ASSESSING LEAN CONSTRUCTION MATURITY

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ABSTRACT

Embedding Lean Construction (LC) in an organisation typically requires many changes and is a challenging endeavour. In particular when transformations take place it becomes crucial to measure the current state of the maturation process. Hence there is a requirement for organisations to be able to demonstrate where they are in their LC journey. It has been widely acknowledged that maturity models (MM) provide organisations with such an assessment of the current state. Further benefits of MMs are the guidance and support when implementing a change or improvement strategy. The research presented aims to integrate both LC and MM to enable organisations to measure their current maturity in LC. A qualitative mixed method design was used including focus groups and interviews to explore the phenomenon of LC maturity from key informants. The major findings of the research are: MM can be integrated with LC, and a proposed validated framework can assess the current state of LC maturity within an organisation. The proposed LC maturity assessment framework labelled (LCMM) comprises five maturity levels, 11 Key Attributes, and 60 defined Behaviours, Goals & Practices with 75 Ideal Statements to measure the maturity within organisations embedding LC. This framework provides important support and guidance in the organisational LC maturation process.

KEYWORDS

Lean Construction Maturity, Maturity Models, Organisational Assessment, Maturation, Embedding Lean.

INTRODUCTION

The global construction industry faces the central challenge in improving its productivity and innovation (Larsson *et al.*, 2013). Consequently the productivity of the construction industry is a key driver with significant impact on the economic growth of countries globally (Abdel-Wahab and Vogl, 2011). Improving the productivity and innovation in the construction industry has recently been highlighted by the joint industry and government strategy in the UK 'Construction 2025' which

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has set out an ambitious call for improvement (Department for Business, 2013). The vision statement for the construction industry is to achieve by 2025, the reduction of the project overall time from inception to completion by 50% for both new-build and refurbished assets; 33% less cost for construction and whole life cost; 50% lower greenhouse gas emissions linked to the built environment; and improvement of the exports for construction products and materials. As a response, many organisations are seeking to achieve the required improvement through embedding LC; as one of the most prominent improvement approaches within the construction industry (Sage *et al.*, 2012). However, embedding LC requires changes in many ways (Green *et al.*, 2008, Koskela and Ballard, 2012, Nesensohn *et al.*, 2013b). It becomes crucial in evolving transformations to measure the gap between the current state in the organisation and where they want to be, in terms of embedding Lean (Meiling *et al.*, 2012). Hence there is a requirement for organisations to be able to demonstrate where they are in their LC journey.

LITERATURE REVIEW

CURRENT ISSUES WITHIN LC

In recent years, numerous reports have conveyed significant performance improvement through the adoption of LC, such as Bernstein and Jones (2013), Liu *et al.* (2011), and Mossman *et al.* (2011). Major benefits of using LC according to practitioners are: higher quality construction, greater customer satisfaction, greater productivity, improved safety, reduced project schedule, better risk management and greater profitability or reduced cost (Bernstein and Jones, 2013). The implication of this is that LC is increasingly recognised as an improvement approach of choice (Sage *et al.*, 2012), which delivers many of the desired outcomes This resulted in a growth of research activities and theory building (Jacobs *et al.*, 2012). Therefore, applying LC for design and construction within the industry is becoming a highly pertinent issue.

However, Koskela and Ballard (2012) observed that the effective delivery of projects through LC requires the organisations to develop new ways of thinking and integrate elements of production management and project management (PM) into a holistic system for construction. Another implication of this study is that such a project delivery system cannot be achieved by only applying certain tools or principles. Hence a major consequence of this is the radical organisational change often undertaken when implementing LC (McGrath-Champ and Rosewarne, 2009) – in whatever way LC is conceptualised and operationalised by individual organisations (Sage *et al.*, 2012). Nesensohn *et al.* (2013b) posited on the general requirement of organisational change initiated by embedding LC. This study pointed towards the concept that the transformation towards a Lean organisation that delivers construction projects in a Lean way requires a long-term and deep-rooted cultural change. This facilitates the embedment of Lean philosophy as second nature within the thinking of the organisation and its processes, by using Lean tools and techniques. Certainly the transformation towards LC will lead to changes in the culture and in its people (Green *et al.*, 2008), at both the temporary organisation (project) and the management level (Ballard and Howell, 1998). Consequently, this seems to be true for contractors, suppliers, or client organisations. Moreover, the process of transforming also requires

the involvement of the top management, in financial terms, as well as human resources, although even with this support, success is not guaranteed (Almeida and Salazar, 2003). Therefore organisational assessments such as MM become vital to embed Lean, because they measure the current state of maturity (implementation) in order to shaping future improvement activities (McElroy, 1996, Meiling *et al.*, 2012).

MATURITY MODELS

When talking about MM people often refer to the Capability Maturity Model Integrated (CMMI) as a synonym (Wendler, 2012). This MM is the successor of the Capability Maturity Model (CMM) that originated in the 1990s within the software industry and became the first widely-known maturity model (Tapia *et al.*, 2008). This CMMI claims to be a framework that guides organisations to improve their processes and to develop a culture of excellence for managing, developing and controlling of products or services through a number of best practices (CMMI Product Team, 2010). Furthermore, it is claimed that MM provides people with directions and information to priorities improvement actions, and initiating a cultural change (Pennypacker, 2005). In a similar way posit the developers of the CMMI that it would guide and improve the ability within an organisation to develop a culture of excellence (CMMI Product Team, 2010). Nevertheless, the CMMI and its predecessor have been criticised for its lacks of a guaranteed pay-off in relation to the additional effort and cost of moving upwards in maturity (Anthes, 1997).

Notwithstanding the criticisms on the CMMI has the construction industry recognised the potential offered by MM (Nesensohn *et al.*, 2013a). Furthermore remind us Veldman and Klingenberg (2009) in their study that measurable-stepwise process improvement stages as included in the CMMI are generally applicable to construction and engineer-to-order (ETO) organisations. In fact they describe the CMMI maturity levels as implementation ladder for organisations. Further empirical evidence for the usefulness of MM based on the CMM in construction is provided by a study from Amaratunga *et al.* (2002). A major research from Sarshar *et al.* (1999) developed an MM on the basis of the CMM for the construction industry: the Standardised Process Improvement for Construction Enterprises (SPICE). More attempts have been made to contextualise for instance the CMMI, to construction processes and areas such as the development of a standard model for e-procurement from Eadie *et al.* (2011). However there are many MM based on the CMMI which address different disciplines in the construction sector, for example PM or knowledge management; and 53 of them have been identified by Eadie *et al.* (2012) as CMM based models which are in general applicable to the construction sector. Generally, benefits derived from MM and maturity assessment efforts may be summarised as:

- Generate awareness and importance of the current state, identify potentials complexity and requirements for improvement (Wendler, 2012).
- Offer directions and information to prioritise improvement actions, and initiate a cultural change (Pennypacker, 2005).
- Deliver crucial information about strength and weaknesses to plan and direct on-going transformations (Perkins *et al.*, 2010a, Perkins *et al.*, 2010b).

- Serve as reference or benchmark to implement a change or improvement approach in a systematic and well-directed way (Cooke-Davies, 2007).
- Establishment of a common and shared language (Klimko, 2001).
- Provide the ability to develop a culture of excellence within an organisation (CMMI Product Team, 2010).
- Enable a sustained embedment of business processes (Eadie *et al.*, 2011).

A current series of texts published by CIRIA (UK) where academics and professionals have conflated their knowledge about LC, sustainability, and Building Information Modelling (BIM) pays a little attention on MM. Hence it confirms that the application of LC becomes more and more a pre-requisite within the supply chain of the UK Government and within the global environment in order to deliver more with less (CIRIA, 2013). Within this series of reports it is also demonstrated that maturity assessments within Lean are considered as a way to measure where organisations are on their journey whether it is a Lean- or a BIM-journey (Dave *et al.*, 2013). Furthermore there are notable developments within the UK Highway Agency (HA) and other institutions that advance the topic. For instance the HA created a Lean Maturity Assessment Toolkit (HALMAT) on the basis of the Lean Enterprise Self-Assessment Tool (LESAT) which has been used within the aerospace industry and was developed by the Massachusetts Institute of Technology (MIT). The aim of the HALMAT is to determine the Leanness (current maturity in LC) of the supply chain in relation to the objectives of the HA (Highways Agency, 2010). Finally Nesensohn *et al.* (2013a) and Nesensohn *et al.* (2014) call for further work into LC maturity and an appropriate framework that enables the measurement of the current LC maturity.

On the basis of this the following research focuses to answer the research question: How can we assess the current level of LC maturity in organisations and provide them with support and guidance towards greater LC maturity?

METHODOLOGY

To answer this question this research aimed to capture and interpret the meaning of the consensus of LC key informants on a phenomenon, a qualitative mixed method design including focus groups and semi-structured interviews to explore the phenomenon of LC maturity from key informants was adopted. Focus groups are considered as an appropriate method, through the production of a consensus of a group that experienced the phenomena (Morgan and Krueger, 1993). Semi-structured interviews were adopted to strengthen the validity of the data from the focus groups (Smithson, 2008), and enhance the depth and breadth of the phenomenon under investigation in particular within the construction sector (Shehu and Akintoye, 2010). Both the focus groups and the interviews utilised purposive sampling to select participants (Bryman, 2012), on the basis of quality experience in LC. Hence the key informants practiced LC over time (min two years) and therefore could attach meaning to the phenomenon of "LC maturity" and to the maturation of LC within organisations. Two focus groups involving five and six LC key informants respectively in the group discussions were conducted in the UK. In addition semi-structured interviews were undertaken with eleven LC key informants. These interviewees have experience in LC from six countries: UK, USA, Germany, Spain,

Peru, and Chile. Both the focus groups and the interviews were recorded, transcribed and later analysed with a phenomenological analysing approach (STEVICK-COLAIZZI-KEEN presented in Moustakas (1994)) for the focus group transcripts and the framework method© (Ritchie *et al.*, 2003) was utilised to analyse the interview data. Through combining the findings with current knowledge from the literature in particular on the basis of the CMMI a framework was developed called the Lean Construction Maturity Model (LCMM). This LCMM was then validated through three interviews and a focus group discussion with six key informants that participated in the study through the interviews and the focus groups in the first place.

SUMMARY OF THE FINDINGS

FOCUS GROUPS

The analysis of the focus group data led to the development of three overarching themes, which were labelled as follows: 1) LC maturity, its culture & behaviour and relevant competencies; 2) outputs and outcomes of being mature in LC; and 3) improving maturity in LC. Within these themes the experience of the LC key informants and their degree of consensus about LC maturity was revealed. Therefore an in-depth understanding of what maturity in LC looks like, how it is characterised, how maturity can be achieved and what outcomes and outputs are associated with being more mature in LC was developed. The results suggest that LC maturity can be described through attributes which include: a certain culture and behaviours, crucial competencies and Lean leadership that owns and drives a LC philosophy. Additionally, being mature in LC means having the knowledge that everything is a process with deliverables and every entity exists for a purpose. Also 'greater maturity' implies an understanding of what *value* ultimately means for the customer and knowing that culture and behaviour is more important than the tools and techniques – coupled with developing a clear vision as to the goal and purpose of LC. Therefore maturity in LC is not about the tools and techniques; rather it is, in part, about choosing the right tool to address specific problems, and supporting the processes that deliver ultimate customer *value.* Maturity in LC was further described as a culture that accepts changes and incorporates a systemic and scientific thinking for learning and strategic decisions. Organisations with more maturity in LC perform active learning and utilise their learning, making things simpler and having a high level of motivation that embeds Lean thinking in the DNA of the organisations.

SEMI-STRUCTURED INTERVIEWS

The interview findings provided further insights to understand LC maturity. The analysis revealed three major themes: 1) the attributes of maturity in terms of LC; 2) the importance and application of a LC maturity framework; and 3) dimensions through which LC maturity can be measured or recognised. There was wide consensus amongst the interviewees that the current state of LC maturity indicates where an organisation is on their Lean journey and how well the Lean philosophy, principles and methods have been assimilated throughout the organisation. Additionally, attributes of LC maturity have been confirmed and these include the organisation's processes, culture, way of thinking, training of people and behaviour of individual employees. In terms of the second theme it is widely perceived that

maturity and MM play a vital role in some organisations that are seeking to utilise more mature LC. In this respect most interviewees found that a LC maturity framework helps identify areas for further improvement in their LC transformation programme. The third theme identified a total of 96 separate dimensions through which LC can be measured or recognised, e. g. a) understanding customer value b) measuring of waste c) the thinking of the people d) their expertise e) culture and f) behaviour.

PRESENTING THE LEAN CONSTRUCTION MATURITY MODEL (LCMM)

Derived from the findings and linked with the literature the framework LCMM were developed. This framework is based on the CMMI because its suitability as fundament for an organisational maturity model for Lean has been proofed through the LESAT by Nightingale and Mize (2002). Hence the LCMM adapts the generic structure of the CMMI which is illustrated through Figure 1. Therefore addresses the LCMM similar as the CMMI the institutionalisation and implementation while at the same time indicating the capability and maturity (in terms of the LCMM in LC).

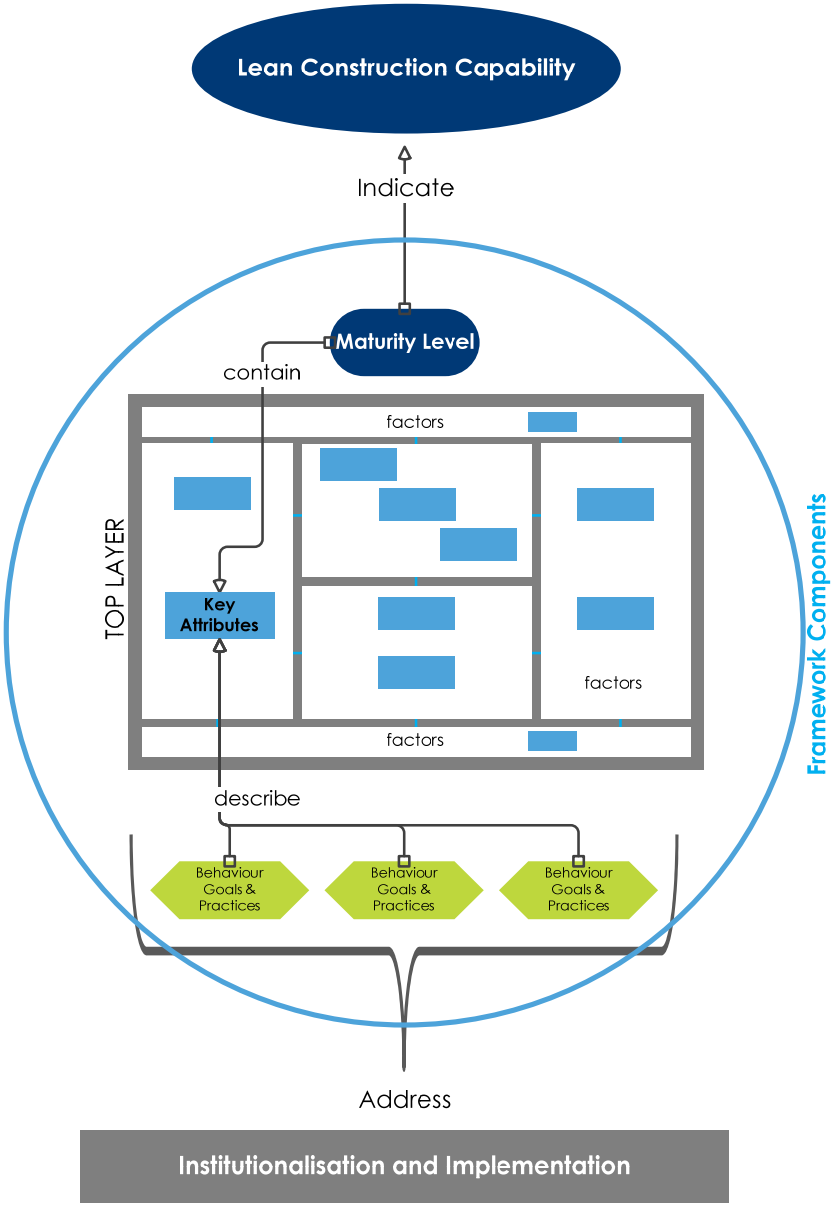

Figure 1: Structure of the developed LCMM

TOP LAYER, KEY ATTRIBUTES AND BEHAVIOUR, GOALS & PRACTICES

In total defined this research 11 Key Attributes (blue rectangles) which simplify LC maturity. These 11 Key Attributes are: Lean Leadership, Customer focus, Way of Thinking, Culture & Behaviour, Competencies, Improvement Enablers, Processes & Tools, Change, Work Environment, Business Results, and Learning and Competency Development.

These Key Attributes were organised into a Top Layer (grey box) which establishes a simple overview of what the LCMM is focusing on. Furthermore indicated the focus groups and interview findings that behaviours are an integral part of LC maturity. Therefore it was decided to develop not only goals and practices – which are part of the CMMI (CMMI Product Team, 2010) - but also elements related to behaviours to measure LC maturity accurately. This was achieve by integrating

goals and practices with the framework of the Shingo Prize self-assessment tool SCOPE (The Shingo Prize, 2013). SCOPE focuses on the behaviours of leaders, managers and other individuals within an organisation in terms of Lean. As a result, Behaviours, Goals & Practices (BG&P) were created these BG&P capture either:

- a *behaviour* associated with LC maturity
- a *goal* in the form of the [desired] characteristics of a more mature organisation
- a *practice* which is considered to be important for LC maturity.

In total 60 BG&Ps were defined, with each comprising of a name, as an identifying component, and at least one Ideal Statements per component, which must be met for an organisation to satisfy the related Key Attribute for a given maturity level. These Ideal Statements play a vital role in measuring the maturity of LC. Because of the constraints of space in this paper for illustrative purposes we present in Figure 2 one example of a Key Attribute including its BG&Ps and Ideal Statements; namely: Lean Leadership.

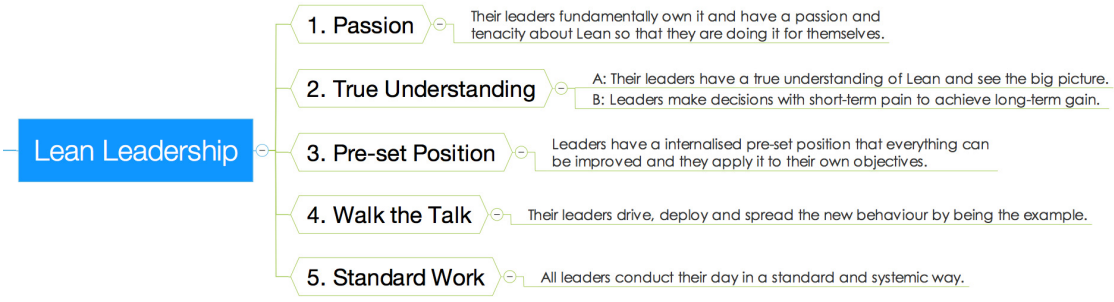

Figure 2: Example Key Attribute including its BG&P and associated ideal statements

MATURITY LEVELS

The maturity levels are utilised for the maturity assessment. Hence similar to the CMMI five maturity levels have been defined and are shown in Figure 3. The maturity levels measure the deviation between the Ideal Statement and the current state of the assessed organisation. This evaluation is carried out on the basis of evidence, observed behaviours, and actions of the organisation collected through a practitioner lead maturity assessment. Hence each of the Ideal Statements in the LCMM is evaluated against this data and mapped to a maturity level. For example, if evidence for Ideal Statement is weak, as demonstrated by the actions of the organisation then it would be evaluated as maturity level (0) – which is called "uncertain". If evidence for Ideal Statement is strong as demonstrated in the actions of the organisation it is classified as maturity level (2) – "systematic". Furthermore is important that the levels are seen as staircase which means that being on level 2 involves also the satisfaction of level 1. Table 1 illustrates the definition of each maturity level which will be used for an assessment.

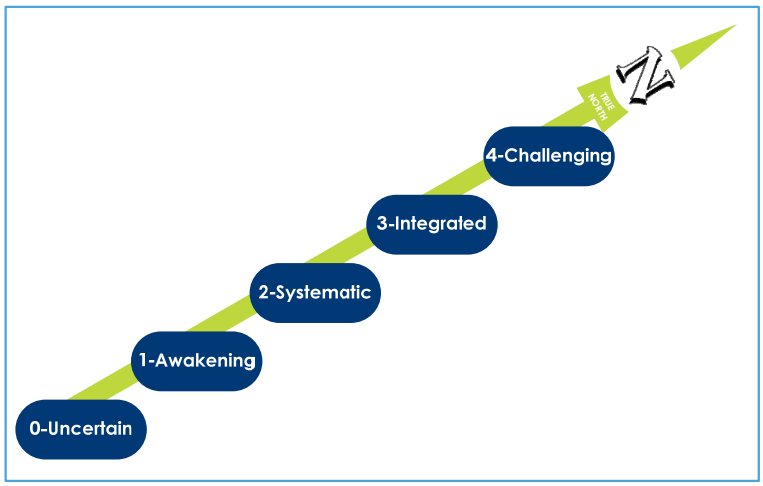

Figure 3 Maturity levels of the LCMM

Table 1: Definition of the Maturity Levels

Maturity level	Definition
0-Uncertain	The Ideal Statement is hardly evidenced in action
1-Awakening	General awareness exists and the Ideal Statement is inconsistently evidenced in action
2-Systematic	The Ideal Statement is systemically evidenced in action
3-Integrated	The Ideal Statement is interrelated as a whole and happens automatically
4-Challenging	The Ideal Statement is status quo which is challenged to improve further

CONCLUSIONS

There is an increasingly positive trend in the industry to implement LC and seek the required improvement targets. Hence knowledge about LC maturity and the ability to measure the current state of maturity as well as supporting organisations around the world in their transformation towards greater maturity in LC becomes vital. Returning to the research question - How can we assess the current level of LC maturity in organisations and provide them with support and guidance towards greater LC maturity? It is now possible to state that the integration of maturity models and LC to a framework enables organisations to measure their current state of LC maturity. This integration was achieved through the development of a validated framework for assessing LC maturity called LCMM. The framework was developed through the findings that emerged in this qualitative mixed method design research. The proposed LCMM provides a significant contribution to knowledge as it does enable organisations to achieve and enhance their understanding of LC and the awareness of their current maturity as well as by simplifying LC maturity into 11 Key Attributes. Furthermore has been proven through a validation involving a focus group and three interviews with previous participants of the study that the LCMM can measure the current state of LC maturity. The LCMM also defined a LC maturity assessment

method utilising five maturity levels, 11 Key Attributes, which have been described through 60 Behaviours, Goals & Practices, and 75 Ideal Statements that more mature organisations will exemplify. This LCMM is predominantly expected to be used within entities such as: clients, contractors, sub-contractors, and others in the supply chain; and perhaps long-term projects that are implementing LC. According to the practitioners involved in the validation of the proposed LCMM, this framework is an appropriate method if used by the right person to measure the current state of maturity and to support organisations in planning and directing their transformation towards greater maturity in LC. Furthermore, using the framework can foster discussions amongst teams and individuals about LC, which will enhance the understanding and awareness of Lean. Finally, the framework provides a unique opportunity to improve the LC capability in organisations as it provides a systemic and holistic overview of the current state, and the strengths and weaknesses of LC maturity.

FURTHER WORK

Thus, the findings of this research provide a solid foundation to investigate further LC maturity and, in particular, the LCMM. Further work needs to be done to test and demonstrate the whole range of benefits, and implications of the LCMM. This should be considered within a case study-driven research. Additionally, the 11 Key Attributes and their use in a project environment can be confirmed or disconfirmed.

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