The current issue and full text archive of this journal is available at
www.emeraldinsight.com/0969-9988.htm

Exploring lean construction practice, research, and education

Thaís da C.L. Alves
Department of Civil, Construction, and Environmental Engineering, San Diego State University (SDSU), San Diego, California, USA
Colin Milberg
The ReAlignment Group, Ltd, USA, and
Kenneth D. Walsh
Department of Civil, Construction, and Environmental Engineering, San Diego State University (SDSU), San Diego, California, USA

Abstract

Purpose – The purpose of this paper is to investigate the history of dissemination and use of lean concepts in construction and potential challenges for continued use, as application of lean concepts transitions from a small group of first adopters to an industry-wide community.

Design/methodology/approach – Using insights obtained from a meeting with industry practitioners, literature review, and published cases in which different approaches were used to disseminate lean production/construction, evidence is presented that supports these challenges.

Findings – The authors identify three challenges facing lean construction (LC) practitioners, researchers, and educators. One challenge is lean has many meanings (whether denoted or connoted) when applied to construction. Another challenge is to have academics constantly working with industry practitioners to keep working on the adaptation of concepts/systems and not only tools. The third challenge is that without a sustained effort to engage people in meaningful learning experiences, LC may be viewed as a fad in the construction industry.

Research limitations/implications – The discussion presents the authors' interpretation of facts and existing literature reviewed to support the arguments made. Moreover, while the literature reviewed addresses sources from different parts of the world, the preponderance of the authors' research activities and experience are limited to two countries, Brazil and the USA.

Practical implications – In the face of overwhelming interest in lean by the construction industry, research on effective methods for disseminating lean concepts is overdue.

Social implications – By partnering with industry practitioners who are already implementing LC or want to start the journey, academics have access to projects (labs in the real world) and can bring back to the classroom examples to educate future generations of professionals who can push for changes in the industry. This partnership also helps the validation of experiments regarding LC implementation, as data can be collected and analyzed in a scientific way, and can be documented for dissemination within the industry.

Originality/value – The paper discusses challenges 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.

Keywords United States of America, Brazil, Construction industry, Education, Lean construction, Construction management

Paper type Viewpoint

1. Introduction[1]

Lean Production (LP) concepts, principles, and tools have been studied by academics for over 20 years (e.g. Schonberger, 1982; Womack *et al.*, 1990). Nonetheless, for many the term LP 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;

Engineering, Construction and Architectural Management
Vol. 19 No. 5, 2012
pp. 512-525

0969-9988
DOI 10.1108/09699981211259595

Green and May, 2005; 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). At this point in the construction industry, as in other sectors, a large body of "Lean" literature and implementation examples abound (e.g. International Group for Lean Construction (IGLC), 2010; Lean Construction Institute (LCI), 2010).

The need for change in construction practices has been discussed time and time again throughout the years and their echoes are still present in people's minds (e.g. Laufer and Tucker, 1987; Latham, 1994; Egan, 1998; Koskela and Howell, 2002 to name a few papers published in the past 25 years). These calls for change did not merely request the adoption of new technology and tools, or the acquisition of the new skills needed to operate them. Rather, they called for a change in the way the industry fundamentally operates and invariably focussed on the management of the entire construction process.

The industry is clearly facing a change of paradigm, and whether or not this combination of theory and related practices will still be called LC ten years from now is yet to be seen. However, early adopters in the industry are reaping benefits, which cannot be achieved without a change in the current mindset as suggested by previous studies (Miller *et al.*, 2009).

In this paper, the authors focus on how LP has evolved in the construction industry and speculate about the implications that evolution brings to LP's widespread dissemination in this industry through academic and industry communities of practice located all over the world. The authors discuss one way to bridge the gap between theory and practice through education and applied research. Even though this is not the only way to advance LC as an applied theory, it certainly has its merits which are discussed throughout the paper. According to Kuhn (1970, p. 169): "The scientific community is a supremely efficient instrument for maximizing the number and precision of the problem solved through paradigm change." Additionally, educators in many institutions in the field of Construction Management carry out applied research, are in close contact with the industry, and can bring back to the classroom examples to be discussed with students who will join the industry and help in promoting changes in the current *modus operandi*. LC practitioners and academics have been trying to expose the flaws of old systems to move on with the new (e.g. Koskela and Howell, 2002; Miller *et al.*, 2009). However, most practitioners do not have time to write papers and textbooks to inform future generations, and currently few candidate textbooks are available to discuss the topic (and some are hotly criticized, e.g. Howell, 2011).

2. Research method and goals

This paper discusses the challenges related to the current understanding of LC and its development and dissemination in the industry and academia. Overall, the paper aims to discuss important aspects related to LC learning and training programs, in order to create a basis for further research into sustainable approaches for teaching LC in different settings within the construction industry.

The discussion presented here has its limitations as it presents the authors' interpretation of facts and existing literature reviewed to support the arguments made. Moreover, while the literature reviewed addresses sources from different parts of the world, the preponderance of the authors' research activities and experience are

limited to two countries, Brazil and the USA. These countries have very active academic institutions promoting practice, research, and education in LC. Also, in the US professional institutions have led the dissemination of LC in the country and elsewhere (e.g. the LCI chapters in the USA and abroad, or the American Institute of Architects which have promoted the use of LC concepts in one of its families of contracts).

The identification of the challenges was made via literature review, first-hand interactions with companies attempting to deploy LC in research-related projects carried out by the authors, and the authors' interaction with different communities of practice in the USA, more specifically in California, and in different parts of Brazil (based on previous work developed by the first author).

The idea to write this paper, and the first step taken toward it, came after a discussion on LC education in a seminar held at University of California, Berkeley during the Fall 2009. The second author invited a group of companies located around the San Francisco, CA, Bay Area to participate in a meeting to discuss the topic. Participants shared their experiences about LC education, including the challenges and rewards their educational efforts offered for them and others who work with their organizations. Some companies had developed their own programs to teach LC, and others seemed to be searching for guidance. During the meeting, the second author of this paper moderated the debate, and the first two authors gathered comments for further discussion and potential development of an LC educational curriculum. After reviewing the discussions and outcomes of that meeting a few conclusions were made: participants had different interpretations of important tenets of LC; to some companies the focus of LC implementation was more on tools and marketing than the development of a deep understanding of LC; and even though participants wished to see some sort of structured LC education, and potentially certification to attest proficiency on the topic, no one could agree on how that could be done. Not surprisingly, similar issues had been noted by the authors in the communities of practice in which they had been working or previously worked.

In a following stage, the authors gathered evidence from the literature on the topic and from current developments related to the advance and implementation of LC practices in the construction industry in the USA and abroad. We searched the literature in academic conferences and journals, and professional publications (e.g. *Engineering News Record* magazine in USA, books such as that of Miller *et al.*, 2009) for different cases about LC implementation. Finally, the authors organized their thoughts into three main challenges, which are presented for discussion in this paper:

- Challenge 1 (C1): "There are many meanings (whether denoted or connoted) for Lean when applied to construction."
- Challenge 2 (C2): "Academics should work closely with the industry (organizations and consultants) in the translation of concepts from the manufacturing industry to construction and to promote the systemic use of concepts/systems and not only the use of tools."
- Challenge 3 (C3): "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."

3. Discussion of challenges

Challenge 1 (C1): "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 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, p. 392) argue that "a coherent philosophy for lean construction has not yet been developed." However, Ballard *et al.* (2007, p. xi) define Lean as "a fundamental business philosophy – one that is most effective when shared throughout the value stream" and Diekmann *et al.* (2004, p. iii) define LC as "the continuous process of eliminating waste, meeting or exceeding all customer requirements, focusing on the entire value stream and pursuing perfection in the execution of a constructed project." In this context, waste is understood as the actions and/or the use of resources or features that are not necessary to deliver a product or service to the customer. Wasteful practices consume resources but do not add value to the final deliverable. The concept of value stream refers to the chain of tasks value adding and non-value adding, which are necessary to deliver the final product to the customer, and reminds practitioners of the need to see the whole process that deliver a product or service, and not only isolated activities.

According to Ballard *et al.* (2007, p. 2): "Lean can be characterized in terms of objectives, principles, and methods or tools." The Lean objective refers to an ideal to be achieved through the implementation of principles, methods, and tools. The objective is generic in nature and drives continuous improvement (Rother, 2010) (e.g. provide what the customer wants, when wanted, with no waste throughout the value stream). The principles are still generic but narrowed down to get closer to implementation, they may come accompanied by a verb and a major concept (e.g. increase transparency, define the value stream) or represent the implementation of a major concept (e.g. flow) to drive changes. Finally the tools allow the implementation of principles to help in the pursuit of the objective (e.g. use of devices to share information (indicators, safety instructions) to drive continuous improvement and drive waste out of processes). However, a review of the literature supports the idea that there is a lack of agreement regarding the definition of Lean.

One of the reasons for the lack of a precise (and widely accepted) 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, pp. 972-3) 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) LT 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 Ollivella *et al.* (2008) there is a group of work organization practices that are related to the implementation of LP, e.g. standardization, discipline, and control; continuing training and learning; participation and empowerment, among others. Diekmann *et al.* (2004) also point out, on their report to the Construction Industry Institute, a series of fundamental principles and knowledge areas which have evolved over the years to form LP. These practices and principles 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 solely as a set of tools and practices aimed at reducing waste in construction projects and the implementation of the Last Planner System (LPS™) of production control, as this system emulates many concepts, principles, and tools found in the literature on TPS (i.e. Ohno, 1988; Shingo, 1989): planning based on actual needs of the project and its actors (pull planning) rather than on forecasts, analysis of the root causes of problems, and definition of sound assignments, to name just a few. That LPS™ often acts as a starting point for LC implementation is suggested by the predominance of papers on project management in the IGLC conferences, such as the ones analyzed by Alves and Tsao (2007).

As Ohno (1988) and Shingo (1989) reinforced the need to identify and banish waste in their classic books, the construction industry started its 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 recently published papers, and in discussions in forums, by those who are in the initial stages of LC implementation (e.g. Forsberg and Saukkoriipi, 2007).

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."

Green and May's (2005) research suggests that there are (tacit) "concurrent and competing" Lean models, which they characterize as: Lean Model 1 – waste elimination; Lean Model 2 – partnering; and Lean Model 3 – structuring the context. Model 1 focusses on Lean as waste elimination and its proponents have blended the

new discourse based on waste elimination with the one based on "improvement story lines" (p. 508) and a "pre-existing industry recipe." Model 2 focus on teamwork and partnering throughout the supply chain, and the need to reconcile different goals found in projects. Both models 1 and 2 fail to recognize the importance of the human resources. Model 3, recognizes the need for "continuous evolution" and training as a fundamental piece of the industry change toward LC implementation. Green and May's (2005) research attempted to categorize how construction sector policy makers view LC and provided some clues as to what kinds of definitions and discourses are found across the industry.

In addition to the existence of multiple Lean models across the industry, 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 LPS™ and apparently some understanding of Lean as partnering.

Some practitioners argue that they have been using Lean concepts for years, but a trained eye soon realizes that this is not the case. In fact, many are focussed on the use of tools, and may have a narrow understanding of what LC entails (Green and May, 2005; Emmitt *et al.*, 2005). Practitioners may have used bits and pieces of practices that resemble Lean concepts and tools but these may not behave like a system and may not promote some of the Lean tenets.

In addition to the evidence found on the literature, through close interaction with industry practitioners, the authors have also found anecdotal evidence of Challenge 1:

(1) LC as prefabrication: "Is LC something like SIPs (Structural Insulated Panel)? […] To save time and money."

(2) LC as keeping high efficiency: "We have been using Lean concepts for many years. We keep track of our workers productivity to make sure no time is wasted and to improve their efficiency." Recently, Lean was defined, in an article found in an association's online magazine, as "asset productivity, referring to current and fixed assets along with people" (Stevens, 2010).

(3) Lean as LPS™ implementation: the LCI has trademarked the LPS™, and copyrighted its related ideas and materials to "prevent people who misunderstand or misrepresent the system from using it in trade" (Mossmann, 2009). It is not uncommon for the authors to hear people who say they are using the LPS™ or Lean interchangeably, or attempting to do so, and have their own interpretation of the topic.

- "We are using the Last Planner but the foremen are not involved in the meetings."
- "The lookhead plan is a formality and it is something that we do to send to our offices."
- "I've been in pull planning sessions in which tasks and constraints are identified but no one tracks the commitments people make during the meetings." Then, is that really a pull planning session or just a disorganized meeting?

(4) Lean as using visual aids and tools to manage production: some people who visit construction sites using LC tend to pay close attention to the visual aids

used to communicate information about production and try to replicate them in their organizations. This is in some ways similar to early adopters of the quality movement who copied visual tools and procedures after visiting Japanese plants (Cole, 1999).

(5) Lean as building information modeling (BIM) and virtual design and construction (VDC): contractors, who are using BIM and/or VDC, even in the early stages, claim they are "doing Lean" because they use them both as a means to coordinate design and construction.

The abundance of LP and LC meanings calls for more research to explain what their constituent concepts represent, and to search for more uniform definitions to shape a common understanding throughout the industry. Furthermore, the practical execution impacts of this condition require additional study. One potential impact relates to how newcomers, specially owners who hire services related to the construction industry, understand LC, and how they can differentiate between organizations truly invested in implementing LC from those using it as part of their marketing campaign or adopting a shallow perspective as indicated in the work of Green and May (2005).

Challenge 2 (C2): "Academics should work closely with the industry (organizations and consultants) in the translation of concepts from the manufacturing industry to construction and to promote the systemic use of concepts/systems and not only the use of tools."

The migration of these concepts to the construction industry initially happened as consultants with strong ties to academia and academics, through trial and error, adapted these concepts to the peculiarities, and needs of the construction industry. "Incorporation of lean into the theory of production has lagged behind innovations in practice" (Ballard *et al.*, 2007, p. 3). The ideas presented in LT were (and still are) considered by some as applicable to the manufacturing industry but not to construction, or at least not without adaptation. "Lean [in construction] is still in its early adopter phase" says Miller *et al.* (2009) as owners, in most cases, are the ones trying to overcome the inertia of a big industry and pushing for change.

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. Koskela's report is one of the most popular, if not the most popular, text on LC among academics. However, despite his efforts to translate what he called the new production philosophies to the construction industry, the report was never a popular reading in the industry setting and may not have influenced practitioners' perceptions regarding LC (Green and May, 2005). It took other rounds of academic and practical work to bring Koskela's ideas, and especially the 11 principles he outlined, to the broader industry.

Jorgensen and Emmitt (2008) criticize the lack of detail presented in publications regarding Japanese management practices, and the lack of description of data collection and validation. Green and May (2005) also accuse LC advocates of having a unitary perspective, meaning that LC can be implemented irrespective of the context and the actions of different organizational actors.

It is worth informing the reader that research on LC implementation is very much based on the development of case studies and action research settings, and the quest for a theory of construction management. LC is not widely implemented in the industry, thus making it difficult for researchers to work with large populations or make any statistical sense of much of the data collected across projects. Although

many directions could be pursued from this discussion, the point here is only to call attention to the role of academics in translating and disseminating LC.

Koskela (2004) stresses the need for adaptation when LT principles are applied to construction. Management principles are context specific and depend on culture, local market and business conditions, level of education, and incentive structures, among 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).

Even as 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. In addition to that, Morrey *et al.* (2010) draw attention to the importance of path dependencies in making the transition from traditional to Lean systems. Past experiences dictate the course of future undertakings and how organizations learn new ways of dealing with their daily tasks.

Lillrank (1995) uses the "high-voltage electric transmission analogy" to explain that the transfer of ideas travel through an "idea line" in which losses will 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, p. 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." Along these lines, academic groups such as the IGLC and its European branch (EGLC), as well as industry organizations such as the LCI play an important role in bridging the gap between practice, research, and education. For instance, in the USA many LCI chapters have academics in their steering committees which allow academics to have direct access to projects, and actively participate in the discussion on how to promote LC to their local communities of practice. Similarly, the IGLC and the EGLC have promoted yearly events that attract mostly academics but also practitioners who present papers and engage in discussions about LC implementation around the world.

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?" In this regard, academics should keep working with practitioners to put the theory into test, after all the industry holds the keys to the labs (projects) that academics need to advance and document knowledge. As academics conducting research have access to multiple organizations and types of projects, they should also work to make the theory more robust and general in terms of its application to the construction industry. This leads to the third challenge, which points out the need for

continuous learning to sustain improvement and promote change in the construction industry.

Challenge 3 (C3): "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 the authors have encountered many examples of companies and individuals who are eager to learn about LT, but few who are willing to spend the time, money, and effort necessary to learn the basis of what the literature presents as LT 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.

The authors believe that many companies in the construction industry have currently embraced systems and tools (e.g. LPS™, pull planning, *kanban*, A3) but not necessarily the principles they are designed to support. This is a very similar environment to the one described by Cole (1999) about the quality movement in USA in its early years. The quality management movement was perceived by US 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." 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 (Berggren, 1993).

Hirota *et al.* (1999) investigated potential ways to disseminate LC in organizations and came up with three approaches: the use of a tool to negotiate meanings, organizational learning, and action learning. Concept mapping was used 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. Organizational learning was used to engage the organizations in the development of a collective learning process and collective competencies to promote the implementation of LC. Action learning was set forth through regular meetings 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 solutions to be discussed with the group.

An approach similar to action learning meetings is the study-action team (Lean Project Consulting, 2010) in which participants are tasked with reading a book and meeting to discuss it and reflect on how its 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 one-hour per week spent on these activities as inactive work, and as activities that "legitimized non-work" in just-in-time environment in which people were rewarded for being "visibly active urgent, loud, and hands-on in the factory."

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.

4. Recommendations

In order to address points raised by this paper, recommendations are presented and may represent opportunities for research into effective methods for disseminating LC. Creating sustainable initiatives to implement and teach LC requires academics and practitioners to come to grips in terms of what is fundamentally wrong with current practices and how LC can address these problems, as pointed out in the LC literature, instead of treating old problems with new names:

- Developing an undergraduate curriculum that incorporates LC: some may be in favor of a class to teach LC basics while others will favor that the concepts be introduced in the existing course material. This way the new generation will decide on how to mix and match LC concepts with the most traditional practices in the industry.
- Developing a professional curriculum that incorporates LC: professional associations have started to offer short seminars and workshops on LC, which could become part of their continuous education programs.
- Using metaphors to explain concepts and how they are related: metaphors are extensively used in the Lean literature to present concepts and how they are related. The fable of the "tortoise and the hare," and the need to "lower the river to reveal the rocks" are examples (Ohno, 1988).
- Working toward the "a-ha moment": simulations are usually a group activity which have the power to create the "a-ha moment."
- Using educational videos: a multitude of videos explaining concepts related to Lean implementation can be found in sites such as YouTube, practitioners', and professional associations' web sites.
- Partnering with professional organizations and research institutions: currently, the LCI, research labs, and academic programs still work closely with many organizations to train professionals in LC and develop case studies to advance the knowledge on LC. Many practitioners are experimenting with LC but do not have an in depth understanding of Lean. That requires academics to analyze these experiments for other variables that could impact success or failure, to analyze these multiple streams of experimentation for common practices that can be attributed to the success or failure. This is important to future adoption and dissemination as well as identification of practices adopted by organizations.

5. Conclusions

This paper discussed challenges 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 basis of LP is somewhat undefined (C1), 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. According to the discussion presented in C2, academics should work closely with industry practitioners to aid in the translation and test of LC concepts and to promote their use not solely focussed on tools but rather in a more holistic understanding of the concepts. Without a foundational definition to use as a touchstone, it is difficult to assure that throughout its dissemination it will keep 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.

Having a holistic understanding of what LC entails would also help in disseminating the concepts to the broader society, and in the education of the future workforce. For instance, owner organizations that hire construction-related services in private and public sectors would benefit from distinguishing companies that have adapted its practices to promote value and banish waste from those simply stating it as part of their marketing campaigns. For public owners, this would mean the potential for projects that address the population's needs with more efficient use of public resources.

By partnering with industry practitioners who are already implementing LC or want to start the journey, academics have access to projects (labs in the real world) and can bring back to classroom examples to educate future generations of professionals who can push for changes in the industry. This partnership also helps the validation of experiments regarding LC implementation as data can be collected and analyzed in a scientific way, and can be documented for dissemination within the industry.

Challenge (C3) builds on the previous two challenges. 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. 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 order to prevent LC from becoming a fad, the problem in C1 should be addressed, the roles discussed in C2 should be defined, and research needs to be done on evaluation/validation of current suggestions and an understanding of the components necessary for successful dissemination of LC (C3).

Note

1. An earlier version of this paper appeared in the Proceedings of the 18th International Group for Lean Construction Conference (IGLC-18), 2010, Walsh, K. and Alves, T. (Eds), Technion, Haifa, Israel, pp. 435-4, and was presented during that event.

References

Alves, T.C.L. and Tsao, C.C.Y. (2007), "Lean construction 2000-2006", *Lean Construction Journal*, Vol. 3 No. 1, pp. 46-70.

Ballard, G. (2008), "The lean project delivery system: an update", *Lean Construction Journal*, pp. 1-19, avaliable at: www.leanconstruction.org/lcj/paper2008issue.html

Ballard, H.G., Kim, Y.W., Jang, J.W. and Liu, M. (2007), *Roadmap for Lean Implementation at the Project Level*, CII Research Report No. 234-11 Construction Industry Institute, The University of Texas, Austin, TX, 409pp.

Berggren, C. (1993), "Lean production: the end of history", *Work Employment Society*, Vol. 7 No. 2, pp. 163-88.

Cole, R.E. (1999), *Managing Quality Fads: How American Business Learned to Play the Quality Game*, ASQ, Oxford University Press, New York, NY, 284pp.

Diekmann, J.E., Krewedi, M., Balonick, J., Stewart, T. and Won, S. (2004), *Application of Lean Manufacturing Principles to Construction*, CII Project Report No. 191-11 Construction Industry Institute, The University of Texas, Austin, TX.

Egan, J. (1998), *Rethinking Construction*, Department of Trade and Industry, London, 37pp.

Emmitt, S., Sander, D. and Christoffersen, A.K. (2005), "The value universe: defining a value based approach to lean construction", *Proceedings IGLC-13, Sydney*, pp. 57-64.

Forsberg, A. and Saukkoriipi, L. (2007), "Measurement of waste and productivity in relation to lean thinking", *Proceedings IGLC-15, East Lansing, MI*, pp. 67-76.

Green, S.D. and May, S.C. (2005), "Lean construction: arenas of enactment, models of diffusion and the meaning of 'Leanness'", *Building Research and Information*, Vol. 33 No. 6, pp. 498-511.

Hines, P., Holweg, M. and Rich, N. (2004), "Learning to evolve", *International Journal of Operations and Production Management*, Vol. 24 No. 10, pp. 994-1011.

Hirota, E.H., Lantelme, E.M.V. and Formoso, C.T. (1999), "Learning how to learn lean construction concepts and principles", *Proceedings IGLC-7, Berkeley, CA*, pp. 411-22.

Howell, G. (2011), "Book review: build lean: transforming construction using lean thinking by Adrian Terry & Stuart Smith", *Lean Construction Journal 2011*, pp. 3-8, avaliable at: www.leanconstruction.org/lcj/paper2011issue.html

International Group for Lean Construction (IGLC) (2010), "Home," available at: www.iglc.net (accessed May 3, 2010).

Jorgensen, B. and Emmitt, S. (2008), "Lost in transition: the transfer of lean manufacturing to construction", *Engrg, Constr., and Arch. Mgmt*, Vol. 15 No. 4, pp. 383-98.

Koskela, L. (1992), "Application of the new production philosophy to construction", CIFE Technical Report No. 72, Stanford University, Stanford, CA, 87pp.

Koskela, L. (2004), "Moving-on – beyond lean thinking", *Lean Construction Journal, Lean Construction Institute*, Vol. 1 No. 1, pp. 24-37.

Koskela, L. and Howell, G. (2002), "The underlying theory of project management is obsolete", *Proceedings of the PMI of the PMI Research Conference*, Project Management Institute, pp. 293-302.

Koskela, L. and Rooke, J. (2009), "What triggers management innovation?", *Proceedings IGLC-17, Taipei*, pp. 337-43.

Kuhn, T.S. (1970), *The Structure of Scientific Revolutions*, 2nd ed., The University of Chicago Press, Chicago, IL, 210pp.

Latham, M. (1994), *Constructing the team: Final report of the Government/Industry Review of Procurement and Contractual Arrangements in the United Kingdom Construction Industry*, HMSO, London, 130pp.

Lathin, D. and Mitchell, R. (2001), "Learning from mistakes", *Quality Progr*, Vol. 34 No. 6, pp. 39-45.

Laufer, A. and Tucker, R.L. (1987), "Is construction planning really doing its job? A critical examination of focus, role and process", *Construction Management and Economics*, Vol. 5 No. 3, pp. 243-66.

Lean Construction Institute (LCI) (2010), "Home," available at: www.leanconstruction.org/ (accessed May 3, 2010).

Lean Project Consulting (2010), "Home," available at: www.leanproject.com/ (accessed may 19, 2010).

Lillrank, P. (1994), "Social preconditions for lean management and its further development", in Sandberg, Å. (Ed.), *Enriching Production Perspectives on Volvo's Uddevalla Plant as an Alternative to Lean Production*, Swedish Institute for Work Life Research, Stockholm, pp. 427-35 (digital edition, 2007).

Lillrank, P. (1995), "The transfer of management innovations from Japan", *Organization Studies*, Vol. 16 No. 6, pp. 971-89.

McGill, M.E. and Slocum, J.W. (1993), "Unlearning the organization", *Organizational Dynamics*, Vol. 22 No. 2, pp. 67-79.

Miller, R., Strombom, D., Iammarino, M. and Black, B. (2009), *The Commercial Real Estate Revolution: Nine Keys to Lowering Costs, Cutting Waste, and Driving Change in a Broken Industry*, John Wiley & Sons Inc, Hoboken, NJ, 328pp.

Morrey, N., Pasquire, C. and Dainty, A. (2010), "The impact of path dependencies on lean implementation within a construction company", *Proceedings IGLC-18, Haifa*, pp. 425-34.

Mossmann, A. (2009), "Learning last planner", available at: www.leanconstruction.org/pdf/LearningLPS.pdf (accessed October 13, 2010).

Ohno, T. (1988), *Toyota Production System: Beyond Large-Scale Production*, Productivity Press, Cambridge, MA, 142pp.

Ollivella, J., Cuatrecasas, L. and Gavilan, N. (2008), "Work organisation practices for lean production", *J. of Manufacturing Technology Mgmt*, Vol. 19 No. 7, pp. 798-811.

Pettersen, J. (2009), "Defining lean production: some conceptual and practical issues", *The TQM Journal*, Vol. 21 No. 2, pp. 127-42.

Rother, M. (2010), *Toyota Kata*, McGraw-Hill, New York, NY, 306pp.

Schonberger, R.J. (1982), *World Class Japanese Manufacturing Techniques*, The Free Press, New York, NY, 260pp.

Scott, F.M., Butler, J. and Edwards, J. (2001), "Does lean production sacrifice learning in a manufacturing environment? An action learning case study", *Studies in Continuing Education*, Vol. 23 No. 2, pp. 229-41.

Shingo, S. (1989), *A Study of the Toyota Production System*, Productivity Press, Portland, OR, 257pp.

Stevens, M. (2010), "Lean construction contracting", July-August 14-15, available at: www.dbia.org (accessed October 22, 2010).

Womack, J.P. and Jones, D.T. (2003), *Lean Thinking*, Free Press, New York, NY.

Womack, J.P., Jones, D.T. and Ross, D. (1990), *The Machine that Changed the World*, Harper Perennial, New York, NY, 323p.

Further reading

Mossmann, A. and Koskela, L. (2010), "Data about past IGLC conferences", Presentation by Lauri Koskela at the IGLC-18 at the Technion, Haifa.

NASFA, COAA, APPA, AGC, AIA (2010), "Integrated project delivery for public and private owners", available at: www.agc.org/projectdelivery (accessed October 12, 2010).

About the authors

Thaís da C.L. Alves is a civil engineer specializing in construction management and project-based production systems. Her areas of interest include the application of lean production/construction

concepts, principles, and tools to improve the performance of production systems and products in different stages of their life-cycle and supply chains. For more than ten years, she has been teaching, advising students, researching and collaborating with construction companies towards the dissemination and implementation of lean especially in the field of production planning and control at construction sites. Thaís da C.L. Alves is the corresponding author and can be contacted at: talves@mail.sdsu.edu

Colin Milberg comes to academia with five years work experience on the Central Artery Tunnel (CAT) project in Boston, which was, at the time, the largest civil works project in US history. This work experience influences both his teaching philosophy and his research interests, which converge in a desire to improve construction practice through innovative teaching and industry-relevant research.

Kenneth D. Walsh is Professor and Director of the J.R. Filanc Construction Engineering and Management Department at San Diego State University. He worked in the industry for eight years before entering academia in 2002. He has published 30 refereed journal papers about his research.