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Lean Construction: IGLC research evolution and agenda for the future

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Abstract: The way Lean Construction has evolved is still not entirely clear, inspired by Lean manufacturing, the differences in the nature of the product from manufacturing and construction are reflected in these systems. Jacobs, Folkestad and Glick (2012), have conducted a study analyzing the works published in the International Congress of Lean Construction between 1996 and 2009. The authors have noticed a gap between Lean Construction and the Toyota Production System framework. In view of the high volume of publications between 2010 and 2016, as well as of the dynamics of the sector, this work proposed to analyze the 686 works published in this interval, to verify whether there have been changes in the in the profile of publications on Lean Construction. For this, a content analysis was carried out to identify the research topics of these articles. The results of the analysis have been compared with the findings of the paper of Jacobs *et al*. published in 2012. Some topics, such as work on process improvement, have remained high on the research agenda over the last years. Thereafter, a direction was created by grouping the main topics covered each year by topic, allowing the understanding the profile of Lean Construction publications in time interval.

Keywords: Lean Manufacturing; Toyota Production System; Lean Construction; Content analysis; Civil construction

1. Introduction

The Building Industry (BI) is present all over the world, since it encompasses essential needs such as housing and infrastructure. Even in times of crisis, the demand for these services tends to remain. However, according to the World Economic Forum - Infrastructure and Urban Development, one of the most singular characteristics of this industry is its inefficiency in incorporating technological and management innovations (WEF, 2016).

Considering that this is not a new issue, several proposals have addressed the need to improve the efficiency within the industry. One of these proposals is Lean Construction (LC). This philosophy has gained momentum since the publication of "Application of the New Production Philosophy to Construction" by Koskela (1992). Nonetheless, one of the main questions surrounding this approach has been the specificities of the building industry, which may represent a hurdle while implementing, in this particular context, practices used in manufacturing operations. Considering the growing interest in lean thinking in the Building Industry, researchers and practitioners founded in 1993 the International Group for Lean Construction (IGLC). The group has sought to consolidate the body of knowledge of Lean Construction. Among several activities, a conference takes place every year. The main purpose behind the event is to discuss several research topics related to advances in the Building Industry, encompassing from practical application reports to the development of new theories.

According to Yadav *et al.* (2017), understanding the lean body of knowledge is not an easy task; there are diffuse publications and variations related to the specific sectors where lean is applied. Nevertheless, given the historic importance of the IGLC, the analysis of publications allows a deeper understanding on how the interest of researchers has evolved. This type of analysis also allows the identification of main research trends in a specific area, identifying gaps and leading to the development of a future research agenda (Leong; Snyder & Ward, 1990).

Considering this context, the study aims to understand how the focusof publications on Lean Construction has evolved. The research framework was the publication by Jacobs, Folkestad & Glick (2012), which involved a content analysis of IGLC papers published from 1993 up until 2009. The authors applied the Toyota Production System (TPS) point of view as

described by Liker (2004). Similar coding was used in this study while examining the period between 2010 and 2016.

The most frequent research topics in each year were identified, using content analysis. Camacho-Minano, Fuentes & Diaz (2013) underline the possibility of understanding the state-of-the-art of a specific topic by studying available literature throughout the years. This type of mapping facilitates the understanding of how LC has evolved by building industry professionals. In addition, it highlights elements, which have received less research attention.

This study also indicated that there are many features specific to Lean Construction while using the structure of the TPS as described by Liker (2004). The engineering manager that is aware of these differences can build the foundation for lean transformation by combining the TPS elements with other knowledge areas, which are present in the LC.

2. Literature review

The review of literature discusses the degree in which manufacturing techniques can be apply to construction, considering the specificities of the BI. This is done, since it can assist in the analysis of how IGLC publications are positioned within the TPS structure adopted in this study. Furthermore, they include practices that frequently appear in the LC literature.

Lean Construction (LC) became prominent in the mid-1990s, inspired by lean manufacturing, whose benefits were already consolidated. It demonstrated its efficiency to deal with low productivity problems and poor quality levels, which are common in construction. In order to achieve good results, lean manufacturing used techniques and tools that assist in the operational planning and control, supply chain management, visual management and creation of a continuous improvement culture (Hosseini; Nikakhtar & Ghoddousi, 2014; Salem *et al*., 2006).

According to Stone (2012), Liker (2004) compiled the TPS principles and philosophy in the publication of "The Toyota Way". Even though it is not the only one, it is probably one the most used definitions. After 20 years of study, Liker (2004) compiled 14 Toyota management principles and presented a holistic view of TPS as a business model (Saurin; Rooke & Koskela, 2013). As per Liker (2004), the TPS is composed by 4Ps:

- Philosophy, which is the system foundation and translates long-term thinking;

- The Process of eliminating losses in the systems due to exceptional processes;
- People and partners, which emphasizes the importance of mutual respect;
- Problem Solving, characterized by continuous improvement in a company that is willing to learn constantly.

Each of these categories is divided in principles known as the 14 TPS principles. Even though the TPS can be beneficial to any industry, Koskela (2002) argues that the type of product from the building industry make it difficult or even impossible to transfer lean manufacturing to construction. Especially, considering that, a car can be moved to the final customer, and not the same is possible with a building. Besides this feature, there are other differentiations that deserve attention: building is done in the delivery point; projects are unique and involve a significant degree of complexity.

Nonetheless, the Building Industry employs concepts from the manufacturing, which have generated, in many cases, not only good results but also some problems. This is the case with prefabricated systems. According to Hermes (2015), they facilitate the use of work standards, but it prevents the incorporation of individual client needs. This is one of main issues, which involve the applicability of lean in the BI, i.e., how the degree of product customization affects the implementation of LC (Nahmens & Mullens, 2009).

According to Alarcón *et al*. (2008), another difficulty is related to the management of subcontractors. That is a specific feature of the sector; a significant number of companies and subcontractors are in the building site. As the management of internal issues becomes more efficient, the problems associated with the coordination of the supply chain becomes more evident. One of the alternatives for this hurdle is Lean Governance to manage this complex set of relationships, involving designers, contractors, customers, suppliers, builders and others, focusing on value-driven activities, prospects for positive results and assumptions within the system to create value for all stakeholders.

Along with concepts from the manufacturing, the BI also developed its own solutions, e.g., the Last Planner System (LPS) and Building Information Model (BIM), which were associated with Lean Construction to improve the efficiency of the workflow and reduce waste.

The LPS is a planning practice based on guidelines (Ballard & Howell, 1998):

- a detailed definition of each task, which should be performed;
- availability of all resources (materials, labor force, equipment, information), since the beginning of the project;
- the scheduling of an ideal pathway of activities to be performed;
- adequate labor force scaling;
- a detailed study of late or unrealized tasks, seeking to identify the source of problems.

One of the differences between traditional planning and LPS is that the Last Planner System is a pulling system, in the medium and long terms. On the other hand, BIM has been used with LC, since it assists in establishing a relationship pattern for the different actors involved in the process. It facilitates collaboration and information exchange as it incorporates information such as 3D geometries, materials, structures, mechanic, electric and hydraulic systems and workers (Zhang; Tan & Zhang, 2013).

Even though there is resistance to lean principles from a traditional view of transformation (Minami, Soto, & Rholdes, 2010), it is possible to observe that the development of specificities and particular needs based on lean systems can be beneficial. It is clear that in both settings the combination of human labor and technical aspects assures better performance. However, it is important to determine the tools to be applied to achieve a better performance in building projects. As described in Salem *et al*. (2006), the scope of techniques from the manufacturing to be transferred to the building industry is still an answered question.

3. Research method

Jacobs *et al*. (2012) represented the foundation for this study. The authors performed an analysis of IGLC papers between 1993 and 2009, identifying emergent issues in the LC research and TPS framework.

The study sought to ascertain whether the findings of Jacobs *et al*. (2012) remained or there were changes in the profile of publications. IGLC papers between 2010 and 2016 were reviewed and Liker (2004) was used to represent the TPF framework; Jacobs *et al*. (2012) also adopted the latter.

This piece of research is theoretical; it was developed through a bibliographic study. It is exploratory. A qualitative procedure was adopted, the content analysis.

The categories used for coding were based on the 14 principles listed by Liker (2004), in those defined by Jacobs *et al.* (2012) and in categories that emerged from the study. According to Bardin (1995), a good categorizing system should be reliable, i.e., when the analysis is based on the same system of categories, it should be categorized the same way.

According to Krippendorff (2004), there are three main reliability tests: stability, which aims to verify the amount of data that remains stable over time; reproducibility, which verifies the degree of congruence among researchers; and accuracy, which aims to compare the results obtained with a prestandard or existent reference.

For this study, stability and reproducibility tests were performed, using a kappa coefficient to measure the concordance degree among judges. One of the advantages of using kappa as measure is that this index considers the existence of a percentage of agreement that is random (Crocker & Algina, 2009, as cited in Lima, 2013). The accuracy test was not carried out, since the performance of this test depends on a known pattern, which does not exist in this case.

Three rounds of coding were performed to identify the research topics in the analyzed database as shown in Figure 1. As in Alves & Tsao (2007), the IGLC conference themes were not used, since they change every year. Unlike the authors who used keywords to define emergent topics, in the study, the entire paper was read, identifying the topic that was prevalent throughout the text as in Jacobs *et al*. (2012).

In order not to cause any confusion, in the first coding round, the papers were verified in terms of fit regarding the TPS framework. For a paper to be categorized in the TPS framework, it should address at least one of the 14 principles throughout the text, not necessarily citing Liker (2004). For instance, a paper dealing with supply chain, emphasizing the importance of acknowledging the network of partners and suppliers would be coded as ‘people and partners’, and, afterwards, ‘respect, challenge and help suppliers’.

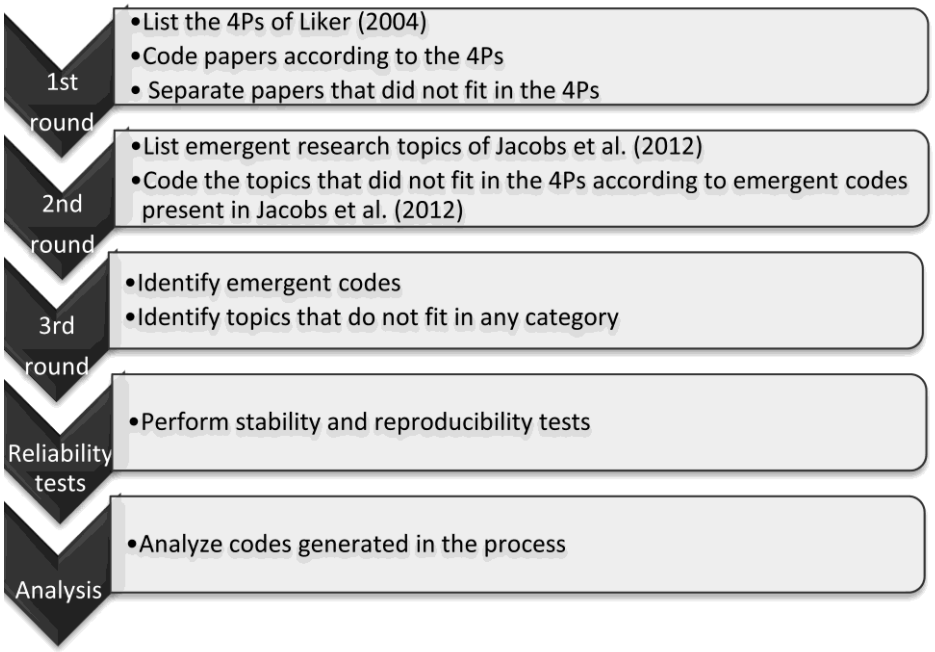

Figure 1 - Research Strategy

Some studies had both TPS framework elements and emergent topics. In this case, the purpose prevailed for the classification. This happened with the proposition of models or frameworks, since many of them used a theoretical basis to propose their model and their main purpose was to present a specific model.

Although, many studies did not use the TPS framework proposed by Liker (2004), they were still related to the LC. As mentioned in the literature review, not all LC practices integrate the TPS such as the LPS. It is important to highlight that the LPS is an approach to assure a better flow of activities. According to this perspective, it would fit in the TPS; however, due to its relevance to the LC, the authors chose, unlike Jacobs *et al*. (2012), to treat it as a specific category.

The second coding round began by listing the emergent coding found in Jacobs *et al*. (2012) and the proxy definition defined by the authors. After that, the papers that were not coded in the first round were analyzed.

The third coding round used the emergent coding technique, that is, the papers that were not categorized according to the TPS framework or the topics proposed by Jacobs *et al*. (2012) were read again. In this process, the topics of the papers were sought. Then, stability and reproducibility tests were performed to guarantee reliability in the process of coding.

After this step, the analyses identified general aspects such as number of publications per year and country of origin for the first author. Moreover, the prominent topics between 2010 and 2016 was sought. Finally, the final conclusions were summarized.

4. Research Results and Development

A total of 686 studies were included in the scope of this research. Three coding rounds were performed. Each paper was coded, being predefined or emergent. The proxies resulting from this study are described in Table 1.

Table 1 - Emergent categories and proxies definition

	Proxy research categories	Definition
Same emergent categories as in Jacobs *et al.* (2012)	Theory	Lean research theory development
	Prefabrication and modularization	Manufacturing parts of a building at a factory
	Outside the lean focus	Not relevant to the 4 Ps (TPS) or 14 proxy categories in lean construction
	Organizational change	Transformations within companies
	Information technology	Computers and telecommunication applications in construction
	Finance	Building activities associated with providing funds and capital
	Design management	Integration of design and management and vice versa
	Waste control	Measures for waste in construction
	Benchmarking	Construction performance comparisons
Emergent categories whose definitions were modifed	Games and simulation	Use of game theory or simulation to test the same tools in construction
	Logistics and supply chain	Impact of the relashionship between supply chain actors for lean construction and handling operations
	Feedback and dissemination of lean	Feedback on applications in construction and dissemination of lean construction within the same parts of the world
	Models	Development of lean construction models
	Safety	Lean impact on safety in construction
	Sustainability and energy management	Lean as a facilitator in the search for sustainability and energy management
emergent categorie	BIM	BIM in construction
	Communication and transparency	Importance of information flows and realiability in lean applications

	Customer satisfaction	Identification and investigation of customer needs
	Customization	Impact of lean construction upon customization
	Lean development products	Applying lean concepts in the development of construction products
	Lean construction education	Teaching lean construction
	Success factors and barriers to lean construction	Factors that should be monitored to guarantee success with lean construction
	Lean governance	Lean governance to create value for stakeholders
	Last Planner System	Impact of the Last Planner System on construction
	Performance evaluation of lean construction	Metrics to evaluate the results of lean construction

After coding, reliability tests were performed. The data was included in the SPSS® software for the kappa test. An index of 86% of concordance was achieved for the stability.

For the reliability, an index of 63% was obtained, Brennan & Silman (1992), Fleiss (1981) and Landis & Koch (1977) regarded it as being good.

In terms of the country of origin of the publications, it is possible to observe that 10 countries are responsible for 82% of the IGLC publications. The United States are the main contributors as per Figure 2. Apparently, countries such as Germany and Norway have increased their participation in the LC research in comparison with the results obtained by Jacobs *et al*. (2012).

Between 2010 and 2016, only 12% of the papers had as main topic one of the 14 principles found in Liker (2004). This result was ratified by the findings of the bibliometric analysis performed by Pasquire & Connor (2011); Liker (2004) did not appeared as one the most cited authors in the IGLC papers between 1998 and 2010.

Considering papers where the TPS framework represented the main topic, as shown in Figure 3, 57% referred to the ‘improvement of processes’, followed by ‘people and partners’, ‘philosophy’ and ‘problem solving’.

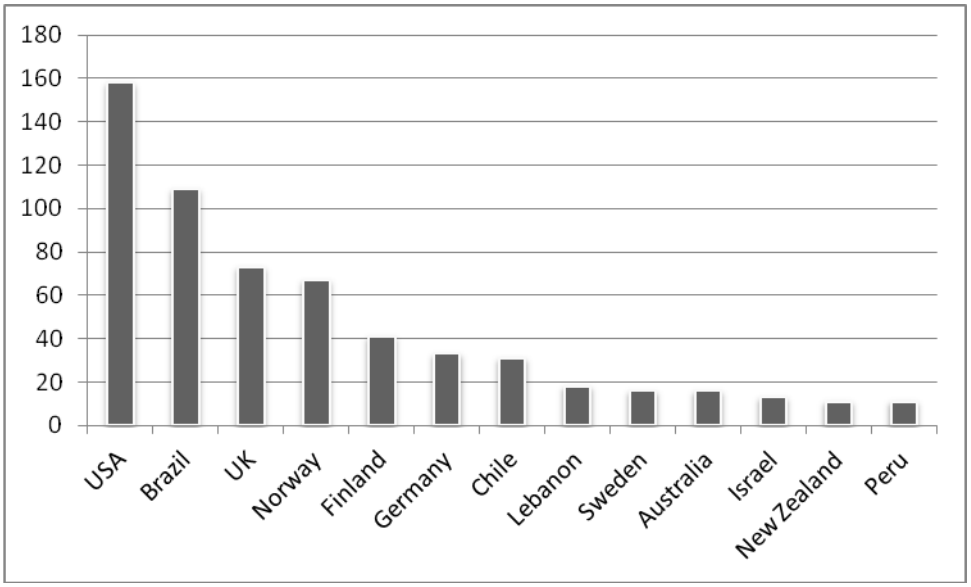

Figure 2 - Number of papers by country responsible for 82% of IGLC publications between 2010-2016

Comparing this finding with those presented by Jacobs *et al*. (2012), the focus on the improvement of processes remained as the most frequently related to the TPS framework. On the other hand, there is a meaningful detachment from the TPS model, which represented 40% of the papers in the study conducted in 2012.

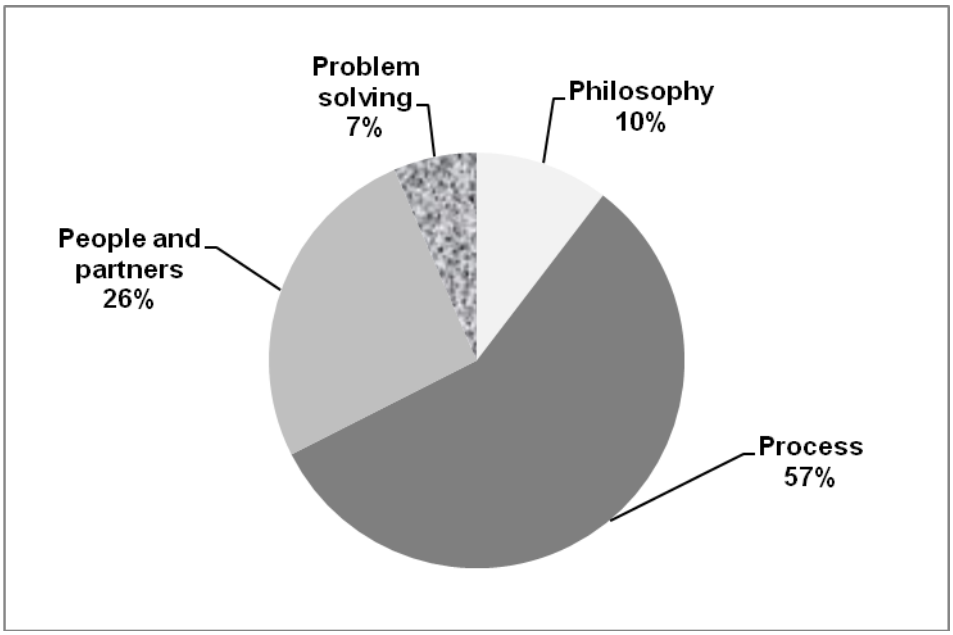

Figure 3 - Distribution of studies according to the TPS framework

The focus on the improvement of processes began in the first days of Lean Construction, and, in consequence, in the IGLC. In the study by Jacobs *et al*. (2012), this topic represented 16% of the total of papers. In this study, it represented approximately 7% of

all publications. Analyzing the content of the research on the improvement of processes, there are inferences that the sector is concerned with creating flows to solve problems. Another concern is the use of visual management to uncover problems. However, Jidoka (autonomation) seems to have received less attention as shown in Figure 4.

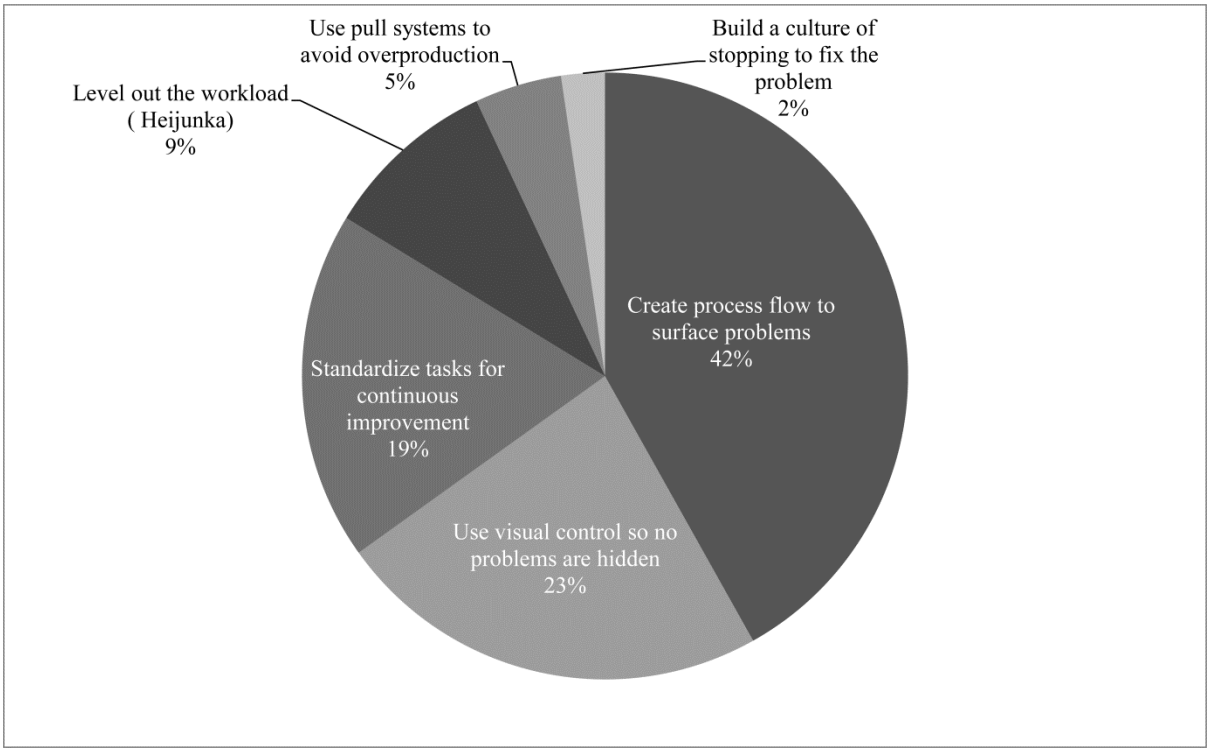

Figure 4 - Distribution by topic of papers focusing on 'Process'

Papers focusing on P & P, 'people and partners', represented 3% of the total of IGLC publications. This topic represented 7.6% of the total of publications in the study conducted by Jacobs *et al.* (2012).

A significant number of studies deals with the development of teams that follow the company values, succeeded by a respectful relationship with the network of partners and suppliers, and, finally, leadership development, as shown in Figure 5.

It is important to point out that the number of studies dealing with tools was far superior to P&P. Nonetheless, in the TPS, the leaders play a major role in maintaining and disseminating the TPS culture. According to Liker & Meier (2007), it is uncommon for Toyota to hire external managers; the company chooses to develop its own managers over time. The same for its employees. Unlike the Building Industry, which characterized by a high turnover of workers. This topic deserves further scrutiny, since it may be a barrier to the

success of Lean Construction. How can a company create a strong culture and identity with temporary and subcontracted workers?

Figure 5 - Distribution by topic of papers focusing on 'People and Partners'

Regarding the 'philosophy', the research addresses the principle: 'support administrative decisions using a long-term philosophy, even at the expense of the short-term'. The role the leadership plays in acknowledging its importance to leverage and maintain a company results, involving all staff members, is emphasized.

The topic 'philosophy' was core in 1% of the papers classified as being in the TPS framework. In 2010 and 2014, there were no publications, which addressed the topic as core.

In the work of Jacobs *et al*. (2012), the same analysis was conducted and a similar scenario was observed. Between 1993 and 2009, only 2% of the papers that contributed to the TPS framework related to philosophy.

Problem solving is directly linked to organizational learning and continuous improvement. According to Liker (2007), the leader should go where the problem occurs to obtain an in-depth evaluation of the situation before any solutions are proposed. Moreover, the participation of the actors involved in the environment where there is adversity is paramount to seek a solution. Any implemented solutions should be standardized to promote a continuous improvement environment.

In the study by Jacobs *et al*. (2012), the number of publications on the topic corresponded to 2% of the total of IGLC papers; it was 1% between 2010 and 2016.

The numbers aforementioned indicate a high concentration of papers on the improvement of processes, which may reflect the maturity level of the LC. Ballé and Regner (2007) argue that the overstated focus on the improvement of processes in detriment of the development of a long-term culture, followed by the low investment in people, are common characteristics where lean is not mature.

According to the authors, the application of lean concepts and tools outside the automotive industry is still a challenge. This occurs because it is not only a toolbox to be executed; on the contrary, it is a system that should built for all, from leadership to operational workers.

Emergent coding was essential in this study, since it allowed the identification of what has been studied and applied in the context of Lean Construction. From the total of papers, 62% presented research topics coincident with the research conducted by Jacobs *et al*. (2012). Nevertheless, the definitions of some of the common themes were adjusted. Figure 6 shows the representativeness of the coincident categories in the total of publications between 2010 and 2016.

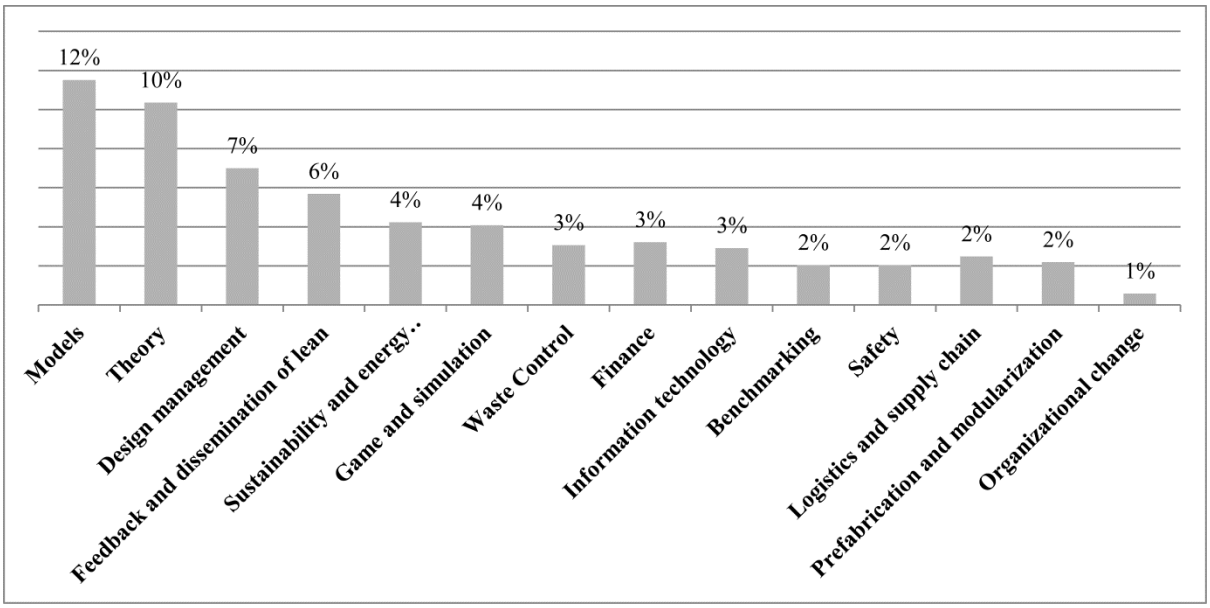

Figure 6. Categories coincident with those presented in Jacobs *et al*. (2012)

The codes (proxys) ‘models’ and ‘feedback’ that were grouped by Jacobs *et al*. (2012) were separated as per the papers analyzed in the study (2010-2016). A high volume of models was proposed, corresponding to 12% of the total of publications. Feedback of applications represented 6% of the total of papers, including not only applications in one particular company, but also studies on the diffusion of lean construction in macroregions. In comparison, between 1996 and 2009, these topics combined represented only 8% of the total of publications, i.e., there is a substantial increase in the interest in them. .

Other topics that stood out in the previous study were less representative in the present research. That is the case with ‘safety’, which represents 5% in Jacobs *et al*. (2012) and 2% in the study.

Furthermore, some topics emerged in comparison with the work by Jacobs *et al*. (2012), as shown in Figure 7. Some topics appeared in significant numbers as the Last Planner System (LPS) and BIM, followed by Customer Satisfaction.

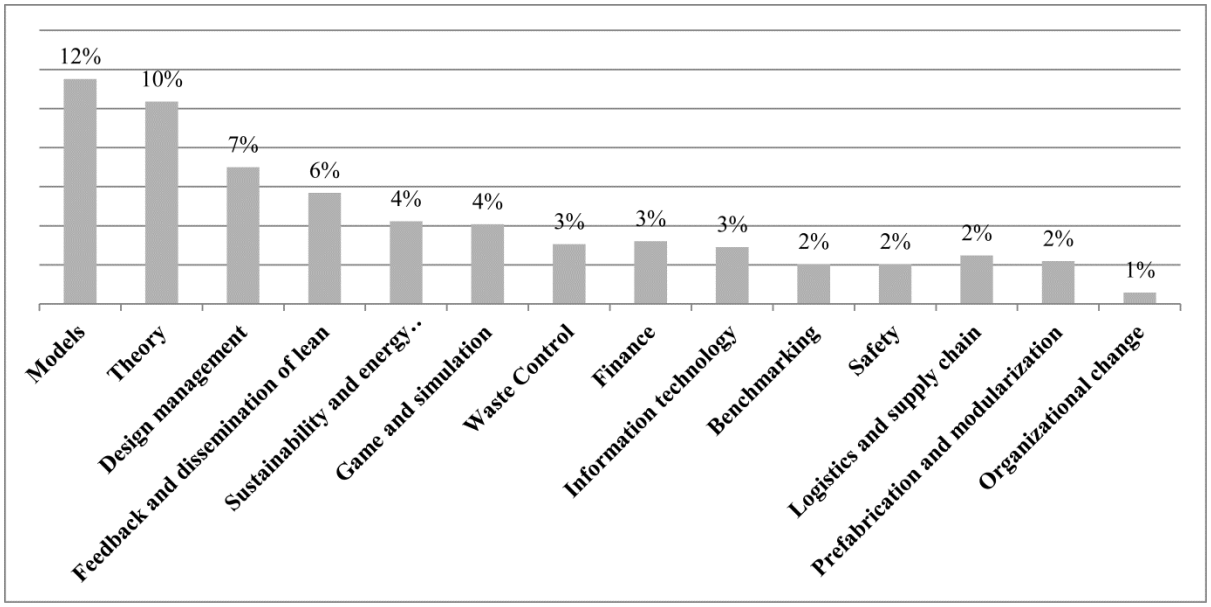

Figure 7. Categories coincident with those presented in Jacobs *et al*. (2012)

The general distribution of more frequent topics in the IGLC papers between 2010 and 2016 can be visualized. Considering the TPS framework presented in Liker (2004), only ‘process’ appeared. The majority of studies addressed the Last Planner System and new model proposals (to implement lean in construction or verify maturity). Mainly theoretical

work was found, which is not surprising, considering that Lean Construction began officially 20 years ago. A subject that has been built.

For a more in-depth understanding on the topics of the IGLC studies between 2010 and 2016, the categories were group (Figure 8). The seven resulting categories were ‘process improvement’, ‘learning’, ‘knowledge development’,‘performance measurement’, ‘human-centered’, ‘society’ and ‘project management’.

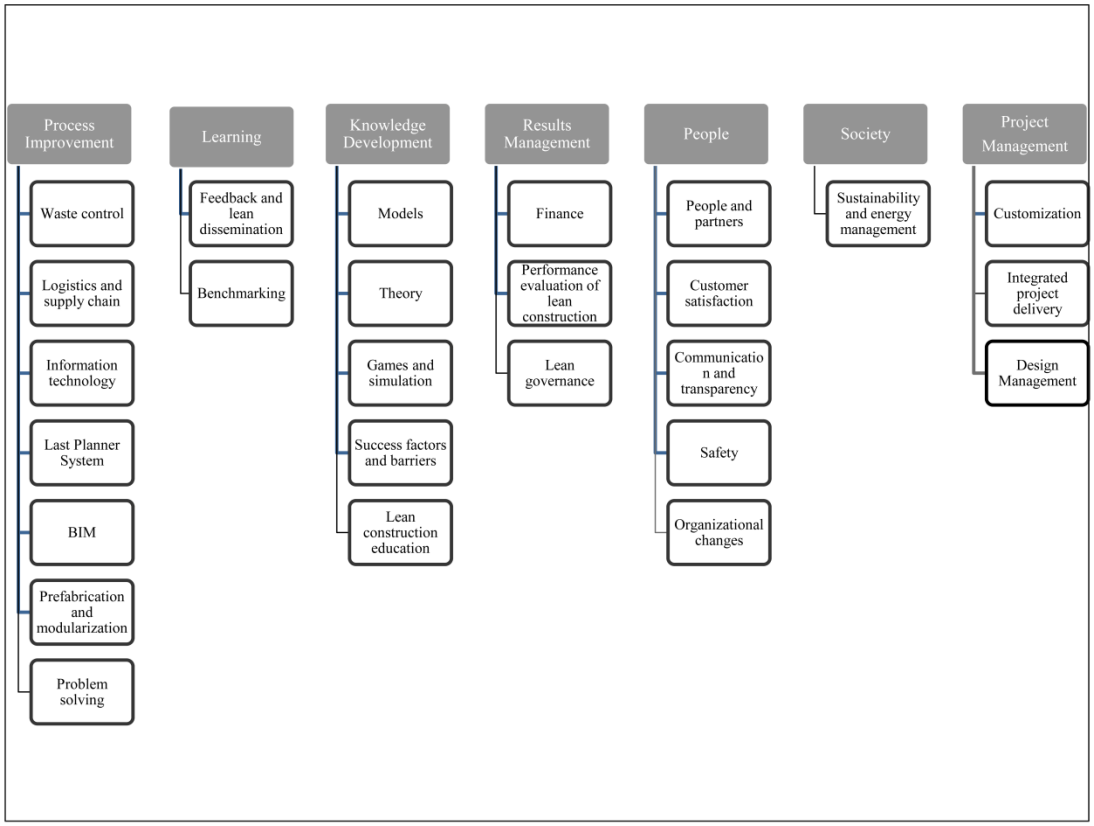

Figure 8 - Grouping codes into categories

The topics grouped as ‘process improvement’ referred to the tools that assist in the performance of routines such as waste control, LPS, BIM, prefabricated, problem solving, information technology, supply and logistics. It is possible to observe that many of the tools within this group assist in reducing the project lead-time; thus, they improve the workflow.

Benchmarking and feedback on lean applications contribute to create a foundation for learning. Over time, it is possible to learn with the experiences from other building companies, which include those in several parts of the world.

'Knowledge development' includes new models for the implementation and maintenance of LC. New theories or consolidation of preexistent theories, studies on implementation barriers or success factors and challenges or experiences in teaching LC contribute to its development.

All aspects of LC contribute to organizational results, but some topics are directly related to results. Studies on finance, performance measurement and lean governance were grouped as 'performance measurement', since the information may facilitate managers activities.

A category centered on the human being was also created, but it is not the same as 'people and partners' described in Liker (2004). In the study, 'human-centered' encompasses all challenges that affect people; being customers or workers. For instance, safety and organizational change are related to workers. Customer satisfaction can be connected with the final customer and internal clients; transparency and communication may affect all stakeholders. 'Society' encompasses global aspects that affect society such as sustainability and energy efficiency, which are issues of global importance. The last category, 'project management', grouped aspects that have modified contract model such degree of project customization and the integrated project delivery (IPD) as well as general aspects related to design management. Figure 9 shows the identification of the main topics inside each category.

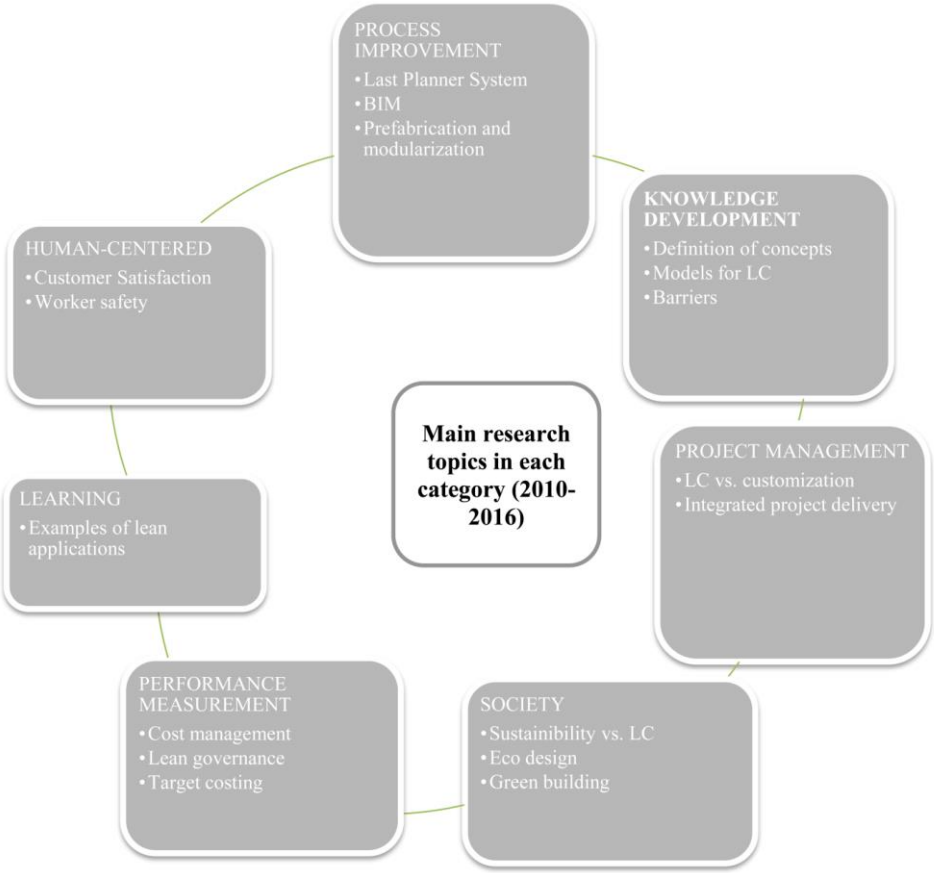

Figure 9. Main themes in each category

5. Discussion

The development of knowledge indicates the LC level of maturity as a management system for construction. In 2010, some authors discussed basic concepts such as value creation and workflow. After that, there was an increase in the number of publications, which supplied models to implement and support the LC, especially in 2014 and 2015.

Another important issue is leveraging the LC. There are potential pathways to involve several actors that are part of a building enterprise. This can be observed in papers on the 'contract management'. This is still a major challenge for the LC, since a project, usually, involves a large network of contracts. This aspect does not facilitate collaborations toward a common result, because many companies are responsible for different parts of the project; they often depend on partial results. Furthermore, it is common for builders to execute parallel projects. In consequence, it is hard to use LPS, since it can provide limited control over the management of the contractor priorities.

The building industry is present is all society sectors; where infrastructure is needed, there is construction. In other words, it would not be possible to have a manufacturing system

that will address the industry interests and ignore society needs. In this context, it was observed that the research studies on LC have begun to explore how this system affects sustainability and the development of green construction as well as the concept of energy efficient buildings. The topic 'performance measurement' apparently has focused on aspects related to the management of costs through research on target costs and target value design. In light of this context, one of the LC challenges is to demonstrate that it can contribute to cost reduction and measurement of gains.

Evaluating the studies involving 'learning', an increase in the variety of LC applications was observed. This was clear in the feedback of applications in different parts of the world and different processes in the building industry. There are records of lean office applications in construction, which will probably become a paramount LC challenge, especially when managing a large number of contractors in a project.

The human-centered topic ranges from internal problems, which is the case with worker safety, a critical aspect in the sector, and external issues such as the relationship with customers and information flow in the construction supply chain. Figure 9 shows the main approached issues and allow the differentiation between consolidated and topics that require further research. Even though 'process improvement' is an aspect of great importance, this topic alone is not sustainable. Thus, all topics should be developed and explored, even if unevenly, but with a more balanced approach.

Although this study is conceptual by nature and based on a literature review, it brings important contributions to engineering managers by identifying issues related to the LC practice. The first contribution refers to the consolidation of LC as a management system for construction. It is clear this is not a passing trend. This theory has gained momentum; it is widespread around the world. Hence, managers that have not yet tried it or have not initiated the LC implementation should be aware of it. The builders that have adopted the system already feel positive results as observed in several studies such as Dunlop & Smith (2004); Yu *et al*. (2011); Pheng, Gao & Lin (2015).

Using the automotive industry as an example, where other manufacturers of vehicles followed in Toyota's footsteps, incorporating many of the lean manufacturing principles in their management systems; building managers that do not try to incorporate LC into their company will likely suffer the effects of a strong competition.

One of the benefits for a manager that decides to initiate the lean journey now instead of those who began in 1992 is the access to information. According to the categories identified in this study through the IGLC publications in the period, it is possible to obtain information on process improvement, knowledge development, contract management, society, performance measurement, human-centered topics and learning.

Engineering managers cannot ignore the complementary tools that have been incorporated into the LC such as the Last Planner System and BIM, which are not included in the TPS toolbox, but are present in the majority of the LC papers. A crucial factor for the successful implementation of LC is the change in the behavior of engineering managers, particularly those that deal directly with workers. The development of lean is improved by a collaborative management environment, especially when many different companies operate on the same site and product. Thus, it is necessary to develop the relationship customer-supplier by understanding the need of internal clients and seeking to address them.

Furthermore, the relationship with external clients should be reviewed, since, in general, the architect's or designer's vision is the one taken into an account, while in a lean system, the customer must represent the focus.

6. Conclusion

In addition to continuing the study by Jacobs *et al*. (2012), the present study sought to verify if there were any changes on the profile of LC publications and what type of changes. Moreover, it sought to outline a direction that will allow the reader to understand how the publications on LC have developed.

The increase in the volume of publications between 2010 and 2016 has surpassed the volume of the first 17 years since the creation of the IGLC. This suggests that the interest in LC has increased, which apparently has its own characteristics further away from the TPS framework.

In the work by Jacobs *et al*. (2012), 71% of the published papers did not relate to the TPS framework developed by Liker (2004). This inference has become more evident between 2010 and 2016, since 87% of the publications were not aligned with the TPS.

Among the topics approached in the publications, which were aligned with the TPS, there was a preference on studies on 'processes' (representing 7% of the total of papers) while 'philosophy' and 'problem solving' did not go beyond 1%.

In comparison with the study by Jacobs *et al*. (2012), in the emergent categories, the majority of papers apparently focused in the 'improvement of processes', which was observed through the significant number of publications on the LPS and BIM.

One of the categories that emerged in the study involved the barriers and success factors that lead the way so that organizations can have a successful implementation and maintenance of lean systems. It is important to point out that some of the studies focus on the importance of the transparency for a good implementation, addressing even sensitive issues such as the corruption in the building industry, a barrier to LC success.

The high volume of models proposed for LC, focusing on execution or supply chain management, suggests that there is a difficulty in implementing existing tools and systems. Nevertheless, it is important to conduct more in-depth studies on the content of such models in order to identify similarities and differences and understand the high number of publications on the proposed models. It is important to underline that, on the one hand, the literature seems to recognize problems related to LC implementation and, on the other hand, there is a deficit in terms of studies related to culture and leadership.

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