EXPLORING LEAN CONSTRUCTION PRACTICE, RESEARCH, AND EDUCATION

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ABSTRACT

Lean Production has been studied for over 20 years, and for many the term is still ill-defined. Our first hypothesis suggests that there are many meanings for Lean when applied to Construction. Our second hypothesis suggests that Lean Construction started not from industry but from a mix of academics and consultants (with strong links to academia) working to translate Lean concepts to construction. We believe that both play a major role in bridging the gap between the theories related to Lean Construction and their implementation. Finally, we have encountered examples of companies and professionals who are eager to benefit from the alleged benefits of Lean Production but few are willing to spend the time and effort necessary to learn it. Our third hypothesis suggests that without a sustained effort to engage people in meaningful learning experiences Lean Construction may be viewed as a fad in the construction industry. We searched the literature and looked for cases with different approaches used to disseminate Lean Production and have found evidence that supports the hypotheses proposed. The paper aims to discuss how lean production transitioned to construction and what researchers and practitioners might do to sustain learning and promote change throughout the industry.

KEY WORDS

Lean implementation, Education, Change

INTRODUCTION

Lean Production (LP) concepts, principles, and tools have been studied by academics for over 20 years (e.g., Womack et al. 1990). Nonetheless, for many the term Lean Production is still considered an ill-defined concept which needs further exploration and agreement in academic as well as in professional settings (Hines et al. 2004, Jorgensen and Emmitt 2008, Pettersen 2009). The application of LP in construction is almost as old, as the term 'Lean Construction' (LC) first appeared in 1992 (Koskela 1992). However, only in the past 5-6 years has it gained widespread momentum with a larger group of construction companies, owners, industry associations, and public institutions interested in becoming acquainted with, and proficient in, Lean implementation.

In California, for instance, a few major events may have boosted the popularity of LC amongst construction companies namely: the decision by Sutter Health to change

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the way its capital projects were contracted, designed, and built (Lichtig 2005); the creation of the Project-Production Sytems Laboratory (P2SL) at UC Berkeley in 2005; the proliferation of Lean Construction Institute (LCI) chapters, starting with the Northern California chapter; and the large state-funded 'California Prison Health Care Receivership' *Coop-etition*, which started around 2008 and brought together competitors and collaborators to work on the design and construction of seven million square feet of correctional healthcare facilities (CPRINC 2010). Currently in California, a number of requests for proposals (RFPs) from public and private owners have incorporated some sort of requirement related to LC use (e.g., Integrated Project Delivery (IPD), Last Planner™, pull planning, use of Lean principles).

Recently, large United States industry associations (e.g., AGC, AIA) and legal experts have also joined the LC community, which in the beginning was largely formed by academics, ostensibly to aid the change towards a more efficient industry based on the tenets of LP. Nationwide in the U.S., contracts are changing to accommodate the needs of IPD teams, and the request for explicit collaboration between project participants is now part of these contracts, e.g., AIA IPD family of contracts (AIA 2010).

By now in the construction industry, as in other sectors, a large body of 'Lean' literature and implementation examples abound (e.g., www.iglc.net), but some authors still criticize LC as a discipline due to the lack of structured research findings and critical discussion based on publication of papers in peer-reviewed journals (Thomas et al. 2004, Jorgensen and Emmitt 2008). Criticisms about the LP system in its original form, i.e., the Toyota Production System (Ohno 1988, Shingo 1989), can also be found in the literature and these help us understand what has to be in place for this system to work (Berggren 1993, Lilrank 1994, Scott et al. 2001). Some authors have highlighted that to make this system work some preconditions have to be met: design of products for easy manufacture; careful selection and management of workers and suppliers; fast-paced work and close monitoring and adherence to standards, amongst others (e.g., Berggren 1993, Lilrank 1994).

In this paper, we focus on how LP has evolved in the construction industry and what implications that evolution brings to its widespread dissemination in this industry through academic and professional communities of practice located all over the world.

RESEARCH METHOD AND GOALS

This paper is based on three hypotheses, related to the current understanding of LC and its development and dissemination in the industry. To some extent, these impressions were formed via interactions with companies attempting to deploy LC. The authors gathered evidence from the literature on the topic and from current developments related to the advance and implementation of Lean practices in the construction industry. We searched the literature and looked for cases in academic and professional settings for different approaches used to disseminate Lean. The paper aims to discuss important aspects related to Lean Construction learning and training programs, in order to create a basis for further research into sustainable approaches for teaching Lean Construction in different settings within the construction industry.

DISCUSSION OF HYPHOTESES

HYPOTHESIS 1

H1: "There are many meanings (whether denoted or connoted) for Lean when applied to Construction."

Pettersen (2009) argues that there is no consensus on a definition of Lean Production (LP), which causes confusion on both theoretical and practical levels. The confusion at the practical level causes more problems because organizations try to implement the LP concepts without uniformity in terms of how to interpret and implement. "Formulating a definition that captures all the dimensions of lean is a formidable challenge" (Pettersen 2009, p.136). In the LC domain Jorgensen and Emmitt (2008, 392) argue that "a coherent philosophy for lean construction has not yet been developed".

One of the reasons for the lack of a precise definition for what a Lean system entails is the lack of definition of LP where it all started. Despite the ever growing literature on the topic, Lillrank (1995, p.972-973) highlights that "The Japanese have not been very articulate about the reasons for their success. (…) There was no great master plan up front and no blueprints that could have been studied. Therefore, the Japanese experience was wide open for various explanations and interpretations."

Womack and Jones (2003) have not claimed that Lean Thinking (LT) is a theory. The authors tried to draw conclusions from the work they presented in The Machine that Changed the World (Womack et al. 1990) and the results obtained by the organizations that they deemed Lean.

Koskela (2004) suggested that the principles presented by Womack and Jones (2003) are highly compressed and that they may be detrimental to the understanding of LP as a whole, as many elements may be missing in the explanation of the five LT principles. Womack et al. (1990) and Womack and Jones (2003) provided an unprecedented basis for the dissemination of Japanese organizational practices, which had not been achieved by other pioneers on the topic. These books popularized LP and made the Toyota Production System (TPS) more palatable to broad audiences. However, Koskela (2004) stressed that Womack and Jones' (2003) Lean Thinking book lacks the discussion of explicit concepts that would provide the foundations of LT as an offspring of the TPS as discussed by Ohno (1988) and Shingo (1989).

Even though many do not agree on possible commonalities in the implementation of LP, according to Olivella et al. (2008) there is a group of work organization practices that are related to the implementation of lean production, namely: standardization, discipline and control; continuing training and learning; team-based organization; participation and empowerment; multiskilling and adaptability; common values, compensation and rewards to support LP. These practices are usually selected based on the social and organizational background of the company and adapted to suit its context. However, often times, the implementation of isolated practices fail because they do not belong to a comprehensive plan that addresses both the social and the technical parts of the organization (Lathin and Mitchell 2001).

Much has been said about the contextual roots of LP and its origins in the mass production environment marked by high volumes of repetitive tasks performed in permanent locations and organizations (Berggren 1993, Lillrank 1994, 1995). Therefore, the application of LP in a project-based environment such as construction,

with temporary teams allocated to geographically diverse projects and clients, and highly worker-intensive and dependent tasks, requires careful understanding of its tenets and adaptation to the peculiarities of the sector.

Over the years, LC was often understood by many across the globe as a set of tools and practices aimed at reducing waste in construction projects and the implementation of the Last Planner System of Production Control™ (LPS™), as this system emulates many concepts, principles and tools found in the literature on TPS (i.e., Ohno 1988, Shingo 1989): pull planning, analysis of the root causes of problems, and definition of sound assignments, to name just a few.

A search on the iglc.net website reveals a repeated focus of early IGLC papers on waste identification and elimination, amongst other topics. As Ohno (1988) and Shingo (1989) reinforced the need to identify and banish waste in their classic books, the construction industry started the LC development by understanding what waste meant for the industry, how it was created, and how it could be eliminated. The understanding of LC as a synonym of waste elimination can still be found in papers submitted to the IGLC, and in discussions in professional forums, by academics and practitioners who are in the initial stages of LC implementation (e.g., Forsberg and Saukkoriipi 2007**,** Ramaswamy and Kalidindi 2009).

LPS™ as starting point for LC implementation could be evidenced by the predominance of papers on project management in IGLC conferences, such as the ones analyzed by Alves and Tsao (2007). The implementation of the LPS™ is seen by many as the door to start LC implementation as it promotes stability and learning through systematic planning and control of weekly assignments as discussed by Ballard and Howell (1998).

The focus on waste elimination and production planning and control has placed much attention on the transformation and flow aspects of the tasks performed by an organization, but missed the third essential component to managing production systems: value (Koskela 2000). According to Hines et al. (2004, p.995): "A critical point in the lean thinking is the focus on value. Often however, value creation is seen as equal to cost reduction. This represents a common yet critical shortcoming of the understanding of lean."

Different countries have understood LC from various perspectives. According to Emmitt et al. (2005), for instance, LC was originally interpreted and applied in Denmark with a very narrow focus which comprised the use of logistics concepts applied to the flows of materials and activities and the Last Planner System™, and apparently some understanding of Lean as partnering.

The abundance of LP and LC meanings calls for more research to explain what their constituent concepts represent and search for more uniform definitions to shape a common understanding throughout the industry. Furthermore, the practical execution impacts of this condition require additional study. This leads us to the second hypothesis discussed in this paper.

HYPOTHESIS 2

H2: "Lean Construction, in contrast to Lean Production, started not from industry but from a mix of academics and consultants (with strong links to academia) working to translate Lean concepts to the construction industry. Therefore, we believe that academics play a major role in bridging the gap between the theories related to Lean

Construction and their field implementation, as they work as translators of the concepts originating in the manufacturing industry."

The first account on the potential use of LP in construction can be found in the seminal work by Koskela (1992) and his attempt to come up with a theory of production management. The first IGLC conference hosted in Espoo, Finland in 1993 comprised a handful of papers, a very different scenario when compared to recent IGLC conferences which have added an 'industry day' before the main event and welcome papers from both academics and professionals working to advance LC (IGLC 2010).

The IGLC has played a central role in the dissemination of LC in the construction industry due to the diversity of views presented about LC and its implementation in different parts of the world. The group has an unwritten policy of inclusion which allows academics and practitioners in different stages of their LC journey to join the conversation and share their ideas by publishing papers made available online to the community.

In addition to the role played by the IGLC group, the Lean Construction Institute (LCI) has bridged the gap between academia and industry by promoting LC to industry practitioners through the development of research projects and the promotion of events to disseminate and consolidate LC practices. LCI represents the LC community to the industry and for many it is the entry door to the global LC network. From its inception in 1997, LCI has made its knowledge base available online, and immensely contributed to the dissemination and support of LC in different regions of the United States and abroad through international LCI chapters (LCI 2010).

However, despite the broad capillarity both organizations have in academic and professional settings, and their fundamental commitment to being self-sustained and disseminating LC free of charge, there is criticism in terms of how LC concepts, principles, and tools have been disseminated. Jorgensen and Emmitt (2008) criticize the lack of detail presented in publications regarding Japanese management practices, and the lack of description on data collection and validation. They also criticize IGLC proceedings for being biased towards describing positive improvements, being self-referential citing mainly the IGLC literature and a handful of papers on construction/production management, and finally lacking criticism and being too slow in promoting a critical and informed debate especially in peer reviewed journals.

While many directions could be pursued from this discussion, the point here is only to call attention to the importance of academics in translating and disseminating LC. Koskela (2004) stresses the need for adaptation when LP principles are applied to one-of-a-kind production with temporary location and organization, e.g., construction. Management principles are context-specific and depend on culture, local market and business conditions, level of education, incentive structures, amongst others (Lillrank 1995). In its original and more orthodox form, LP also has limitations, e.g., the availability of workers capable and willing to work long hours, the stress related to lower levels of inventory, location of suppliers, or design of models that share parts/plants and are easy to assemble (Berggren 1993).

While many in the industry have genuine interest in implementing LC in their organizations, few have the time and the interest to read detailed accounts of LP and LC implementation, and consequently often rely on academics and consultants for that. Lillrank (1995) contends that organizational innovations may take years if not

decades to be transferred (i.e., study of successful practices and learning related to their implementation) from their original context to other applications. Lillrank (1995) uses the "high-voltage electric transmission analogy" as a metaphor to explain how ideas travel through different contexts. In the case of electricity, the electric current is set to higher voltages to overcome resistance in the cables and reach its destination; when it reaches its destination the electric current is switched to lower and usable voltages. Lillrank (1995) mentions that the transfer of ideas travel through an 'idea line' in which losses will also occur based on the geographical, cultural, mental, and historic differences between the start and end points. In order to reduce the losses, ideas are abstracted away from their original context and packaged in a format that allows them to travel through the 'idea line'. By the time the ideas reach their destination they have to be repackaged, triggering multiple cycles of learning related to interpretation and adaptation to local conditions.

One example of how these ideas travel and how they get adapted to specific contexts is the slow, but continuous, evolution of LC ideas in the construction industry as pointed out by Ballard (2008, 18): "the Lean Project Delivery System is not a mere creature of the imagination, but rather an emerging practice fed by multiple streams of experimentation." Ballard goes on to acknowledge that there are multiple companies experimenting with LC and multiple research labs, in addition to the IGLC community, working to collectively advance LC.

Finally, Koskela and Rooke (2009, p.339) also point out that the main question to be answered in management research is whatever is being done, "does it help improve performance?" This leads to the third hypothesis, which points out the need for continuous learning to sustain improvement and promote change in the construction industry.

HYPOTHESIS 3

H3: "Without a sustained effort to engage people in meaningful learning experiences which mix instruction, exchange of ideas and meanings, and guided practice, Lean Construction may be viewed as a fad in the construction industry."

In interacting with the industry we have encountered many examples of companies and individuals who are eager to learn about Lean Thinking, but few who are willing to spend the time and effort necessary to learn the basis of what the literature presents as Lean Thinking and its applications. A number of short seminars and meetings are offered by different organizations in order to respond to requests from professionals trying to learn about the topic quickly but little has been done in the industry to promote sustained and continuous learning. We believe that many companies in the construction industry have currently embraced systems and tools (e.g., LPS™, pull planning, *kanban*, A3) but not necessarily their basic concepts. This is a very similar environment to the one described by Cole (1999) about the quality movement in U.S. in its early years. He points out that quality management was perceived by U.S. companies as the implementation of tools and isolated practices, and it almost became an unsuccessful initiative (a fad), before organizations could consider quality management as an integral part of their businesses.

Lillrank, 1994 (p.427) highlights that "Lean production requires a set of soft enablers, that is, social and organizational conditions to match the inherent fragility of the just-in-time-system. Working under lean management is difficult in two ways: it

requires fast-paced work closely following standard operating procedures (SOP) and a continuous vigilance to improve SOPs." At Toyota, the combination of problem-solving and kaizen on the shop floor is a priority and consists of a methodical process described by many (Ohno 1988; Shingo 1989; Berggren 1993). The development and use of standards and documentation of best practices allow deviations to be quickly identified and acted upon, serving as a basis for organizational learning. In the LP system, workers have to work hard to meet the high standards expected from them, and managers have to work even harder than they would in some other organizations to keep the system running (Berggren 1993).

The fast-paced environment of LP as applied in the manufacturing industry has yet to be a reality in construction. In fact, this may never happen in an industry whose pace is largely dictated by human rather than machine work. However, the message is clear: social and organizational conditions, in addition to strong leadership and management leading by example, have to exist for a system based on LP to work.

Hirota et al. (1999) investigated potential ways to disseminate LC in organizations using a more systematic method and came up with three approaches: the use of a tool to negotiate meanings, development of organizational learning, and the use of action learning. The 'concept mapping' tool was used to negotiate the meanings of different LC-related concepts and principles and their relationships in a group of project managers learning about LC. The goal of this tool was to bridge the gap between the participants thought and speech, and make the understanding of the theory explicit during discussions about how the LC theory and its components interrelate. The second approach investigated was 'organizational learning' to engage the organizations in the development of a collective learning process and collective competencies to promote the adoption of LC and its implementation. Finally, the third approach was the use of 'action learning', in which regular meetings were held with a group of participants steered by a set advisor who questioned participants about their managerial problems and required participants to commit to bringing a solution to be discussed with the group.

An approach somewhat similar to action learning meetings, which has been gaining popularity amongst the LC community, is the study-action team™ (Lean Project Consulting 2010). In this setting, participants are tasked with reading a book and meeting to discuss the book and reflect on how the book's teachings apply to their environment. However, Scott et al. (2001) faced some problems when trying to use action learning in a manufacturing company using LP practices. They found that some of the workers who participated in the action learning sets viewed 1-hour per week spent on these activities as inactive work, and as activities that 'legitimized non-work' in a just-in-time environment in which people were rewarded for being 'visibly active urgent, loud, and hands-on in the factory'. In this case, the manufacturing company workers may have misinterpreted what LP means, but does that remind us of the construction environment and how LC may be perceived by some practitioners?

If activities such as action learning sets and study-action teams™ are not viewed as productive, they do not encourage participation and collective growth. Therefore, we suggest that planning sessions and regular meetings, along the lines of the LPS™, already in place at the organization be used as the starting point for the organizational learning process. In these settings, LC concepts and principles can be used as the basis

for discussion and explanation of the production phenomena and promote learning amongst project participants.

Another important point concerning LC learning is the need to 'unlearn'. According to McGill and Slocum (1993, p.78): *"organizational learning is about more than simply acquiring new knowledge and insights; it requires managers to unlearn old practices that have outlived their usefulness and discard ways of processing experiences that have worked in the past. Unlearning makes way for new experiences and new ways of experiencing. It is the necessary precursor to learning."* This quote illustrates much of what has been happening in the construction industry for years as construction management researchers have called for a reform in the way the industry operates and for a theory of production management (Koskela and Howell 2002).

McGill and Slocum (1993, p.76) also suggest that the learning organization promotes continuous experimentation and the pursuit of continuous improvement, and rewards behaviors that reinforce this pattern: "*a learning organization has a culture of value set that promotes learning. A learning culture is characterized by its clear and consistent (1) openness to experience; (2) encouragement of responsible risk taking; and willingness to acknowledge failures to learn from them. (…) Groups engage in active dialogue and conversations, not discussions. These conversations are reflective, as opposed to argumentative, and they are guided by leaders who facilitate the building of strong relationships among key stakeholder groups."*

CONCLUSIONS

This paper discussed hypotheses related to the evolution of LC in the industry with the aim of forming a basis for an informed discussion on how to promote sustained and informed learning in construction.

The literature review supports H1. The basis of LP is somewhat undefined, even at its source at Toyota, and most books on the topic do not define LP is a theory. That has not been detrimental to its growing popularity. However, in the process of abstracting ideas away from their original context, packaging them for transfer and later for implementation, biases are introduced. Without a foundational definition to use as a touchstone, it is difficult to assure that its dissemination has kept its core concepts. The lack of agreement in terms of what LP means may have an impact on the way LC practices are understood and disseminated across the industry. Thus, a new hypothesis for future research emerges: *"the abundance of meanings related to LP impacts the way academic courses, research, and professional training programs about Lean Construction are developed.*

A review of how LP slowly transitioned to construction starting from the early 1990s supports H2. Papers and information available in the IGLC (2010) and LCI (2010) websites suggest that academics were, and still are, very much involved in LP dissemination in the construction industry.

H3 builds on the previous two hypotheses. The promotion of meaningful learning experiences and informed discussions about LC concepts, principles, and tools should contribute to the advancement of LC in a sustainable way and promote uniformity in the way concepts are learned across the industry. In many ways the construction industry has to both get rid of old habits and learn to work differently. Sharing experiences in communities such as the IGLC, EGLC, LCI, and many research labs

helps industry professionals to engage in new experiences, share their successes and failures, and make the implementation of LC scalable in a sustainable fashion. In conclusion, Figure 1 summarizes this view of the journey starting with the translation of Lean Production to Lean Construction by academics, followed by the translation and implementation in small groups within the industry, and finally broad implementation across the industry

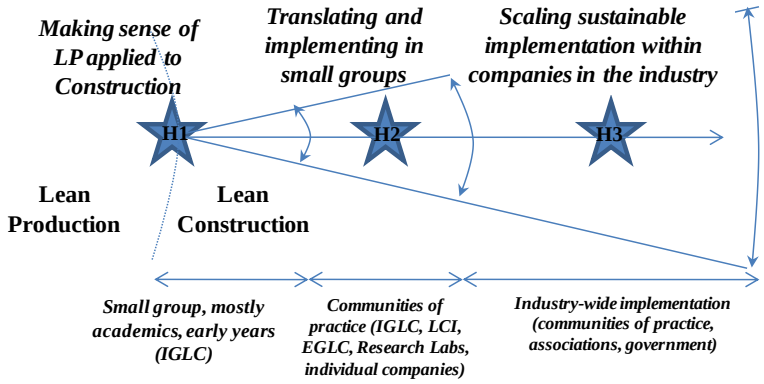

Figure 1: Relationship between the hypotheses presented

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