers from the company. They listened to and discussed openly the main problems that impact their production activities. As output from these three sources of evidence, five pain-points were addressed: i) Quality of budgeting; (ii) Site productivity; (iii) Management of metal forms; (iv) Excessive bureaucracy for services and materials supply chain; (v) Terms in design and construction phases. Regarding the strategic position of the data for Company A, the pain-points could not be detailed in the current paper for reasons of confidentiality

This base of pain-points identified was presented and made available as a reference for the leaders group that was elected to participate in the 1st Workshop on Innovation in Production. 30 leaders (directors, managers and engineers) and 6 moderators participated in an immersive and face-to-face workshop held to reach a more detailed understanding of the production Pain-points of Company A in order to structure innovation project plans for 2023. The one-day Workshop was structured as per the sequence below. The outputs are shown in Table 1:

(i) Pain-points brainstorming: based on the previous analysis of the data, the participants were divided into 5 working groups and by using mind maps or brainstorming dynamics they discovered the pain-points that they identified that impact production. In this stage, the groups mapped 98 pain-points;

(ii) Prioritization of pain-points: in the second stage, the groups were asked to prioritize pain-points using an effort versus impact matrix. 26 pain-points were listed;

(iii) Design-sprint for prioritizing pain-points: Each group took the pain-points prioritized in a table that was divided into 10 themes corresponding to Company A's enterprise cycle. which for them were the ones that had the most impact on production. 8 pain-points were prioritized;

(iv) Linking projects in progress to the pain-points mapped: In the end, the 89 projects at some level of development and already distributed in the 10 themes of the company were made available to the groups The working groups then linked these projects to prioritized pain-points. Of the 89 initial solutions, it was found that 35 would address prioritized pain-points.

The third phase of structuring the innovation process consisted of analyzing prioritized outputs and understanding whether the projects really address the pain-points and which projects will be selected for the 2023 strategy. To do so, a senior management group was formed consisting of the Vice-President of the company, 5 directors and the Innovation team. The post-workshop stages first of all positioned the pain-points and solutions in the progress of the development project, from business planning and real estate development, through the pre-work stages and execution of the construction work, to the delivery and post-delivery technical assistance. A critical analysis of the 35 listed solutions was made to determine the degree to which they actually solve pain-points. Of these, 28 solutions can address 7 listed pain-points satisfactorily.

Table 1: PSF Workshop outputs

Phase	Mapped Pain-points	Linked Solutions
Pre-Workshop	5 Main Pain-points discovered	
Brainstorming to identify Pain-points	98 Mapped Pain-points	89 Projects
Matrix Prioritization	26 Prioritized Pain-points	
Design Sprint	8 Selected Pain-points	35 Potential Projects
Senior management group Analysis	7 Prioritized Pain-points	28 Potential Projects 4 working groups

Finally, senior managers deliberated on the progress of the undertaking, the pain-points identified and the related solutions. Of the eight pain-points identified in the Workshop, seven were prioritized by the senior managers. (1) and (2) are related with commercial strategy, (3) and (4) are related with budget information and accuracy; (5) is related with labor turnover; (6) concerns the planning and construction terms and (7) the effort and bureaucracy needed to control costs and monitor productivity. These seven pain-points were classified into 4 categories and addressed to 4 specific working groups.

It is important to note that there is a convergence of seven prioritized pain-points with those identified in the first stage of Discovery by consulting the analysis and data collection from Company A. Three of the five pain-points identified during the Pre-Workshop phase were maintained and attested to during the Problem Space (Data Analytics, Workshop, Prioritizing and Project Groups): Quality of budgeting, Site productivity and Terms in design and construction phases are still in the final seven main pain-points. The second stage of the Diamond, the Solution Space, is the subject of the next steps of this research.

INTERFACE OF THE INNOVATION STRATEGY WITH LEAN CONSTRUCTION

To meet the second specific objective, this section summarizes the analysis of a survey regarding the perception of possible contributions of Lean Construction in the innovation process. As a first output, 49 of 89 projects were identified with Lean Construction and possible solutions in progress came from approaches of operational improvements catalyzed by the Lean Construction Project, which shows the relevance of the philosophy applied. In the second moment, the participants were invited to fill out an online survey form in order to evaluate in the first stage the level of involvement in the Lean Construction project and then to evaluate to what extent Lean contributes to the participation, knowledge of tools and approaches proposed in the Innovation Workshops

The Form was sent to all participants of the Innovation in Production Workshop or any of its working groups. We had received 26 responses and among the respondents, 18 (69%) had also taken part in the Lean Construction implementation project. For these 18, the Form led them to a specific section with the aim of evaluating the Lean Construction project and its relationship with the Innovation Workshop. In the first question, 14 participants said that they had a high (44%) or very high (33%) level of involvement in the Lean Construction implementation project and assessed their knowledge of Lean as high (39%) or very high (33%).

In the question "In your opinion, how much did Lean Construction contribute to the development of Innovation in Production projects?" 16 participants (89%) answered that Lean's contribution to the Innovation Workshops was high (39%) or very high (50%).

In the third section of the Form, where all the participants responded, the aim was to evaluate their perceptions regarding the format, model, and methodology used in the Innovation in Workshop. The first question was to evaluate the Workshop. The answers were categorized as:

- Methodology, where 69% responded “Very Good” and 31% “Good”;
- Tools presented, where 81% responded “Very Good” and 19% “Good”;
- Moderation, where 69% responded “Very Good” and 31% “Good”;
- None of the dimensions were evaluated by the participants as "Bad" nor did any participant respond that he/she was "Indifferent" towards a dimension.

The answers to the question "How do you evaluate your ability to use the tools proposed in the Innovation in Production Workshop?" are presented in Figure 5. Note that the 5 Whys and Problem-Solution Fit Canvas tools are the ones that were best evaluated i.e., the participant stated that his/her skill in using these tools was high. And the Cause and Effect Diagram and the 5 Whys are the ones which 95% of the participants demonstrated that their skill in using them was average or high. It can be seen that these are tools that interact very well with Lean and indirectly this may have influenced participants to consider they had mastered using them.

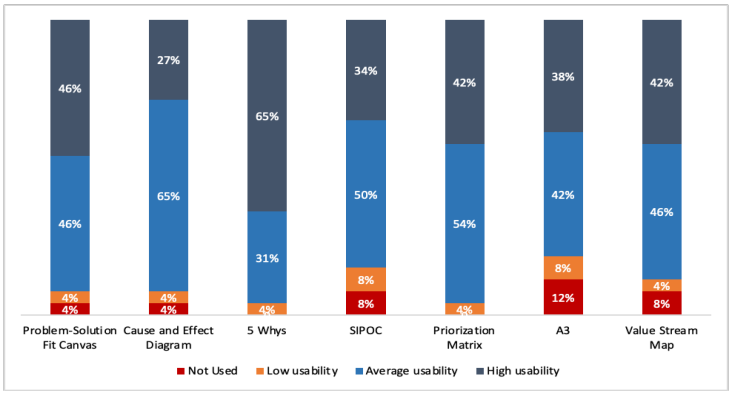

Figure 5: Usage of tools proposed in the Innovation Workshop

DISCUSSION AND CONCLUSIONS

Considering the main objective of this paper is to develop a framework to analyze and identify the pain-points as the starting point for the innovation process in construction companies, this objective was met. This was achieved by developing a model based on the Double Diamond that allowed Company A, in the case study, to direct its approach to a solution by basing it on a deeper understanding of the problem and of the pain-points of its processes and of the market in which it operates. The PSF presented seeks to deepen the understanding of pains by undertaking the steps of (i) conducting data analytics and promoting a collaborative understanding of identifying and mapping pains and by (ii) mounting a collaborative workshop. In the second dimension of the first diamond, we sought to define the focus problem through approaches of (iii) prioritization and (iv) definition of project groups and a work Roadmap. As already mentioned in the literature review, it is only by conducting organized and interdependent processes that significant improvements in performance due to innovation can be achieved in the construction industry and thereby enable the so-called “real problems” to be identified that support the definitions of greatest impact regarding innovation (Taylor et al.,2006; Xue et al., 2017). By providing a comprehensive understanding of pain-points and aligning them with a series of multi-collaborative workshop phases, the Framework focused on the Problem-space offers an innovative approach to the innovation process in the construction industry. This approach not only allows teams to address the real cause of problems more effectively, but also fosters a culture of collaboration and innovation that can drive long-term

success. Figure 3 illustrates the PSF developed and validated in the case study. As results of applying the PSF, we have prioritized 98 pain-points and thereby reduced the number of main pain-points to 8 which will be directed as leverage for designing a solution.

The first research question was validated using qualitative analysis with interviews of experts, which showed that the construction industry is at risk of losing the benefits of its innovation processes and investments due to a lack of directing itself towards the pain points and problems of the sector. A lack of understanding of these pain points makes it difficult to measure and perceive the value of improvements made due to innovative initiatives. The use of discourse analysis revealed that this observation was the view of six out of the eight experts consulted.

Regarding the second research question, it was validated by the participants' perceptions during the Workshops and the proposed PSF that Lean Construction plays a significant role as a conceptual foundation and collaboration environment for fostering innovation. The results showed that 89% of the participants understood acknowledged that the Lean Construction project contributed to the Innovation Workshop, and 46% of them recognized that participating in Lean Construction routines was an effective way to prepare their teams for the Innovation Workshop. Furthermore, the participants evaluated all the tools used in Lean Construction routines as having a high or medium level of usability, with the 5 Whys and the Problem-Solution Fit Canvas standing out with 65% and 46% respectively of participants regarding them as having high usability.

It is worth emphasizing that the themes prioritized during the workshop phases are interconnected and cover the entire life cycle of construction projects, from commercial strategy to construction control. This holistic approach considers key aspects such as project design, budgeting, planning, and productivity in the field, and it recognizes the cause-and-effect relationship between decisions made in the early stages and their impact on construction sites. By taking this comprehensive view, teams are able to identify pain-points and develop effective solutions that drive long-term success.

Finally, while this study is part of a broader research effort and represents the initial exploration of a DSR approach, we can affirm the effectiveness of the proposed PSF framework. Although there may be improvement opportunities, such as to improve aspects regarding the prioritization tools and methods used, or the timing and duration of workshops, the results validate the model's efficiency both in prioritizing pain-points and in the perception of benefits by the teams involved. In line with our research plan and with the goal of continuously improving the model, we will conduct a further round of review and application of the PSF at Company A, to further validate the framework and explore its potential for implementation in other construction companies.

It is important to note the limitations of this paper, which is based on a single implementation cycle in one specific real estate company, that had undergone a Lean Construction project. This limitation is an improvement opportunity for future research as to implementing the PSF in different companies and also in those that are not working with Lean. Another important limitation is that, given the phase of the ongoing projects in the 4 working groups, it has not yet been possible to measure the effective results of the project. It is estimated that the first results will be measured at the end of the first 12 months after the workshop. Therefore, it is estimated they will become available in October 2024.

The use of PSF for defining the strategy for the Innovation process emphasized the significance of an unencumbered approach to innovation. The outcomes of the PSF emphasized that limiting the development of improvements can hinder progress in the innovation process. The 4 stages of the PSF strengthened the link between continuous improvement methods, such as those practiced in Lean Construction, and their relevance in the wider context of innovation.

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