AN INNOVATIVE FRAMEWORK FOR ASSESSING LEAN CONSTRUCTION MATURITY

Claus Nesensohn

A thesis submitted in partial fulfillment of the

requirements of Liverpool John Moores University

for the degree of Doctor of Philosophy

February 2014

AN INNOVATIVE FRAMEWORK FOR ASSESSING LEAN CONSTRUCTION MATURITY

by

Claus Nesensohn

Abstract

This thesis integrates Lean construction (LC) with the organisational assessment method of maturity models (MM) and delivers an original contribution to knowledge in the form of a validated innovative organisational framework to measure the current state of LC maturity, which is called Lean Construction Maturity Model (LCMM). This framework provides and supports organisations towards the development of greater maturity and subsequently enhances the awareness and understanding of LC. The aim of this research was to enable organisations to measure the gap between their current state and where they want to be in terms of embedding LC. Accordingly, the research addressed this aim further by providing businesses with support and guidance in their LC maturation process in particular in measuring sought improvement in their journey towards greater maturity in LC. The study was conducted as a qualitative mixed-method design in order to discover and achieve a rich understanding of the phenomenon of LC maturity from LC key informants and best fulfil the research aim. Consequently, a phenomenological approach was utilised, with focus groups (FGs) as the primary study, combined with a group interview as well as individual interviews as supplementary components. To ensure validity, three different approaches were deployed: first the triangulation of three different methods to collect the data, second a rich and thick-description, and finally the validation of the developed framework by member checks in the form of interviews and a FG. The major findings of this research are: the successful integration of MMs and LC achieved through the development of the proposed framework, and the simplification of LC into 11 Key Attributes that explain LC in a simpler and better way than before. This framework 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. Finally, the most important consequence of this work is the enabling of organisations to obtain a systemic and holistic overview of their current state of LC maturity and providing them with support in their maturation.

I would like to dedicate this thesis to Nadine and my beloved parents for their unconditional kindness and belief in me.

Table of contents

List of Figures

List of Tables

Acknowledgement

I always felt extraordinarily fortunate throughout my research to be able to extend my body of knowledge and learn from many great people. This thesis would not have been possible without the support and help of many individuals who contributed to and influenced my work in numerous ways.

My most grateful and sincere thanks goes to Prof. David James Bryde for his support, suggestions, innovative ideas and wise guidance throughout this research. He has been always there with valuable insights and challenges which played a significant role in my journey. I am also grateful to Dr. Edward Godfrey Ochieng and Damian John Fearon for their support and inspiring discussions on critical issues in this thesis. My gratitude is also extended to the School of the Built Environment for their financial support, provided by granting me a valuable scholarship to undertake this research, the accessibility to resources, and the support and encouragement of the staff and my research colleagues from the BEST Research Institute.

I owe many thanks to Prof. Klaus Peter Rössner (former supervisor) at the University of Applied Science Biberach for his support and recommendation to undertake a PhD study abroad. I also want to thank Alan Mossman for his time, support and inspiring discussions throughout my journey. I would like to also appreciate the participation and the contribution of Prof. Christine Pasquire and Dr. Andrew Ross as examiners of this thesis.

I would like to thank my parents for their continuous support and the love they have given me. They were always there when I needed them. Last, but certainly not least, I would like to thank Nadine, my fiancée, for her endless support and her constant understanding of me and my passion for my work, which enabled me to complete this thesis.

I am also grateful to many others who assisted in my research, without whom I would not have reached its successful completion.

Preface

During the endeavour of this research the author produced a number of research papers.

They are:

Papers in refereed journal publications

---

1. **Nesensohn, C**., Demir, S. T. and Bryde, D. J. (2013). Developing the True North route map as a navigational compass in a construction project management organisation. *Lean Construction Journal* V.2013 (1), pp.1-18.

2. **Nesensohn, C**., Bryde, D. J., Ochieng, E. G. and Fearon, D. J. (2014). Maturity and maturity models in Lean Construction. *Australasian Journal of Construction Economics and Building* V.14 (1), pp.45-59.

3. **Nesensohn, C**., Bryde, D. J. and Demir, S. T. (**IN REVIEW**). Evaluation of teaching experiences in Lean construction. *Engineering, Construction and Architectural Management*, pp.1-18.

4. **Nesensohn, C**., Bryde, D. J., Ochieng, E. G. and Fearon, D. J. (**IN REVIEW**). A Lean Construction Maturity Model for Organisations. *Engineering, Construction and Architectural Management*, pp.1-22.

Papers in refereed conferences or proceedings

---

1. Bryde, D. J., **Nesensohn, C.** (2014). Teaching innovative STEM methods with innovative hands-on simulation in the built environment. *HEA STEM Annual Learning and Teaching Conference 2014 [HEA STEM]*. Edinburgh, UK, 30 April-1 May. University of Edinburgh. [Abstract].

2. **Nesensohn, C.**, Bryde, D. J., Fearon, D. J. and Ochieng, E. G. (2013). Combining Lean construction with maturity models. *Proceedings 29th Annual ARCOM Conference*, Reading, UK, 2-4 September. *Association of Researchers in Construction Management*, ed. by Smith, S. D. & Ahiaga-Dagbui, pp.893-902.

3. **Nesensohn, C.**, Bryde, D. J. and Demir, S. T. (2013). Teaching Lean and Last Planner by using hands-on simulation (Villego). *Innovation In Built Environment Education (IBEE 2013)*. UNIVERSITY OF WESTMINSTER, 29-30 May 2013, pp. [Abstract].

4. **Nesensohn, C.**, Bryde, D. J., Ochieng, E. G. and Fearon, D. J. (2013). The occurrence of the term maturity within a management and construction management context. *Built Environment and Sustainable Technologies [BEAN] Conference*. Liverpool, UK, 6 May 2013, pp.1-2.

5. **Nesensohn, C.**, Demir, S. T. and Bryde, D. J. (2012) Developing a "True North" best practice Lean company with navigational compass. *Proceedings of the Annual Conference of the International Group for Lean Construction*. San Diego, USA, 2012, pp.251-260.

6. **Nesensohn, C.** and Bryde, D. J. (2012). A review of the evolution of Lean construction. *Creative Construction Conference 2012*, Hungary, Budapest, 30 June-3 July. *Diamond Congress*, ed. by Hajdu, M. & Skibniewski, M. J. pp.468-476.

7. **Nesensohn, C.**, Bryde, D. J., Ochieng, E. G. and Fearon, D. J. (2012). Improve performance in construction by improving Lean maturity. *Salford Postgraduate Annual Research Conference [SPARC]*. Manchester, UK, 30-31 May 2012, pp. [published presentation].

8. **Nesensohn, C.**, Bryde, D. J., Ochieng, E. G. and Fearon, D. J. (2012). "LECMM" – Lean construction maturity model: A new innovative maturity model for Lean construction organisations. *Built Environment and Sustainable Technologies [BEAN] Conference*. Liverpool, UK, 30 May 2012, pp.1-6.

CHAPTER ONE

INTRODUCTION TO THE RESEARCH

1 Introduction to the research

1.1 Introduction

This introductory chapter provides a summary of the identified research problem through introducing the background and the driver of this research. The chapter further introduces the research question and subsequently its aim and objectives. Consequently, the value of this research through its original contribution to knowledge is presented. The final section of this chapter provides an overview of this research and the structure of this thesis.

1.2 Research problem

1.2.1 Construction productivity

The global construction industry faces a central challenge in improving its productivity and innovation (Larsson *et al*., 2013). In fact, the construction industry accounts for a sizeable proportion of most nations' gross domestic product (GDP); and the total impact of the global construction industry on the global GDP is approximately 9% (Horta *et al*., 2013). Consequently, the productivity of the construction industry is a key driver with significant impact on the economic growth of countries worldwide (Yan and Chunlu, 2010, Abdel-Wahab and Vogl, 2011, Chia *et al*., 2012). However, productivity in the construction sector can be measured and defined in many ways, and one common way is to measure the labour productivity, as construction is a labour-intense industry (El-Gohary and Aziz, 2014). Thus, Teicholz (2013) explained that since the 1960s labour productivity for the total US construction industry actually declined slightly. Likewise, Ruddock and Ruddock (2011) demonstrated that the labour productivity trends in the UK are more consistent and actually moderately rising in comparison to the US. However, the labour productivity in the UK's construction industry from 1977 to 2007 remained low with little change in comparison to the UK manufacturing industry (three times more) and the UK telecommunication industry (seven times more), which both have grown significantly (ibid.). Another way used to

measure the productivity in the construction industry is by using a model with a multi-factor productivity approach such as the total factor productivity (TFP) (Crawford and Vogl, 2006). For example, the study of Ruddock and Ruddock (2011) showed that the TFP of the construction industry in the UK, US and Germany had declined slightly since the early 1990s. Improving the productivity and innovation in the construction industry has been further highlighted as a major challenge in many countries, including the UK and USA, within several publications, e.g. Latham (1994), Department of Trade and Industry (1998), Teicholz (2001), Wolstenholme *et al*. (2009), and Department for Business (2013). The need for improvement in the construction industry was especially a subject in the UK. Investigations such as Latham (1994) and in particular the 1998 'Rethinking Construction' report to the UK government by the construction taskforce chaired by Sir John Egan revealed huge room for improvement (Department of Trade and Industry, 1998). The Egan report in particular sets targets for the industry to improve its performance. These include: reducing construction duration, Health and Safety accidents, and quality problems while increasing predictability, profit and productivity. More recently, the joint industry and government strategy in the UK 'Construction 2025' has set out an ambitious call for improvement (Department for Business, 2013). So the vision statement for the construction industry to achieve in 2025 is: 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 result, the industry seeks to achieve major improvements and this is further driven by the lack of performance of current project delivery approaches, as Ballard and Tommelein (2012) remind us with a powerful analogy: they link the traditional project management (PM) approach in construction with its attention to measure the deviation of what has been done and what should be done in relation to the original plan to maybe take corrective actions with "driving a car while looking in the rear view mirror", which is indeed different from steering the car towards its destination (p. 94).

The implication from the above is that the lack of productivity, together with the inefficient project delivery approaches in the construction industry, drives more and more organisations to look at LC as an approach to achieving the required improvement. It is not surprising, therefore, that this increased interest in LC can also be recognised in the literature. A systematic overview of the developed attention towards LC-related topics within the academic literature illustrates this. This overview (see Figure 1-1) shows the number of found articles from a keyword search in a selection of relevant journals for the built environment.

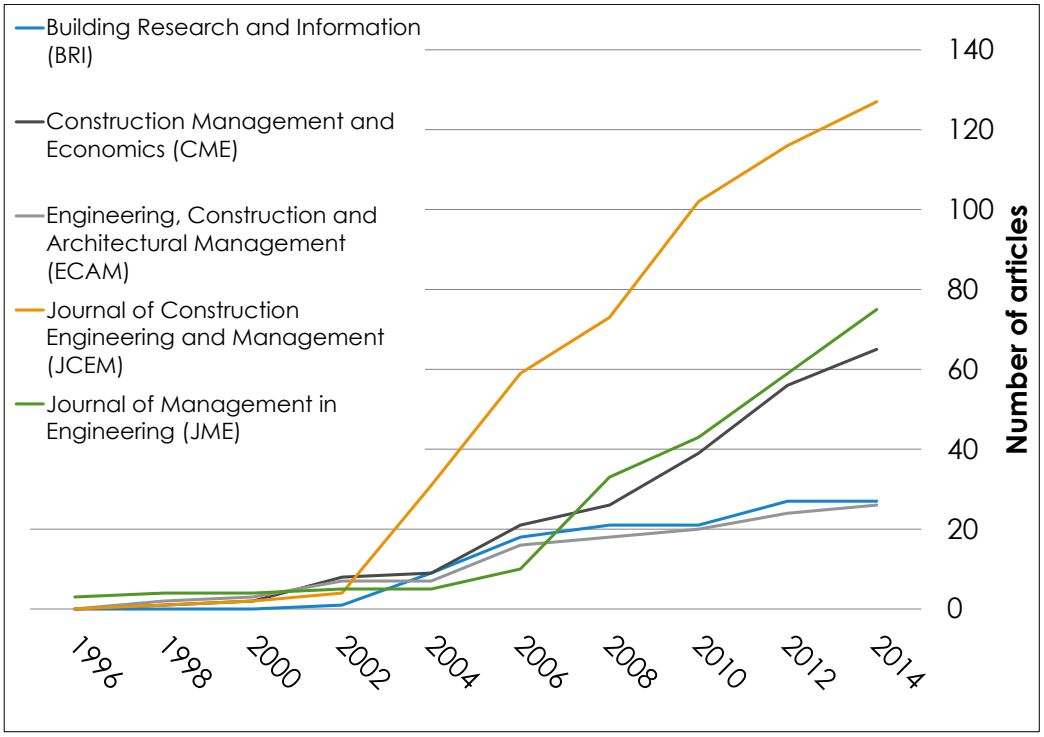


Figure 1-1: Number of Lean construction-related articles published in selected journals within the construction literature

The BRI, CME and ECAM (defined in Figure 1-1) are therefore selected because they are recognised, and the ECAM is a promoted (encouraged) journal for the International Council for Research and Innovation in Building and Construction (CIB). The other two journals have been selected on the basis of their h-index JCEM (50) and JME (28) which is similar to the h-index of the BRI (33) and the CME (44). To clarify: the h-index was proposed by

Hirsch (2005) and defined as "the number of paper with citation number ≥h, as a useful index to characterize the scientific output of a researcher" (p.16569). Similar to its use for individuals, the h-index is used as a robust measure to indicate the performance and impact of journals (Braun *et al*., 2005, Harzing and van der Wal, 2009). Accordingly, this demonstrates a significant selection of journals within the construction literature. As a result, this overview indicates a growth of articles that can be found with the keyword LC. However, it must be acknowledged that LC as a whole is multi-faceted and perceived in many ways (Green and May, 2005), even when articles use the same key word.

Nevertheless, the researcher sees LC more as a management philosophy for construction and design which allows the industry to achieve the required improvement in terms of productivity and project delivery; but it is not limited to this. The underlying philosophy of Lean includes a focus on truly identifying and understanding the ultimate customer value and the processes which deliver this value in the most efficient way. Simultaneously there is a focus on respecting people and allowing them to contribute with their fullest potential by aligning their work with the customer value and the vision of the organisation's strategy. Finally Lean concentrates on continuous learning and improvement. The wider perspective for Lean is that this underpinning philosophy lets us realise that the construction sector is certainly not too different to other industries, such as aerospace/defence or ship building; because in all those industries we keep doing very similar processes, even in one-off projects. In addition it must be stressed that in construction we repeat those very similar processes from project to project. Hence construction may have different constraints and often different locations, but the processes necessary to produce (build) a certain type of concrete or masonry wall are still very similar. The key point is that the Lean philosophy is not only applicable to many industries but also enables these industries to achieve improvement in many ways. That this applies to the construction industry has been recently highlighted in a study involving 193 contractors, of which more than 60% claim that using LC results in major improvements which include (but are not limited to): 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).

However, implementing LC often requires change at an organisation's strategic and operational levels (Green *et al*., 2008, Koskela and Ballard, 2012, Nesensohn *et al*., 2013). This is particularly true when we see Lean as a management philosophy, which needs to be embedded and sustained into an organisation's culture and behaviour to enable the expected improvement. There is no doubt that embedding a new philosophy is difficult and requires many adjustments within processes, value definition and the thinking. In combining these adjustments and changes we must see embedding LC as a complex transformation which organisations have to manage accordingly to enable them to achieve improvement.

Therefore embedding LC is undeniably a challenge; hence why some organisations struggle to move along in their Lean maturation process. After passing the initial phase of embedding Lean and utilising some tools and methods which can teach their user the principles, many fail to acknowledge further actions and have no awareness of the current state in terms of embedding LC. Therefore organisations often find themselves in 'no man's land'; running in a fog, not knowing their current position in their transformation process towards greater maturity in LC. Because it is extremely difficult to plan and direct a journey to a visionary destination without knowing the current location; this can be similarly applied to the challenge organisations face in terms of embedding LC. One way to address this extant problem is the use of MM which have been increasingly deployed to embed various management disciplines, new cultures or processes, and support organisations in their transformation and implementation of change in many industries through indicating the current level of maturity. These models provide organisations with crucial information of their current position and are used to plan and direct the transformation.

1.2.2 The relevance of maturity assessments

Generally, maturity assessments in the form of MMs have been deployed in a variety of industries including aerospace, electronics, health services, transportation, construction, etc. Benefits derived from maturity assessment efforts may be summarised as:

- Generate awareness and importance of the current state, and 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 strengths and weaknesses to plan and direct on-going transformations (Perkins *et al*., 2010a, Perkins *et al*., 2010b);
- serve as reference to compare a change or improvement approach in a systematic and well-directed way (Cooke-Davies, 2007);
- assessment of the current capabilities of an entity on a comparable basis (OGC, 2010a);
- 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); and
- enable a sustained embedment of business processes (Eadie *et al*., 2011).

The increased relevance of maturity is further emphasised by Wendler (2012), who has shown that between 2009 and 2010 34 new MMs were published in academic journals. A further systematic keyword search for the occurrence of the term ‘maturity’ in a management context shows a huge growth in the attention given to maturity in the academic literature. This keyword search process focused on the occurrence of the word ‘maturity’ in abstracts of business management and engineering journals from 1990 to 2012. To serve the wide area of the concept of maturity, four databases were used, namely: Business Source Complete, Emerald, Scopus, and Discover (a research tool of the author’s higher education institute). Because of the variation of those databases the numbers of articles per database for each year

have been used to calculate the growth rate per database and year rather than the number of articles. As shown in Figure 1-2 it is becoming increasingly difficult to ignore the increased attention given to the topic 'maturity' within the literature. Growth rates ranging from seven up to 12.7 from 1990 to 2012 emphasise the spurt in growth of publications with maturity-related topics.

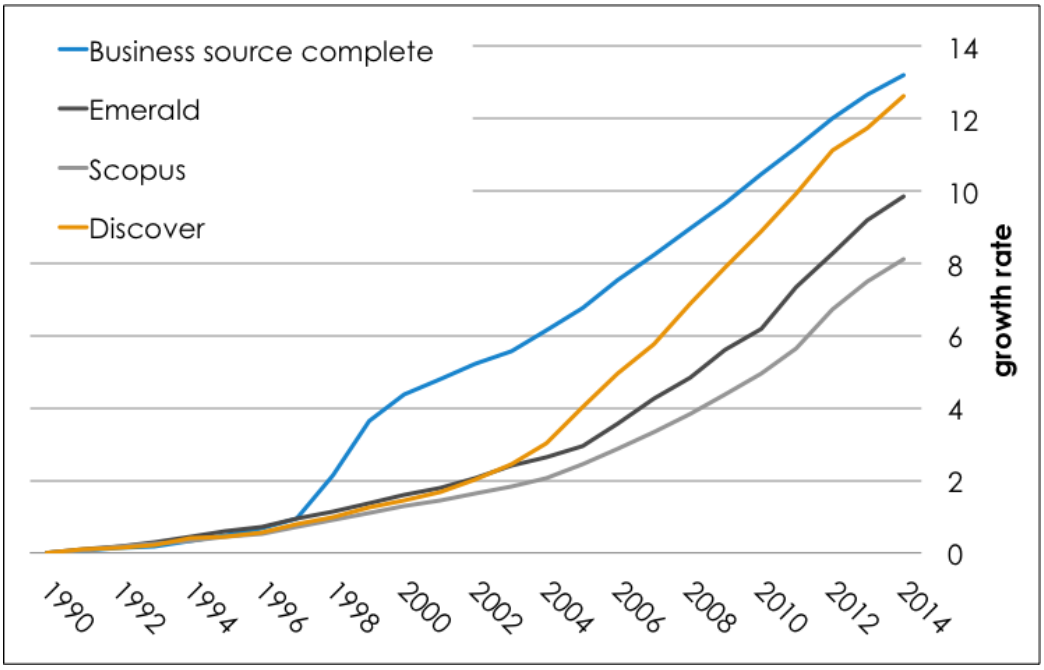


Figure 1-2: Growth rate x (means x times more than in 1990) of maturity-related publications in a management context

The above underlines not only the requirement for further research into LC and MMs to enhance our understanding in terms of integrating LC and maturity as a concept which is widely used in many industries to support the sustained embedment of change - but also in order to address the previously identified requirement for organisations to be able to identify where they currently are in their Lean Journey. Because when the Lean transformation evolves it becomes crucial to measure the gap between the current state in organisations and where they want to be, in terms of further embedding Lean (Meiling *et al*., 2012). Therefore measuring the current state of LC maturity is important to shape future improvement activities to move along in the Lean journey towards greater maturity in LC. Recent developments support this argument through indicating the need and opportunity to integrate

MMs with the Lean approach. Hence in 2010, Perkins *et al*. published a paper in which they reported on the development of a MM for Lean production in aerospace at the Massachusetts Institute of Technology (MIT). This developed assessment tool, called *Lean Enterprise Self-Assessment Tool* (LESAT), claims to provide organisations that embedding Lean production in the aerospace industry an understanding of the current maturity (Leanness) and further supports them in the transformation towards a more lean enterprise. Furthermore some evidence that maturity assessments within Lean are considered as a way to measure where organisations are on their journey has been presented through 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) (Dave *et al*., 2013). Finally 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 LESAT.

In light of this, the central problem of this research was to investigate and build a current understanding of LC maturity and to develop an understanding of whether MM can be integrated with LC to measure the current state of LC maturity and support organisations in their maturation process towards greater maturity in LC.

1.3 Research Question

On the basis of the research problem this research sought to answer the following question:

> *How can we assess the current level of LC maturity in organisations and provide them with support and guidance towards greater LC maturity?*

1.4 Research aim and objectives

In order to answer this question the research aim was: ‘to develop a framework that enables organisations to measure the gap between where they currently are and where they want to

be, in terms of their LC maturity'. The following supportive objectives were developed to achieve the above research aim:

- To integrate the 'LC' and 'MM' literature to provide a sound theoretical basis for a framework for assessing LC maturity;
- to identify attributes towards LC maturity amongst industry key informants;
- to simplify LC through defining Key Attributes that describe LC maturity;
- to propose a framework that can be used to measure the current state of LC maturity in organisations; and
- to validate the proposed framework.

1.5 Contribution to the body of knowledge

This thesis provides an original contribution to knowledge by developing an understanding of the phenomenon 'LC maturity' that can enable organisations to achieve and enhance their understanding of LC and the awareness of their current maturity. The research delivers evidence of LC maturity in the form of a phenomenological study and has developed a new innovative and original framework that enables one to measure LC maturity. In addition, this thesis provides originality through simplifying LC to 11 Key Attributes that explain Lean in a more simple and unique way than before.

1.6 Research overview and structure of the thesis

A holistic overview of the systematic and methodical way this research was conducted is shown in Figure 1-3, p. 11. This overview shows the deployed research processes and their relationships to each other. The research is divided into six so-called process phases (secondary data, research question, collecting of primary/supplementary data, analysis, findings, and validation). The processes within each phase are illustrated as boxes with a short title, and the relationships are shown with arrows. Furthermore summarises this research overview information such as: the number of participants involved within the

different samples, the geographical area of the sample sets, the data collection – analysing – and validation methods adopted.

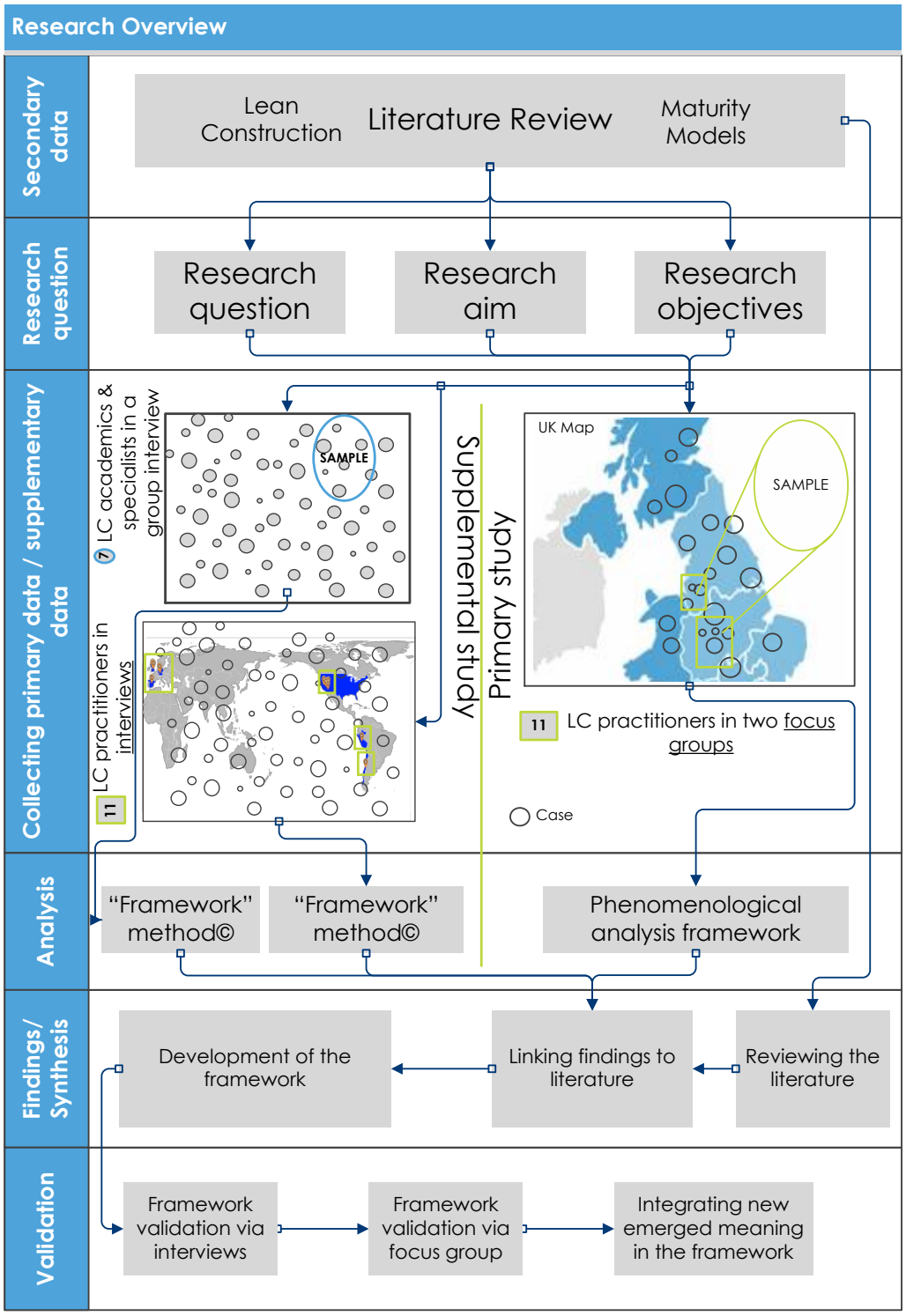


Figure 1-3: Research overview

Figure 1-4 illustrates further the structure of the undertaken research together with the link between the eight chapters of this thesis and the before set objectives. In addition describe short summaries of each chapter the structure of this thesis.

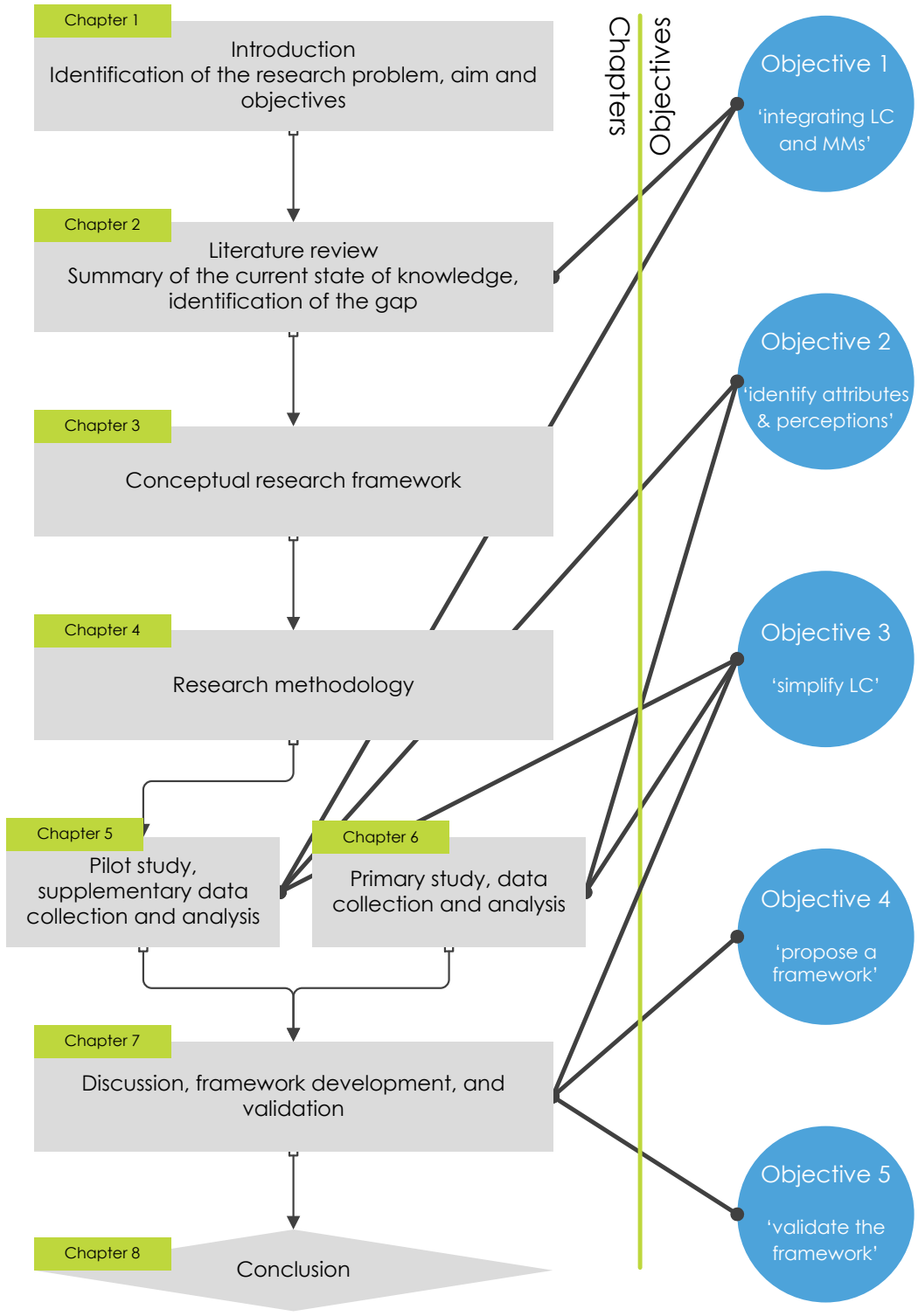


Figure 1-4 Overview of the research

CHAPTER ONE: Introduction to the research

This chapter has set out the research background and problem, and presented the main research aim, its objectives and the structure of the thesis.

CHAPTER TWO: Review of Lean construction and Maturity Models

This chapter critically reviews the related literature of the research. This includes the origin of Lean and LC and the notion and focus of LC as well as contemporary issues. In addition, the review covers the concept of maturity and the origin of MMs, including a review of the widely recognised Capability Maturity Model (CMM) and its maturity assessment procedure. The review also covers the differences between MMs and maturity grids, contemporary issues in MMs and the identification of commonalities amongst the most common MMs. Finally, the review covers an evaluation of the attempts made towards LC maturity assessments and significant MMs for this study. On the basis of available journals, text books and Government reports this chapter provides a comprehensive theoretical background of the current state of knowledge relevant for this research. The dominant purpose was to establish a solid foundation and to provide the main vehicle for the empirical aspect of this research endeavour. Moreover, this chapter addresses the first objective of the study.

CHAPTER THREE: Conceptual Research Framework

This chapter presents and develops the conceptual research framework required to carry out this research. Hence the required research philosophy, logic, methodological choices and approaches are discussed and combined into a framework in order to accomplish the set research aim and objectives.

CHAPTER FOUR: Research methodology

This chapter elaborates on the chosen research methods used in this study. A comprehensive overview of the selected research methods and their deployment in this research is discussed.

Consequently, compelling justification for why those methods have been used is provided. The chapter also discusses the research samples, organisation, analysis and synthesising of the collected data, and the validation strategy. Finally, the chapter points out the ethical compliance.

CHAPTER FIVE: Findings - supplementary data collection

This chapter presents the collected supplementary data, the evidence of the analysis, and the findings. This includes the summarising of the content of both the group interview and the individual interviews and the interpretation of their meaning. The group interview was conducted as a pilot study to ascertain the feasibility of this study and to garner rich information from relevant LC academics and professionals, which delivered a contribution to the first and second objectives. The purpose of the individual interviews was to gather depth and breadth of information about LC maturity to achieve the second and third research objectives.

CHAPTER SIX: Findings - primary data collection

This chapter presents the primary data collected through FGs, the evidence of the analysis and the summarising of the revealed findings. Consequently, the significant content is presented and interpreted through quotations from the data. The dominant purpose of these FGs was to gather an in-depth understanding about LC maturity to achieve the second and third objectives of this research.

CHAPTER SEVEN: Discussion and framework development

This chapter presents the discussion of the relevant findings and assembles the outcome of this into the development of a framework for assessing LC maturity. The discussion is organised into the structure of the developed framework which presents further the simplification of LC through the definition of 11 Key Attributes. The whole chapter elaborates the development of the framework and shows the deployment and outcome of the validation process. Moreover, the validated framework is presented in this chapter. The

purpose of this chapter is to build the research objectives four and five but the outcome of the third objective is also part of this chapter through the definition of 11 Key Attributes.

CHAPTER EIGHT: Conclusions and recommendations

This chapter provides the summarised conclusions and recommendations of this research. The chapter demonstrates how the research aim and its objectives have been achieved and explains the conclusion and contribution to knowledge of this research endeavour. Finally, it provides recommendations for further work.

CHAPTER TWO

REVIEW OF LEAN CONSTRUCTION AND MATURITY MODELS

2 Review of Lean Construction and Maturity Models

2.1 Introduction

This chapter forms the major literature review of this thesis. The aim of this chapter is to build a comprehensive understanding of the 'state of knowledge' relevant for this research. The chapter draws conclusions from different perspectives, limitations, and boundaries to identify the current gaps in the research area by adopting a critical 'integrative review' (Cooper, 1989). Therefore, the chapter justifies the need for this research. The first section of this chapter discusses the general aspects of Lean and LC, the second section critically reviews the concept of maturity and MMs, whilst the final section discusses the gap in the literature and underlines the need for this research.

2.2 Lean

2.2.1 Why Lean?

The primary concern in Lean is the creation of customer value. Early identified in manufacturing, this was addressed through a continuous flow production with just in time (JIT) delivery, less cost, greater quality and respect for people (Ohno, 1988). Lean evolved out of the challenges to overcome the 9:1 productivity disadvantage in a restricted market with a demand for a wide variety of vehicles which does not allow mass production (Womack *et al*., 1990). After World War II, Taiichi Ohno, an engineer at Toyota, took the major role in overcoming these challenges and developed the Toyota Production System (TPS) as an ideal production system (Ohno, 1988). The term 'Lean' was labelled and introduced by Krafcik (1988) (Krafcik, 1988, Liker, 2004, Bhasin and Burcher, 2006) as part of the study conducted by the International Motor Vehicle Program in the 1990s at the Massachusetts Institute of Technology (MIT) (Womack *et al*., 1990). This study highlighted that the Japanese automobile manufacturers, in particular Toyota with its TPS, now had significant productivity advantages compared to their western competitors (Womack *et al*.,

1990, Bhasin and Burcher, 2006). This study proved that Ohno mastered the original challenge. As a result, the Japanese production approach was labelled as Lean production because it produced vehicles with greater quality and more variety while at the same time using less resources, time and money (Womack and Jones, 2003).

2.2.2 The origins of Lean

Today there are claims that the origins of Lean date back to the Arsenal in Venice in the 16th century (Womack, 2011) because the Venetians at this time were able to assemble galleys in a continuous flow with major productivity advantages (ibid.). However, the TPS was initiated in 1950 by Taiichi Ohno, and it enabled Toyota to become the world's best car manufacturer (Liker, 2004). Central for Ohno in the development of the TPS was muda (the Japanese word for waste), which can be found in any process if something adds no value for the end customer (Ohno, 1988). In addition, Ohno identified seven different types of waste/muda, which were: (1) defects (in products); (2) overproduction; (3) inventories; (4) unnecessary processing; (5) unnecessary movement (of people); (6) unnecessary transport (of goods); and (7) waiting (by people at the next process step) (ibid.). Furthermore, muda has been divided into two categories (Womack and Jones, 2003):

- Type one muda: activities that create no value but seem to be unavoidable to create value for the end customer; and
- type two muda: activities that create no value and are immediately avoidable.

So any process could be divided into three categories: first value-adding activities; second type one muda activities; and third type two muda activities, which means real waste. Since Womack *et al*. (1990) describe Lean with a strong focus on systemically eliminating waste/muda (Jørgensen, 2006), Lean has been often reduced to this. A more comprehensive while at the same time more general way of describing Lean is offered by Ballard and Tommelein (2012). They remind us that Lean is a philosophy comprising an ideal that pursues "deliver[ing] exactly what your customer (immediate or ultimate) needs, with no

waste" (ibid. p. 86). In addition, Ballard and Tommelein (2012) state that the ideal continually follows principles and uses methods to embed these principles. Five Lean principles have been defined by Womack and Jones (1996, 2003) These principles have strongly influenced our understanding of Lean, and raised its profile in several industries internationally. The principles are listed below:

- Specification of the value (from the perspective of the customer/end user);
- identify the value stream (process that provides the customer value without waste);
- flow (the value-creating steps to flow without interruption);
- pull (let the customer get what he wants; nothing will be done before it is needed); and
- perfection (operation of continuous improvement (CI)).

However, there are more attempts to explain Lean with principles: e.g. Ohno (1988) and Liker (2004). Hence there are a variety of associations with Lean in existence. Jørgensen and Emmitt (2008) reviewed the literature and identified five common elements that were revealed when describing Lean. These are:

- "A focus on eliminating/reducing waste and sources of waste in relation to the delivery of artefacts or services that represent value to the end customer;
- end customer preference is adopted as the reference for determining what is to be considered value and what is waste;
- management of production and supply chain from a (customer) demand pull approach;
- approaching production management through focus on processes and flows of processes; and
- an (at least to some degree) application of a system's perspective for approaching issues of waste elimination/reduction" (p. 386).

Today, Lean is applied not only in manufacturing industries but also in many other industries (Mao and Zhang, 2008). Nevertheless, customer value is of central concern within Lean (Jørgensen and Emmitt, 2008, Senaratne and Ekanayake, 2012), because only if the customer value is identified can waste be tackled so that more value is delivered in the best possible way. A perspective of this value from a Lean production view is conceptualised as "capability provided to the customer at the right time at an appropriate price, as defined in each case by the customer…[and] value is the critical starting point for Lean thinking, and can only be defined by the ultimate end customer." (Womack *et al*., 1990, p.311). In production, this ultimate end customer is usually the customer that buys and uses a new product. However, this is indeed different in the construction industry since a construction project hardly has a single ultimate end customer/user (Jørgensen and Emmitt, 2008). The next section elaborates LC and how it is applied in the industry.

2.3 Lean construction

2.3.1 The rationale for Lean construction

As highlighted earlier the seeking of more productivity in the construction sector was identified in several studies (Department of Trade and Industry, 1998, Teicholz, 2001, Department for Business, 2013, Larsson *et al*., 2013). Additionally, it has been stated by Ballard (2002) that project management (PM) has neglected the theory of production. In 2002, Koskela *et al*. demonstrated that the current PM in construction fails to successfully deliver projects while it attempts to break down and manage activities and measure its outputs. The authors argue further that these current practices entirely lack a focus on workflow and the creation of value which have been associated as significant criteria of a successful production. Compelling evidence for those claims is shown in a case study by Liu *et al*. (2011). The authors investigated productivity and construction project performance and found that the current PM practices, such as completing as many tasks as possible, or increasing workload and work hours, indeed do not improve productivity. Instead they demonstrated that a reliable and continuous workflow does improve the

productivity. Hence the current (less productive) mainstream practice in PM and the need to achieve major improvements in quality and efficiency drive the rationale for LC. In the UK construction industry LC was particularly highlighted in the Egan report as an improvement approach (Department of Trade and Industry, 1998).

2.3.2 The notion of Lean construction

The first serious discussions and analyses of adopting Lean production in the construction industry emerged from Koskela (1992) when he concluded that it is necessary for the construction industry to adopt the (Lean) new production philosophy to gain improvements and competitive advantages. Since then LC has been of great interest to numerous academics (Green and May, 2005). In recent years, there has been an increasing amount of literature on LC, and several studies have revealed that LC is a well-established theme amongst the construction sector (Jørgensen and Emmitt, 2008). LC is often interpreted as the direct application of Lean production to the construction industry. However, Koskela *et al*. (2002) draw our attention to see Lean production as a significant inspiration for LC. This view is supported by Rybkowski *et al*. (2013). It is claimed that this inspiration includes elements of the TPS as a standard to achieve perfection (Howell, 1999). These elements originally defined by Ohno are: "Produce a car to the requirements of a specific customer, deliver it instantly, and maintain no inventories or intermediate stores" (ibid., p. 2).

Nesensohn and Bryde (2012) observed that the first occurrence of the term LC was in 1993 through the '1st workshop on Lean Construction' co-ordinated by Koskela. However, Koskela and Ballard combined several things in 1992-1993, such as the concept of flow linked with the feedback measure per cent plan (or promises) completed (PPC) and the importance of workflow reliability (Howell and Ballard, 2011). A reliable workflow was further promoted with The Parade of Trade simulation, which shows the impact of variability on workflow in construction projects (Tommelein *et al*., 1999, ibid.).

In recent literature it has been demonstrated that LC is a new paradigm and project delivery system with the potential to deliver outstanding performance improvement in the

construction industry (Sage *et al*., 2012). This is confirmed by reports of projects in the UK and US utilising LC. For example, claims are made about projects such as a hospital building, a medical office building, HEI buildings and an outpatient facility which have an out-turn of approximately 19% below market cost (Mossman *et al*., 2011). Further evidence is delivered by a report including a quantitative and qualitative study amongst the construction industry in the US, which demonstrated that major benefits derived by using LC according to practitioners. These 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). Moreover, the benefits of LC have recently been linked, to be fruitful in creating synergies with sustainable and green construction approaches in particular in terms of improved health and safety, reduction of waste, and social, economic and environmental benefits (Ogunbiyi *et al*., 2014, Rosenbaum *et al*., 2014).

2.3.2.1 How is Lean construction defined?

There is an on-going debate in the literature about a definition of LC (Green and May, 2005, Jørgensen and Emmitt, 2008, Mossman, 2009). Yet the lack of a commonly accepted definition of LC has not prevented its adoptions in the industry (Green and May, 2005). Alarcon (1996) combined the early work in the form of articles of the International Group of Lean Construction (IGLC) in his book; this included the first crucial description of LC:

- Organisational learning and knowledge sharing are part of LC. The principles stated by Womack and Jones (1996) in production organisations and project organisations apply, e.g. teamwork; communication; efficient use of waste; and CI (Fisher, 1997);
- the LC Model facilitates performance improvement by revealing the interdependencies (Ballard, 1997); and
- Howell and Ballard (1997a;b;c) argue in a series of three papers that "The next step of implementation of LC is to work behind the shield to improve

> performance and take full advantage of the reduction in variation and uncertainty thus far achieved" (Howell and Ballard, 1997b, p. 104). Hence LC has at least two foci that distinguish it from traditional construction management: first, the focus on waste reduction instead of improving efficiency in conversion processes; and second, the focus on managing flows in systems and processes along with the production process (Howell and Ballard, 1997c). Based on the work of Ohno (1988) and Shingo (1989), in their third paper the authors advocated the implementation of LC in three phases: begin with stabilisation of the process, follow with reducing flow variations in the process and finally turn those into construction operations (Howell and Ballard, 1997a).

Criticised must be that of much of the literature above is mainly based on a few references. In addition can be criticised that this work does not clearly illustrate which methodology was used to conduct the research nor the validation procedure.

An important step towards a description of LC was the early work of Koskela (Yu *et al*., 2013). In 2000, Koskela analysed production systems to demonstrate that a theory of production for construction can be formulated. In his research Koskela derived the Transformation-Flow-Value generation, also known as the TFV theory of production, which suggests that the three elements such as transformation of input to output, the flow and the generation of value (fulfilling customers' requirements) should be utilised simultaneously. An integrated view of production with the TFV theory is presented in Table 2-1 below.

Table 2-1: Integrated view of production through the TFV theory

	Transformation view	Flow view	Value generation view
Conceptualisation of production	As a transformation of inputs into outputs	As a flow of material, composed of transformation, inspection, moving and waiting	As a process where value for the customer is created through fulfilment of his requirements
Main principles	Getting production realised efficiently	Elimination of waste (non-value-adding activities)	Elimination of value loss (achieved value in relation to best possible value)
Methods and practices (examples)	Work breakdown structure, Organisational charts	Continuous flow, pull production control, CI	Methods for capture of requirements, Quality Function Deployment
Practical contribution	Taking care of what has to be done	Taking care that what is unnecessary is done as little as possible	Taking care that customer requirements are met in the best possible manner
Suggested name for practical application	Task management	Flow management	Value management

Source: Koskela (2000, p.89). Permission to reproduce this Table has been granted by Prof. Lauri Koskela

With the publishing of the report 'Rethinking Construction', LC became accepted as an essential element of the construction best practice programme (CBPP) in the UK (Green, 2000, Green and May, 2005). However, in 1999, Green argued that the publication of this report had a significant impact, on the agenda for change in the UK construction industry. So criticised Green (2002) further that this report as taking a one-sided view, and focusing on the interests of corporate clients while it ignores the critical evidence of Lean Production effects, i.e. the human costs in terms of long working hours, worker autonomy, and stress of work. Consequently, Green derives a critical definition of LC as a "complex cocktail of ideas" (Green, 2002, p. 148). Green (1999) draws our attention further to his observation that the report 'Rethinking Construction' sees Lean primarily as a set of techniques/tools derived from Lean thinking that are applicable to construction. Ballard and Tommelein (2012) remind us that this report created a specific meaning in the UK that through standardisation of the product design Lean production methods can be applied in the construction industry. They further offer a definition of Lean "a philosophy of management specified by the ideal pursued, principles, followed in that pursuit and methods employed in application of the principles" (p. 95).

In 2005, Green and May investigated with a critical lens the meaning of 'Leanness' amongst UK industry policy-makers and identified three models as an attempt to characterise LC. The first model focuses on the ‘elimination of waste’, the second model emphasises ‘partnering’, and the third model concentrates on ‘structuring the context’ such as structural realignment and innovation. However, Green and May (2005) found in their study that, so far, the lack of a definition of LC had not limited its acceptance; rather, they argue that this flexible interpretation is similar to other management disciplines, essentially the way to its effective diffusion. Despite such misgivings, LC has initiated a revolution of the scientific construction management area (Abdelhamid, 2004).

Koskela *et al*. (2002) give us a simple understanding of LC when they state that “Lean construction is a way to design production systems to minimise waste of materials, time, and effort in order to generate the maximum possible amount of value” (p. 1). This reflects the argument of the Lean Construction Institute (LCI), which defines LC as “[…] a production management-based approach to project delivery - a new way to design and build capital facilities” (Lean Construction Institute, 2014). Here we can recognise that LC links the product design (the designing of a building) and the production system which is necessary to deliver the product. More general is LC articulated by the AGC-Lean Construction Forum as “[…] a set of ideas, practiced by individuals in the construction industry, based in the holistic pursuit of CI aimed at minimising costs and maximising value to clients in all dimensions of the built and natural environment: planning, design, construction, activation, operations, maintenance, salvaging, and recycling” (Lean Construction Forum AGC, 2014). A more philosophical perspective was presented by Howell who defines LC as “A new way to see, understand and act in the world” (Howell and Ballard, 2011). It is however important to note that a dominant view in academic literature perceives LC as a system of production control (Ballard and Howell, 1998, Choo *et al*., 1999); or as a conceptual model of the production process (Koskela *et al*., 2002, Green and May, 2005). What both interpretations have in common is that projects are conceived as temporary production systems (Howell *et al*., 2004) which aim to eliminate waste activities, decrease non-value-adding activities and

maximise value-adding activities (Koskela, 1992). A similar and broader international recognition of LC is the idea that construction projects are a fundamental type of a production system (Ballard and Tommelein, 2012). Equally, Pasquire (2012) demonstrated that construction has many communalities with other forms of production such as in manufacturing, farming, and film production. More recently a report presented a study that interviewed both Lean practitioners and construction professionals familiar with Lean, and found, with regard to defining a Lean approach, that Lean practitioners define LC from a strategic point of view including waste reduction, collaboration and efficient scheduling whilst the others think of LC more tactically and as a set of tools (Bernstein and Jones, 2013).

However, research by Green and May (2005), with empirical support from 25 semi-structured interviews with construction policy makers, resulted in the claim that LC is multifaceted, which would challenge a universal definition of LC. Considering this there are many views of Lean and certainly there is also the possibility for an open ended view of LC. Nevertheless, a working definition of LC for the context and purpose of this research is proposed to make things simpler. Hence the working definition of LC which is, however, not an attempt for an authoritative definition of LC is as follows.

Working definition of LC

LC is defined as a management philosophy[1] for construction and design which is inspired by the Toyota Production System (TPS) and its interpretation as Lean production and Lean thinking. Similar to its inspirations LC has a focus on creating and delivering ultimate customer value, respecting people, reducing waste, creating a smooth workflow and practising CI and learning.

The following sections elaborate the focus of the above definition in more detail.

[1] This interpretation derived from Ballard, G. and Tommelein, I. (2012). Lean management methods for complex projects. *Engineering Project Organization Journal* V.2(1-2), pp.85-96., and the inaugural lecture of Prof. Glenn Ballard in Nottingham (2013).

2.3.2.2 The creation of value

The focus to create and deliver value to the ultimate customer does not yet have a global understanding of the concept of 'value' in respect of LC, whether by practitioner or researchers (Salvatierrra-Garrido and Pasquire, 2011). The understanding of value in the construction industry from the perspective of LC differs from the understanding of value in the manufacturing industry. One common view in the construction sector focuses on Koskela's TFV generation model which "[…] represents the current value vision of LC practitioners" (Salvatierrra-Garrido and Pasquire, 2011, p.12). However, the creation of value can only take place when the customer gets something delivered that they value.

Customers in a construction project receive value generally when the project provides them with what they need when they need it (Womack and Jones, 1996). Hence the most important point in delivering value is to ensure the comprehensive capturing of the customer requirements as well as an actual flow of this information to the location where the value is added (Sacks *et al*., 2010).

Emmitt *et al*. (2005) studied the value approach within LC and argued that value should be separated into (1) external value: the customer value which is the end-goal of a project; and (2) internal value: the value amongst the delivery team. Furthermore, it was shown that the external customer value should consider the requirements of at least three different clients such as the owner, the user, and the society (Salvatierrra-Garrido and Pasquire, 2011). In their work, Erikshammar *et al*. (2010) provide a further factor which needs to be considered when creating value. They identified that individual clients in a project have an individual understanding of value and the key is to understand those different perceptions.

Neglecting the importance of creating customer value may limit the performance (Hines *et al*., 2004), and is most likely to end with the delivery of something the customer is not willing to pay for. Hence the creation of value requires a comprehensive understanding and definition of what the chain of customers (internal and external) values. However, this alone does not ensure that value is created and delivered throughout a project because the

customer's perception of value is subjective and will change over time (Emmitt *et al*., 2005, Salvatierrra-Garrido and Pasquire, 2011). Considering this complexity of value generation and the fact that customer value is the critical starting point of Lean thinking (Womack and Jones, 1996, Senaratne and Ekanayake, 2012), the first crucial focus for LC is a continuously updated understanding of value alongside the system of customers (chain of internal and external customers). Without this, it will be truly difficult to create and deliver what the ultimate customer and customer system values.

2.3.2.3 Respect for people

It has conclusively been shown that respect for people is embedded in the interpretation of the TPS (Ohno, 1988, Womack and Jones, 1996, Womack and Jones, 2003, Liker, 2004). As demonstrated in section 2.2, the TPS builds a significant foundation for Lean and is therefore part of the inspiration for LC. Respect for people played a particularly important role in the '4P' model of Liker (2004), in which he describes the TPS with 14 principles. Liker's principles show that respect for people and their development for the better are not contradictory. This is evident in Liker's (2004) principles 9, 10, and 11: "Grow leaders who thoroughly understand the work, live the philosophy, and teach it to others… Develop exceptional people and teams who follow your company's philosophy… Respect your extended network partners and suppliers by challenging them and helping them to improve." (p. 169-199). This outlines the focus towards respect for people within and beyond the organisation that the TPS sets. There is further the aim within the TPS to develop and maintain respectful relationships with partners, suppliers and their people. So respect for people is a crucial part of production systems and Lean, but do we apply this equally to current approaches within construction PM?

Biton and Howell (2013) critique that one reason for the failure of traditional PM is the hindering of people from effective collaboration and working together through separating work into silos. They further discuss that LC and in particular the LPS realises this and addresses it while it does gather commitments to enable working in collaboration towards a

project optimisation. Furthermore, Pasquire (2012) reminds us about the collaborative focus within Lean as a learning system, which is complemented by the fact that people are seen as important within LC (Ballard, 2000). This is especially true when we consider that with the LPS a project is managed by a network of commitments which are gathered by the last planners who are usually the person or group who defines the daily tasks, which are referred to as assignments (ibid.). Considering this, the making and keeping of commitments across hierarchies demonstrates respect to people in particular from the management to the last planners and amongst the project team. Numerous approaches and methods which embed respect for people and collaboration have emerged alongside LC, e.g. Integrated Project Delivery (Kent and Becerik-Gerber, 2010, Zhang *et al*., 2013); Lean Project Delivery System (Ballard, 2008); and Target Value Design (Zimina *et al*., 2012). As a result, it must be argued that not only is Lean about respecting people, LC incorporates respect for people as well when it does recognise that optimisation cannot be achieved without respecting, communicating and effectively collaborating with people. Finally it must be clarified that the current UK initiative "Respect for People" and the related toolkit available from the Construction Excellence are different to respect for people from a Lean perspective within this research.

2.3.2.4 Reduction of waste

The concept of waste in LC goes back to the pioneering work of Koskela (1992) in which he adopts the seven wastes identified from Ohno (1988) (presented in section 2.2.2) to construction. This list of seven wastes has been adopted in many areas such as health care, service industry, and billing systems, and the central concept within it is the elimination of overproduction (Koskela *et al*., 2013).

More generally, the concept of waste in LC is understood through the evaluation of whether something (information, action, material, etc.) does or does not add value from a client's perspective. A dominating focus on the elimination and reduction of waste was initially evident in the first descriptions of LC (see section 2.2.3). Over time several studies have

indicated additional wastes which are claimed to be more specifically for the construction industry. These include: quality costs, loss of value, constructability, lack of safety, design errors (Koskela, 1992); 'making-do', which considers tasks that have been started without having all preconditions ready (Koskela, 2004); and the failure to speak, and the failure to listen (Macomber and Howell, 2004). Several studies investigating the concept of waste have been carried out from a LC perspective (Koskenvesa *et al*., 2010, Koskela *et al*., 2013, Viana *et al*., 2013).

The recent work of Koskela *et al*. (2013) proposes the development and identification of a new list of wastes considering both construction and design from a LC point of view. However, it can be argued that the current and more fragmented concept of waste in LC did not prevent its development or its application. Perhaps this resulted from the general differentiation between value and waste (does it add value from a client's perspective) which applies to construction and design in a similar way as it does in other areas. Moreover, someone must know the ultimate customer value to be able to identify waste, whether this is general waste or classified waste (seven types of waste) (Womack and Jones, 2003). Accordingly, the reduction of identified waste is a primary concern of LC (Howell and Ballard, 1997c, Kemmer *et al*., 2013). This leads to the interpretation that LC does systematically identify and reduce all forms of waste. One approach amongst others adopted from Lean production is Value Stream Mapping (VSM) (Yu *et al*., 2009). VSM is a technique that graphically enables one to identify and reduce waste while mapping every activity and information that is required to deliver value (Hines and Rich, 1997).

2.3.2.5 Continuous workflow

A fundamental part of a continuous workflow is the reduction of variability, which goes back to the work of Shewhart (1931). Furthermore, it is argued that the reduction of the cycle time correlates with this variability, and construction cycle times incorporate total construction duration or the time material needs to arrive on site (Koskela, 2000). Likewise, it is claimed that reducing the batch size has the potential to achieve a single piece flow and

shorter cycle times (Sacks *et al*., 2007). So if batch sizes, cycle times and variability are reduced a smoother workflow can be achieved. Howell *et al*. (2001) showed that the achieving of a continuous and reliable workflow builds the prerequisite of the reduction of the project cost as well as its duration. Hence continuous workflow in a LC context is associated with improvement of the project delivery.

A recent study by Brodetskaia *et al*. (2013) showed that LC does improve the productivity in projects by stabilising the workflow at three levels: (1) in the design of the project production system to avoid interruptions of the continuous workflow; (2) production control and making work ready on demand; and (3) CI to improve the production system as a whole. The best known and major LC method, the LPS of production planning and control, is claimed to play a significant role in addressing this improvement (e.g. stabilising processes/workflow and reducing uncertainty and unreliability within the resources) (Ballard and Tommelein, 2012, AlSehaimi *et al*., 2014).

As a production planning and control system the LPS provides the levelling of the production and through the look-ahead approach it facilitates a pull system which triggers activities on the demand of the system of customer requirements (Sacks *et al*., 2010). The principles of the LPS that guide the thinking and the actions include:

- "Plan in greater detail as you get closer to doing the work;
- produce plans collaboratively with those who will do the work;
- reveal and remove constraints on planned tasks as a team;
- make and secure reliable promises; and
- learn from breakdowns" (Ballard *et al*., 2009, p.490)

Ballard and Tommelein (2012) demonstrated that the LPS has been a successful method for effectively stabilising and creating a continuous workflow. Moreover, in the past further correlations of a reliable and smooth workflow were identified. Hence it is demonstrated that continuous workflow improves the labour productivity with construction projects (Thomas *et al*., 2003, Liu *et al*., 2011).

The previous sections presented the role of flow within Lean and the TPS. However, through the major role of flow within the TFV theory as well as within the LPS it becomes evident that a continuous workflow combines the Lean principles of flow and pull. As such, a smooth workflow becomes a vital element within LC.

2.3.2.6 Continuous learning and improvement

Sacks *et al*. (2010) reminds us that CI is again related to the work of Shewhart (1931), because it builds on the provided scientific approach of experimentation, which is known as the Deming cycle Plan Do Check Act (PDCA). However, CI is prominent beyond the Lean context, and further related to Total Quality Management (TQM) (Caffyn, 1999), and as a systematic form of improvement that is more than learning (Sacks *et al*., 2010). Imai (1986) explains that CI is similar to an incremental, continuing effort of improving products, processes, and services.

Salem *et al*. (2006) showed that CI is not limited to a few techniques; rather, it is embedded in many deployed techniques that seek improvement through creative thinking and problem solving. This is in particular true for methods such as the LPS which imply and drive CI, e.g. first run studies with the embedded Deming cycle (Howell and Ballard, 1997a, Ballard and Howell, 2003). First run studies explore operations in detail to generate ideas and alternative ways of doing the work, in order to improve the operation – such first run studies utilising the PDCA Deming cycle to achieve this (Salem *et al*., 2006). Moreover, the LPS strives to continuously improve the production system as a whole (Brodetskaia *et al*., 2013).

CI is further closely connected with ‘standardisation of work’ and the use of ‘visual management’ for production methods and processes; both focusing on simplifying the management and communication, and contribute towards compliance and the current state of improvement (Sacks *et al*., 2010). Visual management in particular can improve the transparency of processes which will aid communication and decision making (Brady *et al*., 2012). Another element strongly related to CI is ‘going to Gemba’, which stresses the practice that managers rely more on personal observations rather than on reports (Liker,

2004). Within LC Sacks *et al*. (2010) explained that 'going to Gemba' can be applied through site visits of, for instance, managers and estimators who do not normally practise them. Finally, CI is further related to becoming a learning organisation (Liker, 2004). Therefore, implementing LC requires to an extent the change towards a learning organisation, which sustains competitive advantage (Henrich *et al*., 2006). The learning organisation in this context means "an organisation which facilitates the learning of all its members and continuously transforms itself in order to meet its strategic goals" (Pedler *et al*., 1989, p. 93). One of the best exemplars of a learning organisation is Toyota, who apply this through their 'True North' approach.

While acknowledging that CI is an essential element of LC, it is argued by Rother (2010) that this might be not enough because an additional overall direction is required, i.e. when applying Lean to construction a long-term thinking is required (Mossman, 2009, Nesensohn *et al*., 2013). Long-term visions or directions will help to navigate through different actions to finally achieve the aim (Rother, 2010). With its True North focus Toyota achieved a lead position over the past 50 years in eliminating waste, creating value and improving its own products and processes continuously (ibid). The goal is zero defects, 100% value with the lowest costs and continuous flow production. The True North in this case works as a compass providing a direction towards the set goal (ibid.).[2]

2.4 Contemporary issues in Lean construction

Regardless of the contributions towards LC theory mentioned in the previous sections, there are still open debates on the implementation of LC in the construction industry and its effectiveness in different types of projects. For instance, Bryde and Schulmeister (2012) considered Lean principles applied to refurbishment projects as problematic. They proposed in particular that the 'pull-drive scheduling' as well as the applied JIT delivery and reduction

[2] Parts of this have been original published in Nesensohn, C., Demir, S. T. and Bryde, D. J. (2013). Developing the True North route map as a navigational compass in a construction project management organisation. *Lean Construction Journal* V.2013(1), pp.1-18. http://creativecommons.org/licenses/by-nc-nd/3.0/

of stocks held on site were problematic. Others have clamoured to consider LC as the way forward to managing project complexity, and ensure a successful delivery of construction projects (Kemmer *et al*., 2013, Ochieng and Hughes, 2013).

Indeed, in recent years, numerous reports have reported LC as a form of successful project delivery system; Sage *et al*. (2012) emphasised that by pointing out that many reported construction projects achieved significant performance improvement through the adoption of LC. These can include: the reduction of waste, improvement of productivity, profitability, stakeholder satisfaction, shorter construction periods, labour reduction, higher system flexibility, higher quality, and improved safety and health (Thomas *et al*., 2003, Höök and Stehn, 2008, Mossman, 2009, Nahmens and Mullens, 2009). Moreover, it is reported from experience of projects managed under Lean and relational contracts such as the Integrated From Of Agreement (IFOA) using a combination of Set based and Target Value design, that these resulted in better understanding of the defined value of the owner and relations to the stakeholders (Howell, 2011). This implies LC can deliver many of the desired outcomes of the construction sector, which has resulted in a growth of research activity and theory building in relation to LC (Jacobs *et al*., 2012). Therefore, applying LC for design and construction within the industry becomes highly relevant.

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 PM into a holistic system for construction. Another implication pointed out from 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 being undertaken when implementing LC (McGrath-Champ and Rosewarne, 2009) – in whatever way LC is conceptualised and operationalised by individual organisations (Sage, Dainty and Brookes 2012). Nesensohn *et al*. (2013) posited the general requirement of organisational change initiated by embedding LC. From this study, it was discovered that the transformation towards a Lean organisation that delivers construction projects in a Lean way requires a long-term and deep-rooted cultural

change to embed the Lean philosophy as second nature within the thinking of the organisation, its processes, and the used Lean tools and techniques. Certainly the transformation towards LC will lead to changes of the culture and 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 organisations such as contractors, suppliers, or the owners. 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). However, the expected outcomes of such transformations are not always achieved, hence organisational assessments become essential when the implementation evolves (McElroy, 1996, Meiling *et al*., 2012), to help organisations to identify where they are on their transformation journey.

Finally, a current series of texts published by CIRIA (UK) where academics and professionals have interrelated their knowledge about LC, sustainability, and BIM, reminds us that the application of LC becomes more and more a pre-requisite within the supply chain of the UK Government and further within the global competition to deliver more with less (CIRIA, 2013). Within this series of reports it is also illustrated 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). Consequently, it is suggested to identify weaknesses and strength in the implementation of LC through a MM. This implies that supporting the transformation towards LC with organisational maturity assessments must be embraced and considered as work in progress until more precise models and research results are achieved. Consequently, the literature about maturity and MMs is reviewed in the followings sections.

2.5 The concept of Maturity

What is maturity? The Collins Dictionary (2011) defines mature as fully developed physically or mentally grown-up of plans or theories, sensible and balanced in personality and emotional behaviour, etc. Merriam-Webster's Dictionary (1984) adds to this that mature

in its basic meaning stresses the completion of development. Maier *et al*. (2012) see maturity as the "[…] state of being complete, perfect or ready" (p. 145).

From a management point of view maturity is "[…] the sum of action (ability to act and decide), attitude (willingness to be involved), and knowledge (an understanding of the impact of willingness and action)" (Andersen and Jessen, 2003, p.458). Maturity also specifies the understanding of why success occurs and therefore it enables one to identify common problems and ways to correct or prevent them (Schlichter, 1999). However, the measuring of maturity is generally more subjective than objective (Andersen and Jessen, 2003). Nevertheless, the concept of maturity has enjoyed widespread attention from academics in numerous fields (Maier *et al*., 2012). Although it is most widely used in the software industry and engineering, it is also used in other industries and in specific disciplines like PM (Cooke-Davies and Arzymanow, 2003).

Maturity is a widely used concept in different management contexts, i.e. organisational maturity, project maturity and process maturity. The combining of a process orientation with the maturity concept describes the ability to deliver high performance (Hammer, 2007). Process maturity has its roots in the TQM movement, which identifies a 'mature' process as one with increasing performance through consistency in process implementation (Cooke-Davies *et al*., 2001). Hence the term 'maturity' as seen from a process perspective implies an increasing process capability (Humphrey, 1993). According to Van Looy *et al*. (2011), process capability is a detailed concept of maturity because the general growth in capability is focused on narrowing the gap between targeted and actual achievement in the processes.

Process maturity is further dominant in project environments through the need for continuously performed processes by the project organisation (Amaratunga *et al*., 2002b). Therefore, the maturity of processes is quantifiable and can be illustrated through a lifecycle. This leads to defining process maturity as the extent to which an organisation is able to explicitly define, manage, measure and control their specific processes (Lockamy III and McCormack, 2004).

However, a general agreed definition of maturity in a project organisation does not exist (Cooke-Davies, 2004). Nevertheless, maturity viewed with a lens of 'project maturity' or 'project management maturity' has been derived through re-contextualising of the concept of organisational maturity (in respect of the software development process) to PM (software) (Ibbs and Kwak, 2000, Cooke-Davies and Arzymanow, 2003, Maier *et al*., 2012). Hence 'project maturity' should be understood as the ability of the organisation to manage different types of projects effectively and efficiently whilst achieving their project objectives (Andersen and Jessen, 2003). As a result it can be argued that projects need a mature organisation and their support to be successful (Richardson, 2010).

Whilst PM maturity is reliant on organisational maturity, it can be described as the application of maturity to an organisation which, depending on the degree of organisational maturity, is perfectly conditioned to achieve its objectives (Andersen and Jessen, 2003). For example, this includes the extent to which the organisation has explicitly and consistently deployed their processes (Van Looy *et al*., 2011).

Research in 'project maturity' or 'PM maturity' shows further variations in the concept of maturity (Maier *et al*., 2012). The work of Ibbs and Kwak (2000) illustrates project maturity through actions which are conceptualised as things organisations and people do. This notion of the combined actions of the organisation can be extended to reflect the overall receptiveness of an organisation (Skulmoski, 2001). Furthermore, combining these operational actions with the identification of key competencies/skills and attitudes enables maturity to be measured along three dimensions: knowledge, attitudes and actions (Andersen and Jessen, 2003).

2.5.1 Maturity and immaturity

To understand maturity it is useful to consider the differences between 'mature' and 'immature' organisations. Sarshar *et al*. (2000) remind us that immature organisations have no objective foundation with which to assess the quality of their products and services nor to solve product or process problems. They are further characterised as not achieving all their goals, with poor quality assurance and higher actual costs compared to estimated costs (Harmon, 2004). Nevertheless, immature organisations may occasionally deliver excellent results (Humphrey, 1989, OGC, 2010a) through the heroic efforts of individuals or by acting spontaneously (Sarshar *et al*., 2000, Harmon, 2004). Project managers of immature organisations mainly focus on solving immediate issues in a reactive mode of operation (Sarshar *et al*., 2000, OGC, 2010a).

By comparison, mature project organisations are characterised as being proactive and by planning, e.g. creating schedules for projects and keeping the projects regularly on track through timely corrective actions (Harmon, 2004). They have automatic behaviours, systematic processes, clearly defined roles and responsibilities, clear ways of doing things and constantly achieve their planned goals with minor deviation (Harmon, 2004, OGC, 2010a). They further demonstrate the ability to attract and develop individual talents (resources), which then perform consistently as expected from their position (Curtis *et al*., 2001, Curtis *et al*., 2009). Hence project managers of mature organisations monitor their capability, quality and customer satisfaction continuously (Paulk *et al*., 1993a, OGC, 2010a). Paulk (1993a) argues that an increase of organisational maturity institutionalises the organisation's behaviour, culture, practice, procedures, standards and structures.

Literature conceptualises the characteristics of a mature construction organisation as being one that communicates with all participants in order to manage design, construction and maintenance activities to fulfil the planned processes (Sarshar *et al*., 2000). Immature construction organisations, by way of contrast, are characterised as having improvised construction processes which are being undertaken by project managers and practitioners,

regardless of whether the process has been specified within the project or not. Since construction projects are thought of as temporary organisations and each project is unique to some degree, as with other organisations, they may share the general characteristics of both maturity and immaturity.

2.6 Maturity models

Assessing the maturity of an organisation will involve a large element of subjectivity (Andersen and Jessen, 2003). Yet the use of a MMs enables a degree of objectivity to be introduced to the assessment process (Richardson, 2010). However, it is important for a clear understanding to distinguish between the terms 'model' and 'framework'. Veldman and Klingenberg (2009) suggest that a framework with a lens of maturity can be understand as a set of rules and guidelines which could be applied to the reality. This is in line with Male (1998), who reminds us that a framework is a reference we can benchmark against. To describe the term ‘model’ from a MM perspective it is necessary to consider two viewpoints; first by, using a lens of science to look at ‘models’, as it must be acknowledged that the term is widely used by philosophers of science, (Aris and Penn, 1980). In this context models have always been very important (Frigg and Hartmann, 2006). So a “science point of view” by Apostel (1960, p. 160) is combined with a second lens from a MM perspective (CMMI Product Team, 2010, p. 4), which leads us to define MMs for this work as:

A system A, which is used by an organisation in order to obtain information about their maturity and capability regarding a subject, through a (visionary) mature organisation (system B).

Moreover, MMs apply a lifecycle approach where an area or process develops over time until it reaches a higher maturity level (Klimko, 2001, Tapia *et al*., 2008). Therefore, MMs are indispensable for organisations when they want to measure the current organisational capability (OGC, 2010a). Further, it is claimed that MMs enable organisations to implement change or improvement in a more systematic and directed approach that reduces errors and ensures quality while generating a comparable basis of assessing the maturity (Kohoutek,

1996, Cooke-Davies, 2007). In addition, it has been shown that MMs describe the evolution over a defined period of time through the development of people, technology, products and processes within an organisation in order to achieve its aim and objectives (Tapia *et al*., 2008, Khoshgoftar and Osman, 2009, Wang *et al*., 2011). Others have claimed that MMs are essential for organisations to plan and direct their on-going transformation efforts (Perkins *et al*., 2010a). MMs also provide a common and shared language that supports a shared understanding (Klimko 2001). Nevertheless, MMs have been mainly developed to assess specific areas against a standard, which is based on maturity levels (Tapia *et al*., 2008).

2.6.1 The origin of maturity models

The discourse on MMs often uses the Capability Maturity Model Integrated (CMMI) as a synonym (Wendler, 2012). The CMMI is the successor of the Capability Maturity Model (CMM), which became the first widely known MM (Tapia *et al*., 2008). However, in general MMs are based on techniques and methods from the work of the leading quality thinkers in the 20th century (e.g. Deming 2000, Juran 1998 and Shewart 1986), and Crosby (1979) was the first scholar who presented a MM (Fraser *et al*., 2002, Vaidyanathan and Howell, 2007, Van Looy *et al*., 2011). Crosby's (1979) Quality Management Maturity Grid (QMMG) showed that the usual behaviour of an organisation evolves through five stages of 'maturity' (Fraser *et al*., 2002). Crosby considered these stages of maturity for each of the six measurement categories of quality management, namely (1) Management understanding and attitude, (2) Quality organisation status, (3) Problem handling, (4) Cost of quality as % of sales, (5) Quality improvement actions and (6) Summation of company quality posture, in order to rate the quality of the organisation (Sun *et al*., 2009). The evolutionary theory of the QMMG suggested that companies can evolve towards quality management excellence through the five phases as shown in Table 2-2 below: (1) Uncertainty, (2) Awakening, (3) Enlightenment, (4) Wisdom and (5) Certainty (Fraser *et al*., 2002).

Table 2-2: Crosby's five maturity stages of the QMMG

Measurement Categories	Stage I Uncertainty	Stage II Awakening	Stage III Enlightenment	Stage IV Wisdom	Stage V Certainty
	Immature				**Mature**
Management understanding and attitude	No comprehension of quality as a management tool. Tend to blame quality department for "quality problems"	Recognising that quality management may be of value but not willing to provide money or time to make it happen.	While going through quality improvement programme learn more about quality management; becoming supportive and helpful.	Participating. Understand absolutes of quality management. Recognise their personal role on continuing emphasis.	Consider quality management as an essential part of company system
Quality organisation status	Quality is hidden in manufacturing or engineering departments. Inspection probably not part of organisation. Emphasis on appraisal and sorting.	A stronger quality leader is appointed but main emphasis is still on appraisal and moving the product. Still part of manufacturing or other.	Quality department reports to top management, all appraisal is incorporated and manager has role in management of company.	Quality manager is an officer status reporting and preventive action. Involved with customer affairs and special assignments.	Quality manager on board of directors. Prevention is main concern. Quality is a thought leader.
Problem handling	Problems are fought as they occur; no resolution; inadequate definition; lots of yelling and accusations.	Teams are set up to attack major problems. Long-range solutions are not solicited.	Corrective action communication established. Problems are faced openly and resolved in an orderly way.	Problems are identified early in their development. All functions are open to suggestion and improvement.	Except in the most usual cases, problems are prevented.
Cost of quality as % of sales	Reported: Unknown Actual: 20%	Reported: 3% Actual: 18%	Reported: 8% Actual: 12%	Reported: 6,5% Actual: 8%	Reported: 2.5% Actual:2.5%
Quality improvement actions	No organised activities. No understanding of such activities	Trying obvious "motivational" short-range efforts.	Implementation of a multistep programme (e.g. Crosby's 14-step) with through understanding and establishment of each step.	Continuing the multi-step programme and starting other pro-active / preventive product quality initiatives.	Quality improvement is a normal and continued activity.
Summation of company quality posture	"We don't know why we have problems with quality".	"Is it absolutely necessary to always have problems with quality?"	"Through management commitment and quality improvement we are identifying and resolving our problems."	"Defect prevention is a routine part of our operation."	"We know why we do not have problems with quality"

Source: Crosby (1979, p.38), Quality is free. Permission to reproduce this Table has been granted by McGraw-Hill Education LLC

Crosby's pioneering work within the topic on maturity and the developed QMMG greatly influenced Watts Humphrey in the development of a framework to improve software processes, which resulted in the CMM (Sun *et al*., 2009). Therefore, the QMMG led to the most significant published work in terms of MMs, the development of the CMM by the Software Engineering Institute (SEI) at the Carnegie Mellon University (Paulk *et al*., 1993b) as well as the successor, CMMI (Ahern, Bate and Konrad 2000).

2.6.2 The evolution of the CMM and CMMI

The development of the CMM dates back to Humphrey's work on 'software process improvement' at IBM in the 1980s (Humphrey, 2002). Here a series of assessments was

developed and later coupled with Crosby's QMMG (Humphrey, 1993). In 1986 Humphrey joined the SEI and worked together with researchers on the development of a process maturity framework to improve software processes (Humphrey, 2002). This was driven by the US Government – in particular the Department of Defence (Air Force) because the majority of their projects were over budget and time, and the Air Force requested a method to assess the capability of the contractors delivering these projects (Saiedian and Kuzara, 1995, Paulk, 2009). The researchers at the SEI developed the CMM through combining Humphrey's assessment questionnaire with Crosby's QMMG, and with the work from Shewart and Deming described in Deming (1986) and Humphrey (1989, 1993, 2002). In 1991 the first version of the CMM (1.0) was published and used, until in 1993 the revised version CMM 1.1 was released (Paulk *et al*., 1993b).

The fundamental concept of the CMM is that all methods, practices, activities and transformations utilised to develop software and products become defined and consequently implemented when the organisation matures (Paulk *et al*., 1993b). Gaining maturity further institutionalises processes through standards, organisational infrastructure, and corporate culture which supports the people and their activities, methods, and practices (ibid.). The CMM provides a framework to guide, control and maintain the organisation's processes and develops a culture of excellence with a number of recommended practices in key areas (Paulk, 2009). This is achieved through identifying the current process maturity and the critical issues that have to be addressed with evolutionary steps – the five maturity levels shown in Figure 2-1 (Paulk *et al*., 1993b).

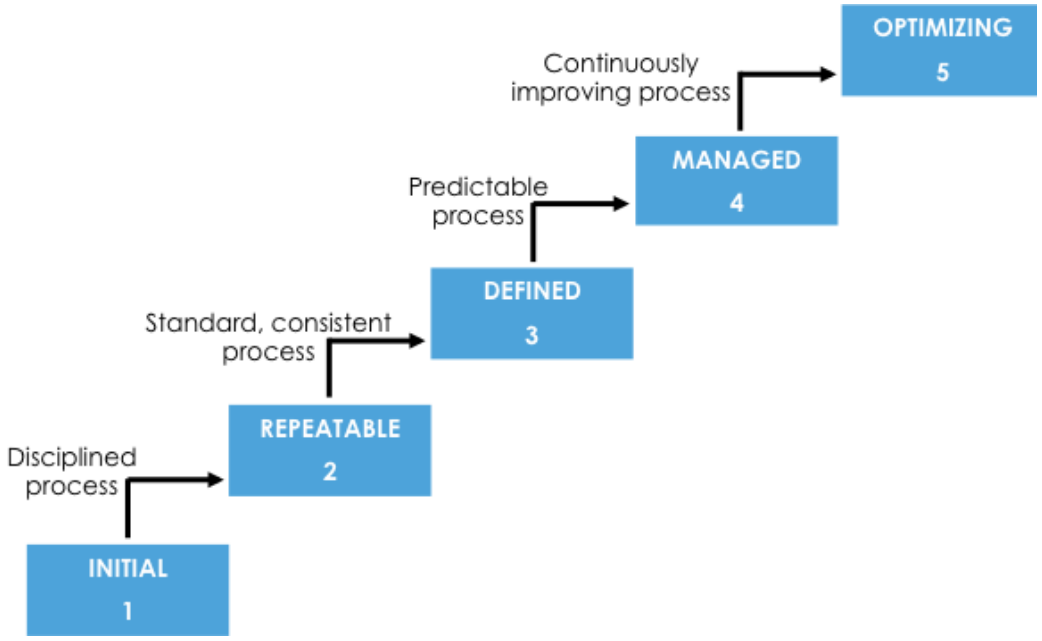


Figure 2-1: Maturity levels, adopted from Paulk *et al.* (1995)
Permission to reproduce this Figure has been granted by CMMI Institute

The five maturity levels: (1) Initial, (2) Repeatable, (3) Defined, (4) Managed, and (5) Optimising provide progressively the foundations for the next higher level as representation of evolutionary improvement (Humphrey, 1993, Paulk *et al*., 1993a, Paulk *et al*., 1993b, Paulk *et al*., 1995, Paulk, 2009). These levels are based on the product quality movement described by Shewart, Deming, Juran and Crosby (Cooke-Davies *et al*., 2001, Paulk, 2009). Therefore a maturity level is best described as "a well-defined evolutionary plateau towards achieving a mature software process" (Paulk *et al*., 1995, p. 30).

The maturity levels illustrate the overall structure of the CMM characterised by activities and a way of behaving (Paulk *et al*., 1995). As Paulk argues "[…] level 1, capability is a characteristic of individuals not organisations" (Paulk *et al*., 1993b, p. 22). Level 1 is only described as ad hoc, occasionally even chaotic, and the success of a level 1 organisation is based on the effort and commitment from individuals (Paulk, 2009). Levels 2 to 5 are described through 18 key process areas that indicate what an organisation has to improve in order to move from maturity level n to n+1 (Paulk *et al*., 1993b, Paulk, 2009). Table 2-3 below illustrates the key process areas of each maturity level (Paulk *et al*., 1993a, Paulk *et al*., 1993b, Paulk *et al*., 1995).

Table 2-3: CMM – key process areas

Maturity Level	Key Process Area	Focus
5 – Optimising	Defect prevention Technology change management Process change management	Continuous Process Improvement
4 – Managed	Quantitative process management Software quality management	Quantitative Management
3 – Defined	Organisation process focus Organisation process definition Training programme Integrated software management Software product engineering Intergroup coordination Peer reviews	Process Improvement
2 – Repeatable	Requirements management Software project planning Software project tracking and oversight Software subcontract management Software quality assurance Software configuration management	Project Management
1 - Initial	Non-existent	

Source: Paulk *et al.* (1995), Permission to reproduce this Table has been granted by CMMI Institute

The CMM was so successful that it rapidly expanded internationally and into the commercial industry, where several non-software industries used various CMMs in one project simultaneously (Glazer *et al*., 2008). Therefore, in 1997 the work on the CMM was stopped officially in favour of the development of the CMMI (Paulk, 2009). Nevertheless, it has been reported that contractors using the CMM in the US achieved productivity gains with more than double the amount of the maturity assessment and improvement costs (Saiedian and Kuzara, 1995). So it remains that the CMM had a great impact on many other recognised MM and frameworks including the People CMM (Curtis *et al*., 2009).

Yet, the CMM has not escaped criticism (Hartman and Skulmoski, 1998). One of its long-standing critics is software guru Capers Jones (Anthes, 1997), who argued that the CMM is

lacking a quantitative benchmark of specific levels for quality and productivity (Jones, 1995). Furthermore, it is claimed that the CMM increases bureaucracy; and that focusing on the CMM holds organisations back from other equally important activities and could result in a shying away from projects with high risk (but potentially high rewards) in order to move forward to the next level of maturity (Bach, 1994, Herbsleb *et al*., 1997). Moreover, the lack of a guaranteed pay-off for the additional effort and cost of moving upwards in the maturity levels is highlighted as a limitation (Anthes, 1997).

2.6.2.1 Major changes from the CMM to the CMMI

The CMMI integrates three MMs (Chrissis *et al*., 2004): (1) the unpublished version of the CMM v2.0, (2) a system engineering capability model (EIA/IS) and (3) the integrated Product Development Capability Maturity Model (IPD-CMM V0.98) (Ahern *et al*., 2000, Paulk, 2009). Furthermore, the CMMI is now applicable to other non-software areas (Glazer *et al*., 2008), such as PM, system engineering, risk management, service development and e-learning (Sun *et al*., 2009).

The five maturity levels (based on Crosby's QMMG) are still the backbone of the CMMI but the names were slightly changed to level two 'managed' and level four 'quantitatively managed' (Royce, 2002, CMMI Product Team, 2010). Further modifications took place in the structure of the model, more detailed within the process areas (PA) through several additions and combinations to each maturity level (CMMI Product Team, 2010). This resulted in the current version of the CMMI, 1.3, and its detailed structure shown in Figure 2-2 below. The PA are yet defined through a set of 'generic goals and practices' which are part of every PA and 'specific goals and practices' which are specific for a PA; both are further sub-categorised with informative components (ibid.).

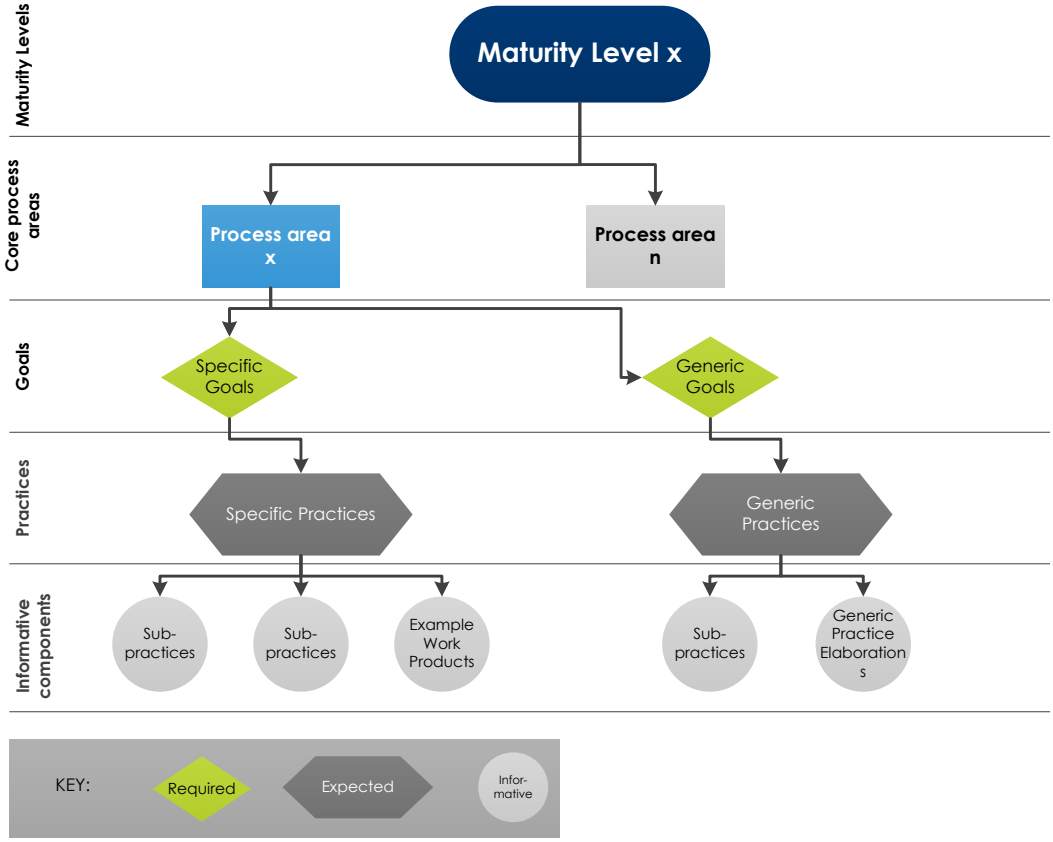


Figure 2-2: Structure of the CMMI
Adopted from CMMI Product Team (2010), Permission to reproduce this Figure has been granted by CMMI Institute

2.6.2.2 Maturity assessment

Since the CMMI is the most advanced MM it was decided to review its approach for the maturity assessment. Accordingly, the CMMI performs both the assessment of the process and the evaluation of the capability, which is labelled 'appraisal' to integrate these two concepts into one term (Paulk, 2009). This appraisal is carried out in three classes: A, B, and C. These are differentiated as: (1) the degree of confidence in the outcome; (2) the generation of ratings; and (3) the appraisal cost and duration (SCAMPI Upgrade Team, 2006). The requirements of these classes are defined in the documents Appraisal Requirements for CMMI (ARC) and the Standard CMMI Appraisal Method for Process Improvement (SCAMPI).

The most formal method, Class A, requires the gathering of objective evidence by documents and interviews, a minimum appraisal team size of four people, the coverage of

the organisational unit and a lead appraiser. The Standard CMMI Appraisal Method for Process Improvement (SCAMPI) is an example of a Class A appraisal. The less formal method is the Class B method, which requires the gathering of similar evidence but with only two experienced and trained persons. The Class C appraisal is the least formal one, carried out by a single person. It is important to know that only Class A generates a full benchmarking appraisal and a rating of the maturity level and the capability of an entity (CMMI Product Team, 2010). Hence Class B and C focus on the delivery of improvement information (ibid.).

More generally, Fraser (2002) reminds us that maturity assessments are carried out either by external auditors or by self-assessment; he warns us that the second method could be biased in its results.

2.6.3 Differentiation between maturity models and maturity grids

It is becoming increasingly difficult to ignore the publications of improvement frameworks (Maier *et al*., 2012), which are labelled MMs or maturity grids. Therefore it is hard to draw a line in the sand between them. There are some authors, for instance Maier *et al*. (2012) and Fraser *et al*. (2002), who have attempted to make such a distinctions. So Fraser et al. (2002) proposed three basic groups in which MMs can be classified: (1) CMM-like models, (2) Hybrids and Likert-like questionnaires and (3) Maturity grids. Maier et al. (2012) further suggest that MMs and grids can be differentiated in terms of the work orientation, the intent and the assessment mode of the maturity typology:

CMM-like models are MMs which show a typical CMM-like architecture, being more formal and complex than the other types (Fraser *et al*., 2002). Such MMs normally use questionnaires with Likert scales, checklists and observation/interviews as assessment method (Maier *et al*., 2012).

Maturity grids tend to be simpler and less complex improvement and diagnostic techniques (Maier *et al*., 2012). Grids are applicable in different industries because they do not specify

a process in a special entity; they identify general characteristics of processes (Hammer, 2007). The assessment method of a grid is characterised through a descriptive text in a matrix or grid structure (Fraser *et al*., 2002); this allows in each cell a basic description of the characteristics which is known as "[…] behaviourally anchored response scale format […]" (Grant and Pennypacker, 2006, p. 62).

Hybrids can consist of multi-point Likert scales which are illustrated in a maturity grid which results in a grid with more complexity (Fraser *et al*., 2002).

2.6.4 Contemporary issues in maturity models

The Total Quality Management movement formed not only Crosby's QMMG (Crosby, 1979) but also further frameworks with a particular focus on performance measurement, such as the Balanced Scorecard and the EFQM Excellence Model (Wongrassamee *et al*., 2003). The EFQM Excellence Model is a performance management model which aims to stimulate continuous improvement based on eight Fundamental Concepts of Excellence, nine Criteria (five enabler and four result criteria) and an assessment approach called the RADAR logic (EFQM, 2012). Furthermore, the EFQM focuses on the compliance of management systems and not on best practices and process improvement – as for instance the CMMI (Lean Advancement Initiative, 2012). Nevertheless, the EFQM Excellence Model also provides organisations with information about gaps and improvement areas similar to the CMMI and other MMs (ibid.). The second framework, the Balanced Scorecard, was introduced by Kaplan and Norton (1996) and combines financial measures with non-financial performance-based measures. This would arguably enable businesses to achieve a comprehensive view of their management system towards the set strategy (Wongrassamee *et al*., 2003). Kaplan and Norton (1996) claim further that the Balanced Scorecard prepares organisations to achieve performance improvement aligned with their long-term strategy through a view of corporate strategy and performance measurement. Overall, both the Balanced Scorecard and the EFQM Excellence Model are performance frameworks that provide their user organisation with a non-prescriptive template to establish clear visions of

their management processes, and stimulate improvement in terms of their long-term performance (Wongrassamee *et al*., 2003). However, in contrast to the above performance measurement frameworks, Nightingale and Mize (2002) demonstrated that the approach of the CMM and CMMI is the better fit for an organisational Lean assessment framework than the performance measurement approach. Moreover remind us Veldman and Klingenberg (2009) in their study that the CMM provides: guidelines; philosophy; and measurable-stepwise process improvement stages which are generally applicable to construction and engineer-to-order (ETO) organisations. In fact they propose to view the CMM/CMMI maturity levels as an implementation ladder.

In their major research, Sarshar *et al*. (1999) developed a MM for the construction industry: the Standardised Process Improvement for Construction Enterprises (SPICE) MM on the basis of the CMM. This study further identified fundamental similarities between the CMM and the construction industry. Based on this applicability of process improvement methodologies and process capability measurement in the construction sector a number of MMs have been developed over the last decade (Sun *et al*., 2009), e.g. the application of the CMMI to e-procurement from Eadie *et al*. (2011). Yet there are many MMs on the fundament of the CMMI which address different disciplines in the construction sector, as for instance 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 in the construction sector.

2.7 Maturity models comparison

To date there has been little agreement on what a MM for Lean or LC looks like. Hence the most widely used MM are reviewed and compared in this section to derive the commonalities between such models. Since MMs have a strong practical orientation it must be acknowledged that many of these models are presented within practitioner-oriented conferences to their target users and within reports from professional bodies such as the Project Management Institute (PMI). Hence this comparison uses not only academic literature in form of journal publications but also reports and conference publications

In order to analyse a set of MMs in comparison to the CMMI to derive commonalities a context for a systematic and objective comparison was required. Hence two sets of analytical lenses for this activity have been adopted: (1) a lens through which to select MMs and (2) a lens that enables an analytical and systematic comparison of the selected models. The first lens was adapted from Maier *et al*. (2012) and concentrated on MMs which meet the criteria of being based on the CMM-family and on the original QMMG by Crosby (1979) which have shaped the development of numerous MMs that can be characterised as CMM-based MMs (Eadie *et al*., 2012). Therefore, the models adopt the architecture/structure of the CMM-family. To not exclude models that could be potentially beneficial for this analysis a further criterion was added, i.e. any models developed specifically for the construction sector or contextualised and applicable to this industry.

The second analytical lens adapted twelve comparison variables from Khoshgoftar and Osman (2009) to enable, a systematic and comprehensive comparison. It is important to note that, although there will always be some bias within such analytical comparisons, this can be mitigated through the adaptation of valid variables. The comparison variables and their meaning are outlined below:

- *Based on the CMM-family*: the particular architecture/structure from the CMM is adopted. This refers back to the selection criteria;
- *reference*: the author and date of the main source;
- *scope*: the main area that the model addresses;
- *maturity levels*: the number of maturity levels within the model;
- *date of issue*: the date of first publication of the model;
- *definition of maturity*: does the model include a clear definition of maturity in terms of the discipline that is addressed (yes/no);
- *quantitative assessment*: does the model utilise quantitative assessments, for instance a questionnaire to assess the current maturity (yes/no);
- *qualitative assessment*: does the model utilise qualitative assessments, for instance interviews/observations to assess the current maturity (yes/no);

- *tangible results*: does the model offer a clear description of the results, for instance is each maturity level broken down into further areas and does each area have an understandable text description that makes it tangible what must be fulfilled to be on this maturity level (yes/no)? If a model contains a numeric system to ascertain a maturity level without any description, this would be considered as an intangible result, because the user only gets the information to be on a certain maturity level without any tangible and understandable justification – and would therefore be answered 'no';
- *assessment expenditure*: the required expenditure of time, resources and effort for the proposed assessment (low/medium/high). For instance, an assessment carried out by one individual that includes handing out a questionnaire or a review of a small amount of documents to judge the maturity is considered as low assessment expenditure. A more comprehensive assessment performed from an internal assessment team which plans, prepares, and carries out the assessment is considered as medium assessment expenditure. High assessment expenditure would be using an assessment team supported by an external certified lead assessor to gather objective evidence by questionnaires, interviews, etc.;
- *identify strengths and weaknesses*: does the MM offer the basis to identify strengths and weaknesses of an organisation to inform the planning and directing of improvement efforts? This means the extent to which the model follows an approach that builds a maturity level through various areas and sub-areas (two levels) which are assessed individually. This is considered as identifying strengths and weaknesses. Hence the results of the various areas illustrate the strengths and weaknesses of each area and therefore of the current maturity level. If the model does not have such a subdivision the identification of the strengths and weaknesses is vague and therefore the answer to the question is 'no'; and

- *simple and understandable*: is the MM easy to understand and comprehensible (low/medium/high)? For instance, is the structure and complexity of the CMMI considered as medium? Simpler structures with less complexity – which makes those models easy to understand – are considered as high. On the other side, any model that is more complex than the CMMI is considered to be low.

2.7.1 Overview of the selected maturity models

A systematic search of the academic literature selected nine models that best met the criteria. These models are presented in Table 2-4.

Table 2-4: Overview of the selected Maturity Models

Model	Abbreviation	Developer
Capability Maturity Model Integrated	CMMI	Software Engineering Institute (SEI) at Carnegie Mellon University
Construction Supply Chain Maturity Model	CSCMM	Kalyan Vaidyanathan and Gregory Howell (US)
Construction Industry Macro Maturity Model	CIM3	Christopher J. Willis and Jeffrey H. Rankin (Canada)
Organisational Project Management Maturity Model	OPM3	Project Management Institute (PMI, US)
Berkley Project Management Process Maturity Model	Berkley PM2	Dr. Williams Ibbs, University of California, Berkley (US)
Portfolio, Programme and Project Management Maturity Model	P3M3	Office of Government Commerce (OGC, UK)
Standardised Process Improvement for Construction Enterprises	SPICE	Centre for Information Technology in Construction (CITC), University of Salford (UK)
Change Management Maturity Model	CM3	Ming Sun, Christos Vidalakis and Tejas Oza (UK)
Maturity Assessment Grid from the Strategic Forum for Construction	MAG	Strategic Forum for Construction, (UK)

2.7.2 Summary of the comparison

A summary of the comparison, using the comparison variables outlined above and the selected models is presented in Table 2-5, p. 53.

Table 2-5: Comparison of Maturity Models

Comparison variables	CMMI	CSCMM	CIM3	OPM3	Berkley PM2	P3M3	SPICE	CM3	MAG
Based on the CMM-family	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NO
Reference	(CMMI Product Team, 2010)	(Vaidyanathan and Howell, 2007)	(Willis and Rankin, 2012)	(Project Management Institute, 2003)	(Kwak and Ibbs, 2002)	(OGC, 2010b)	(Sarshar *et al.*, 1999, Sarshar *et al.*, 2000)	(Sun *et al.*, 2009)	(Strategic Forum for Construction, 2003b)
Main area	Software	Construction	Construction	PM	PM	PM	Construction	Construction	Construction
Maturity levels	5	4	3	4	5	5	5	5	3
Date of Issue	1991	2007	2012	2003	2000	2006	2000	2009	2003
Definition of maturity	Yes	No	No	Yes	No	Yes	No	No	No
Quantitative assessment	Yes	-	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Qualitative assessment	Yes	-	Yes	No	No	Yes	Yes	Yes	No
Tangible results	Yes	-	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Assessment expenditure	High	-	Medium	High	Medium	Medium	Medium	Low	Low
Identify Strengths and weaknesses	Yes	-	Yes	Yes	Yes	Yes	Yes	No	Yes
Simple and understandable	Medium	High	High	Low	Medium	High	Medium	High	High
- = No information available for the comparison.									

Capability Maturity Model/Integrated (CMMI)

Since the CMMI has been comprehensively reviewed in the previous section, this will not be repeated. Table 2-5, p. 53 illustrates key aspects of the model in order to enable a comparison with the other selected models.

Construction Supply Chain Maturity Model (CSCMM)

[This is a framework for a model which is not yet further developed[3]]

The CSCMM is a conceptual framework for a MM for the supply chain of construction organisations, with the objective being to improve the operational effectiveness and efficiency of their supply chains (Vaidyanathan and Howell, 2007). Furthermore, this model takes a multi-enterprise project supply chain into account and is based on the CMM (Vaidyanathan and Howell, 2007). The model is described in four maturity levels called 'stages': (1) Ad-hoc (2) Defined (3) Managed and (4) Controlled. The names are closely related to the CMM as they are the same except for the missing second CMM level (repeatable) and the renamed highest level (optimising). The CSCMM consists of a framework to both assess the current maturity and to guide a move from level n to n+1 (Vaidyanathan and Howell, 2007). Hence the assessment of maturity takes place along three dimensions: functional, project and firm according to four categories: process, technology, strategy, and value-assessment (Willis and Rankin, 2012). The model provides information of what to measure, though it does not provide how this measurement will be accomplished.

Construction Industry Macro Maturity Model (CIM3)

The aim of this model is not focused on a specific construction organisation; rather it is on interpretations and comparisons of the performance in the construction industry over time and in different regions (Willis and Rankin, 2012). It is not surprising that the CIM3 is based on the framework of the CMM (Willis and Rankin, 2010). In contrast to the CMM the CIM3 uses three maturity levels, namely: (1) Immature (2) Transitional Mature and (3) Mature. However, the general structure of the model has the construction industry consisting

[3] Personal conversation in 2013 with Gregory Howell, one of the authors of the model.

of several 'Key Practice Areas' (KPA) which each contain a performance goal and key practices. This concept is similar to the CMMI. Each KPA is linked to three capabilities and their outcome, which enables the model to measure maturity in the form of a capability score within all practice areas. In this way the CIM3 assumes a relationship between performance and key practices in the construction sector. The assessment within this model consists of two parts: first a pair-wise comparison through an expert group of the key practice and KPA - in order to identify their importance; and second a questionnaire survey (Willis and Rankin, 2010).

Organisational Project Management Maturity Model (OPM3)

The OPM3 is the result of work which integrates the PM Body of Knowledge (PMI PMBOK) context with organisational maturity (Cooke-Davies, 2007, Richardson, 2010). The PMI defines the OPM3 as a standard to understand and measure organisational project management maturity "[…] against a comprehensive and broad-based set of organisational project management Best Practices" (Project Management Institute, 2003, p.xiii).

The underlying concept of the OPM3 is that organisations can addresses the model in three areas: portfolio management, programme management and PM – hence the term 'PM3' (Cooke-Davies, 2007). Another significant characteristic of this model is that it is structured in three main areas: (1) knowledge - the main body of the model that explains organisational maturity in relation to the industry best practices; (2) assessment - the measuring method to identify the maturity; and (3) improvement - describes what to change (Richardson, 2010). Furthermore, the heart of the model consists of a list of over 600 best practices for organisational PM (Project Management Institute, 2003, Willis and Rankin, 2012). The OPM3 illustrates maturity through four process improvement stages: standardise, measure, control, and continuously improve in each of the three main areas (Cooke-Davies, 2007). In order to determine organisational PM maturity an assessment survey is used, which is performed by completing worksheet templates and results in two lists. The first demonstrates the best practices that the organisation performed and the second illustrates the gaps between the best practice level and the performed practices (Richardson, 2010).

Berkley Project Management Process Maturity Model (Berkley PM2)

The Berkley PM2 was developed by Dr. Williams Ibbs and the University of California at Berkley. The PM2 is built on the basic structure of the CMM and industry best practice, which is used to assess the maturity (Richardson, 2010). This model benchmarks organisational maturity in terms of PM against other organisations and provides sequential improvement steps for the PM processes (Kwak and Ibbs, 2002). Being based on the CMM structure it also takes the five maturity levels, though, as with most variants on the CMM, with slightly different names: (1) ad-hoc, (2) planned, (3) managed at project level, (4) managed at corporate level and (5) continuous learning (ibid.). Each of these maturity levels consists of key PM processes, organisation characteristics and focus areas. Furthermore, the model divides PM processes into five project processes and nine PM areas, in order to identify strengths and weaknesses in the current processes and to provide a focus towards the addressing of the weaknesses (Ibbs and Kwak, 2000). To identify the level of PM maturity the PM3 uses a questionnaire (Kwak and Ibbs, 2000).

Portfolio, Programme and Project Management Maturity Model (P3M3)

The P3M3 was first published in 2006 by the Office of Government Commerce (OGC). Based on the CMM it aims to improve quality and efficiency within organisations in the public and private sectors (OGC, 2010a). The most recent version of the P3M3 was published in 2010. The P3M3 combines three independent models – the Portfolio Management Maturity Model (PfM3), the Programme Management Maturity Model (PgM3) and the Project Management Maturity Models (PjM3) – under one umbrella (ibid). This enables an independent use of each model or the use of more than one. The P3M3 uses five maturity levels: (1) awareness of process, (2) repeatable process, (3) defined process, (4) managed process and (5) optimised process (ibid.). Furthermore, the P3M3 assessments focus on seven process perspectives, which are sub-divided into ‘specific attributes’ and ‘generic attributes’. This allows an assessment of every maturity level and is used in all three models (OGC, 2010b). The P3M3 provides both a self-assessment tool in the form of a questionnaire and a formal review through an Association of Project Management Group

(APMG) Accredited Consultancy Organisation (ACO) which uses an APMG assessment tool (ibid).

Standardised Process Improvement for Construction Enterprises (SPICE)

The SPICE framework is the result of a research project which attempted to tailor the CMM to the construction industry (Sarshar *et al*., 1999). Its aim was to develop a practical management diagnostic and improvement tool across construction organisations (Sarshar *et al*., 2000). Therefore, the SPICE is based on the experience of the software industry in MMs and process improvement. It re-contextualises many basic concepts from the CMM into a specific framework for construction (Sarshar *et al*., 2004). Similar to the CMM the SPICE framework has five maturity levels that build sequential layers to prioritise the efforts of CI and to benchmark the maturity of a construction organisation (Sarshar *et al*., 2000). The first SPICE maturity level is 'initial/chaotic' and serves as an entry level; the second level, 'planned and tracked', focuses on predictable, tracked, planned and enforced projects; level 3, 'good practice sharing', concentrates on capturing and sharing good practice; based on level 3 a quantitative process management focus can be established at level 4, 'quantitatively controlled', across the organisation; whilst level 5, 'continuously improving', expects CI across the whole supply chain of the organisation (Siriwardena *et al*., 2005). In addition to identifying maturity levels the SPICE framework adopts the key processes from the CMM and re-contextualises these to construction within levels 2 and 3 (Sarshar *et al*., 2004). To indicate the capability of each key process area the SPICE uses 'process enablers', which are a type of thinking or activity that can be expected as the outcome of a key process (Sarshar *et al*., 2000). The process enablers, which are the same in all key process areas, are: commitment, ability, verification, evaluation and activities (Sarshar *et al*., 2004). The assessment using the SPICE framework is similar to the CMM appraisal process and includes three elements: a questionnaire, interviews and the review of documents (Sarshar *et al*., 2000). Hence maturity is achieved if all key processes in a given level are satisfied.

Change Management Maturity Model (CM3)

The CM3 is a measurement framework to assess the capability and improvement of a project team (client, contractor and consultant) in order to deal with change management (CM) based on contract changes during construction projects (Sun and Oza, 2008). The CM3 is principally based on the structure of the CMM and therefore consists of five maturity levels, namely: (1) ad-hoc CM, (2) informal CM, (3) systematic CM, (4) integrated CM and (5) CI in CM (Sun *et al*., 2009). The CM3 integrates the KPAs of management process, risk management, communication, management information, collaboration and leadership/objectives.

Each KPA is related to activities that enable the achievement of a set of goals (Sun and Oza, 2008). The CM3 adopts the design and structure of maturity grids, as it presents the five levels and the six KPAs in the form of a matrix. Each cell of the matrix consists of a detailed text KPA description at a particular maturity level (ibid.). Therefore, the CM3 assesses the capability of the project team through a comparison of the project capability and the performance, with the text descriptions in the matrix (Sun *et al*., 2009). Additionally, the CM3 adopts the three types of assessment from the CMM (Class A, B and C), though it still uses the direct comparison to the grid regardless of what class is used. The end result of the assessment is the rating of the maturity level to each KPA, which allows a contrast to the CMM different maturity levels in different KPAs (Sun and Oza, 2008, Sun *et al*., 2009).

Maturity Assessment Grid (MAG) from the Strategic Forum for Construction

The MAG was developed under the umbrella of the Strategic Forum for Construction, with the aim being to both measure cultural maturity and to guide both individuals and an organisation in how to introduce a change of culture and behaviours towards better ‘integration’ within the construction industry (Strategic Forum for Construction, 2003c). Integration in this context means to introduce working practices, behaviours and methods that enable it to work collaboratively, effectively and efficiently (ibid.). The maturity assessment grid is part of a toolkit which is labelled the ‘Integration Toolkit’. This toolkit is

a pan-industry guide and a framework for change, though without step-by-step instructions (ibid.). The toolkit evolved through the experience of leading-edge practitioners and it offers to its users several practical suggestions of how others achieve change (Strategic Forum for Construction, 2003a). The maturity assessment enables organisations and individuals to identify Key Attributes, which are in the broad areas of: culture, behaviours and industry attitudes, and it illustrates how change could evolve from an 'historic' (traditional) phase through 'transitional' to an 'aspirational' phase (Strategic Forum for Construction, 2003c). These phases can be seen as maturity levels, so the grid consists of three maturity levels.

Furthermore, the assessment grid includes three main areas, which can be classed as KPAs as they are similar to the CMM. These areas are: supply chain integration, project team integration and culture (Strategic Forum for Construction, 2003b). They are further sub-categorised into 30 criteria with a descriptive text for each phase (maturity level) (ibid.). Hence the assessment follows a grid approach, which compares the text description with the current situation (Fraser *et al*., 2002). The focus of this assessment is on the behaviours and critical elements which have to be considered within a change towards integration. It offers tools, methods and techniques to support a suitable culture in which an integration can thrive (Strategic Forum for Construction, 2003a). The maturity grid assessment identifies the key areas which should be established in an action plan of change for the organisation (Strategic Forum for Construction, 2003c).

2.7.3 Identified commonalities

The comparison of the selected MMs reveals commonalities which are as follows:

- A structure comprising five maturity levels arranged around key process areas, and dimensions like goals and best practices;
- a systematic and objective approach of the maturity assessment;
- uncovering strengths and weaknesses;
- supporting a common language;
- raising awareness and enable prioritising of improvement; and

- monitoring, directing and controlling.

Since the first analytical lens selected MMs that have the CMM architecture/structure and therefore the Crosby QMMG as a fundament it is not surprisingly that with an exception of the MAG all models reflect this common background either implicitly or explicitly. In particular, the OPM3 mirrors the structure of the CMMI through the adaptation of the concept of best practices combined with key processes. The CIM3 seems to be a model that adapted the structure of best practices in the form of key practices and smaller sub-divisions which are still very similar even though it does have only three maturity levels. A different approach, with only three maturity levels, is taken by the MAG. This has a maturity assessment grid which does not follow the CMM-family, but is based on the original QMMG from Crosby (1979). Hence the majority of the models adapted the five maturity levels together with best practices, key process areas, and goals which form the backbone of the CMM-family. Equally, identified Eadie *et al*. (2012) in their study that more than 53 MMs can be claimed to be CMM-based and 88% of those CMM-based MMs comprising five maturity levels. So taking into account that the previous comparison showed that 5/9 MMs have five maturity levels and the result from Eadie *et al*. it is clear that this number of levels must be the first commonality. Furthermore, through its widely recognised structure the CMM-family embedded in the majority of the models compared delivers a fairly systematic and objective approach for the organisational assessment of the current state of maturity.

The comparison further identified that the assessments used predominantly built on quantitative as well as qualitative data which is used in interplay to uncover strength and the weaknesses of the organisation and its current state. Therefore, uncovering strengths and weaknesses were identified as the third commonality. Further, it was understood that simpler and more understandable models seem to establish a common language for their management discipline. Although this is considered to be much more difficult for more complex MMs, it has been taken on as the fourth commonality.

That not all MMs include a clear definition of the specific maturity which is assessed could be considered as a kind of immaturity within the models. Hence the models that included a

clear definition are considered to be raising the awareness of the maturity and the particular subject within interplay of the further description of the model itself. All models with the exception of the CSCMM (not sufficient information) have been considered on the basis of their descriptions to deliver tangible and understandable results. These results then contain rich information for each area within a maturity level that enables the user to plan, direct and prioritise the improvement actions to be taken towards greater maturity. As a result, raising the awareness and supporting the prioritising of improvement efforts is another commonality.

Finally, it was identified that the majority of the MMs deliver enough detailed information to monitor and direct the impact of the implemented improvement. This is certainly a desired outcome of a MM, and the last commonality for MMs.

2.8 The gap in the literature

Recently, researchers have shown that it becomes important when implementing Lean to be able to measure the current state of implementation as well as to identify strengths and weaknesses to plan future improvement efforts (Meiling *et al*., 2012). As has been demonstrated earlier, MMs enable organisations to achieve this need. Further, Veldman and Klingenberg (2009) showed that in particular the CMMI provides the construction sector with a framework which is widely applicable. However, far too little attention has been paid to organisational assessments in LC and little or no discussions have been about LC in terms of maturity and MMs. In addition, no research has been found that investigates the phenomenon 'LC maturity' or the potential of MMs for LC. In fact, a systemic literature search specifically for terms like LC, Maturity, and MMs within Discover (the online research tool of the LJMU) found only a few studies which are at best an attempt towards an organisational assessment for LC. Further, studies have been found outside of LC – in particular within the Lean production literature – that provides a fruitful combination of those domains. All the attempts found are summarised in Table 2-6, p. 62, in which they are presented with the six identified commonalities of MMs from the previous section.

Table 2-6: Transparent demonstration of the gap in the literature

Search terms/ combination	Results	Attempt towards a MM for LC and Lean	Source	Claim	Common factors of a MM					
					1	2	3	4	5	6
Lean Construction, Maturity	13	BIM and Lean interactions from the BIM capability maturity model perspective: A case study (Hamdi & Leite, 2012)	Academic Conference	Lean principles support improvement of BIM maturity	No	No	Yes	Yes	No	No
		Diffusing cultural awareness and maturity in Lean managed organisations (Chesworth *et al.*, 2010)	Academic Conference	Provide cultural awareness about how and why cultural maturity in Lean-managed organisations occurs	No	No	No	No	No	No
Lean Construction, Maturity Model	7	No other findings								
"Lean Construction", maturity grid	0	No other findings								
"Lean Construction", maturity assessment	0	No other findings								
"Lean Construction", assessment	36	Indonesian contractors' readiness towards Lean construction (Abduh & Roza, 2006)	Academic Conference	Measure the LC readiness of contractors to identify improvement areas	No	No	Yes	Yes	No	No
		Lean Construction: From Theory to Implementation (Salem *et al*., 2006)	Journal	A new Lean self-assessment tool to track the improvement of Lean implementations towards project performance	No	No	Yes	Yes	No	No
"Lean Construction", rating	6	Rapid Lean Construction-Quality Rating Model LCR (Hofacker *et al*., 2008)	Academic Conference	An easy model to evaluate the quality and degree of Leanness to understand the main areas for improvement	No	No	Yes	Yes	Yes	No
"Lean Construction", evaluating	8	No other findings								
"Lean Construction", evaluation	31	No other findings								
Lean, maturity model	289	Development of a Lean Enterprise Transformation Maturity Model (Nightingale & Mize, 2002)	Journal	Judged that a MM approach fits best to a self-assessment tool for Leanness - propose the LESAT-Model for Lean Aerospace	Yes	Yes	Yes	Yes	Yes	Yes

This table is quite revealing in several ways. First, it demonstrates the lack of knowledge in terms of LC and MMs, as the difference in the number of results compared to Lean and MMs emphasise. Second, the research to date within LC has tended to focus on measuring the effect of LC implementation rather than on supporting the transformation towards greater maturity in LC by measuring the gap between the current and the desired state of maturity. Most studies in LC that include the keyword 'maturity' have mentioned maturity when it is linked to BIM or cultural awareness/cultural maturity of organisations rather than in particular about LC.

Equally, the first identified attempt towards a MM for LC seeks to identify potential improvement for BIM through a construct inspired by the CMMI which assesses BIM maturity. The authors Hamdi and Leite (2012) further found that it could be fruitful to develop a combined maturity assessment tool to support the implementation of LC as well as BIM. However, the presented tool addressed only BIM and does not have many things in common with the CMMI. Similarly, the work of Chesworth *et al*. (2010) utilised a rather random use of maturity in the context of cultural awareness. Indeed, the presented theoretical framework tends to understand cultural maturity in Lean-managed organisations rather than the current state of maturity in LC. Moreover, Chesworth *et al*.'s work – which is currently presented in the form of a published PhD thesis – aimed to understand cultural maturity, i.e. how employees respond to innovative ideas of their management, through combining cultural maturity and diffusion theory (Chesworth, 2013). This framework is focused on the identification of drivers and factors that influence the cultural maturity through the diffusion of Lean (ibid.). However, the focus of this study towards cultural implications associated with the implementation of Lean and the underpinning of diffusion theory, is centrally different to the before-described MM concept and the identified common factors.

Abduh and Roza (2006) actually presented just a protocol which has been used to identify the readiness of LC amongst contractors. A more comprehensive work was proposed by Salem *et al*. (2006), when they produced a checklist comprising six 'arguable' elements of

LC which are evaluated with projects. Further, this self-assessment tool is claimed to be simple and comprehensive. However, this attempt is still too different from the common factors of MMs. The self-assessment tool from Hofacker *et al*. (2008) is equally based on six categories that are derived from the work of Koskela (1992) and Womack and Jones (2003) combined with a quality questionnaire for construction. This tool claims to assess the degree of an LC-application within a one-hour site visit and a questionnaire with 30 questions. Although this simple assessment tool seems to have some value, it does not offer the sufficient commonalities identified for MMs.

However, all the previously mentioned approaches suffer from some serious weaknesses. First, with the exception of Salem *et al*. (2006), the attempts to assess the implementation of LC are presented as conference publications. This makes the generalisability problematic. Second, and more important, the researchers have not treated the dimension against which they measure in detail. Utilising exclusively published Lean thinking principles or not generalisable LC principles and techniques seems to be rather inappropriate as a basis for an LC assessment. A much more systematic approach would identify how LC could be simplified to attributes that are believed to be linked to greater maturity or Leanness.

2.8.1 Attempts in the literature without a construction focus

As Nightingale and Mize (2002) demonstrated that the suitability of the CMMI with their maturity approach for a potential organisational Lean self-assessment tool. The authors further presented a Lean Enterprise Self-Assessment Tool (LESAT), which has been developed under the auspice of the MIT and the Lean Aerospace Initiative (LAI) in the UK and US (Massachusetts Institute of Technology, 2012). In their major study Nightingale and Mize (2002) argue that the LESAT enables its user to understand an organisation's current state and desired state of Leanness as well as the readiness for change. In its application to ten US aerospace organisations the authors found that:

- Lean leadership is a critical success factor which achieved broader and long-lasting results;

- healthy discussion and debate about strengths and weaknesses has been established;
- the perceptions of management hierarchies about Lean have been aligned;
- a more holistic picture of the current Leanness for the participants evolved; and
- they identified holes in their Lean strategy and opportunities for process improvement.

It is important to note that the LESAT provides all the commonalities which have been identified for MMs. However, this is not surprising since it adapts major elements from the CMMI with the exception that it adapts a maturity grid for the assessment. As a final point, the applicability of the CMMI to Lean has been equally identified by Kundu *et al*. (2011) in their comparison study between Lean production best practices and the CMMI best practices. Moreover, the authors argue that the CMMI will be in many cases complemented by the Lean best practices. Finally, the authors' advice is to integrate and harmonise Lean with the CMMI for services to a unified model (Kundu *et al*., 2011).

2.8.2 Other attempts towards Lean & LC maturity assessments from the wider literature

Several attempts outside the academic literature aimed to assess the Leanness when an organisation implements Lean, e.g. The Highways Agency Lean Maturity and Assessment Toolkit (HALMAT) and the Shingo Prize Model.

The HALMAT self-assessment tool actually aims to foster the transformation towards LC and a culture of CI within the supply chain of the Highways Agency (Highways Agency, 2010). The HALMAT is principally based on the LESAT maturity grid previously identified. It is argued that the tool was designed across the whole construction supply chain of the Highways Agency including a wide variety of top tier companies, e.g. construction, design, consultancy and maintenance. The assessment of the HALMAT covers ten areas: (1) Strategic use of Lean; (2) Financial, information, and procurement systems, (3) Lean

leadership, (4) People development, (5) Lean structure and behaviour, (6) Collaborative working, (7) Delivery of value, (8) Standard work, (9) Process flow, (10) Process control and quality assurance. Moreover, the HALMAT claims to enable its users to measure their current state of maturity in terms of their LC implementation and to support their transformation towards greater maturity (ibid.).

The famous Shingo Prize Model has been claimed to be the most comprehensive model to assess the Leanness in organisations (Bergmiller and McCright, 2009). This is based on the philosophy developed by Dr. Shigeo Shingo who identified the relationship between business improvement and guiding principles, systems and tools (The Shingo Prize, 2013c). The model is presented with four domains in which 10 guiding principles and several supporting concepts are organised. The Shingo model further claims to be a roadmap to achieve operational excellence in a systemic manner (The Shingo Prize, 2010). The Shingo assessment method focuses on results as well as behaviour and is applied in many industries worldwide (The Shingo Prize, 2013a). In 2013 The Shingo Prize (2013b) presented SCOPE as a web-based simplified methodology of the Shingo Prize Assessment. This assessment describes ideal behaviours in statements which capture the content of the Shingo Model, and the existence of those statements is evaluated through a questionnaire with a Likert scale.

Both Lean assessment tools found in the wider literature and reviewed so far however suffer from the fact that the generalisability is problematic, as the claims and the development are not backed up with academic literature or published research; although the Shingo Model must be considered as a more accurate account since it is based on the pioneer work of Dr. Shingo, e.g. Shingo (1989).

2.9 Themes drawn from the findings of the reviewed literature

Through reviewing the literature in this chapter, certain themes have arisen which build a suitable justification for this research. So it became clear that LC is more and more the improvement strategy of choice applied for design and construction in the industry; however it has been revealed that it requires a change and long-term thinking for the transition. The

findings from the literature show further the absence of an appropriate organisational assessment to measure where an organisation currently is in their LC transformation, and further the support to achieve greater maturity is limited. Generally, it can be assumed that:

- LC is a management philosophy that can deliver more value to the ultimate customer with less of everything;
- LC progressively plays a major role in improving the productivity lack in the construction industry, and recent research has demonstrated that it can increase project performance more effectively than traditional PM approaches (Liu *et al*., 2011);
- in addition, LC receives global attention, which is evident in the increase of the theoretical ground;
- the effective utilisation of LC requires several changes and a long-term thinking to achieve a transformation, but support for such a transformation is limited, although organisational maturity assessments could deliver it;
- through assessing the maturity benefits generated may include but not be limited to: knowing the current state of maturity, identifying weaknesses and strengths, providing crucial information to prioritise improvement efforts and plan how to achieve the desired state of maturity, establishing a common language, embedding processes and management approaches, implementing a change or improvement strategy in an organised way;
- the concept of maturity and MMs has been neglected from a LC perspective;
- the most common MMs share six commonalities which are different to the identified current attempts towards an organisational assessment of the LC implementation, although there are links between Lean production and MMs as well as practical examples of maturity assessments within LC; and
- finally, there is a need to explore the phenomenon 'LC maturity' and a synthesis towards a MM for LC to enhance the success of organisational transformation towards greater maturity in LC.

As a result, the transformation process from a traditional approach to the adaptation of a LC management philosophy is critical and relies on appropriate information to know the current state, strengths and weaknesses and a clear vision of the desired state. The concept of maturity and MMs can provide this need and maybe more as it has proved its applicability in Lean production and many other disciplines, where it provided a number of benefits. Therefore, proposing the first understanding for LC maturity and a framework for a MM for LC that incorporates the ability to provide the critical information needed, becomes a justified research endeavour.

2.10 Chapter summary

This chapter has reviewed the theory and literature of LC, the concept of maturity and MMs with the aim to build a comprehensive understanding of the current 'state of knowledge', identify perspectives, its boundaries and the gap which will be addressed within this research. The discussion attests the important role of LC within the challenge to increase the productivity in the industry. Indeed, the implementation of LC differs from current and traditional approaches, which causes the need for organisational assessments. In many disciplines including construction and Lean MM have been utilised for such organisational assessments. In addition, MMs provide a number of benefits required for the transformation towards greater maturity in Lean. Hence it has been pointed out that MMs are seen as fruitful for LC and the development of greater maturity in LC. Consequently, this chapter highlights the justification for this research through demonstrating the gap in our knowledge about MMs in LC and the phenomenon 'LC maturity'.

CHAPTER THREE

CONCEPTUAL RESEARCH FRAMEWORK

3 Conceptual Research Framework

3.1 Introduction

This chapter combines the research philosophy, logic, methodological choices and approaches into a conceptual research framework, because a framework is able to combine constructs/concepts, definitions, and propositions in relation to the research question (Sevilla *et al*., 2007). This framework comprises the modified research onion from Saunders *et al*. (2012) – see Figure 3-1. The terms 'Research logic' and 'Research approach' have been modified from the original 'Approach' and 'Strategies'. The onion is a simple analogy as the outer layers protect the centre and influence it at the same time which emphasises that it cannot be reached before one has considered and peeled off the outer layers. In the light of this, the centre is not part of this chapter, but the focus of the next chapter in this thesis. The following sections introduce each layer of the research onion to then summarise in the final section the conceptual research framework for this study. This builds the foundation for the research methodology in Chapter four.

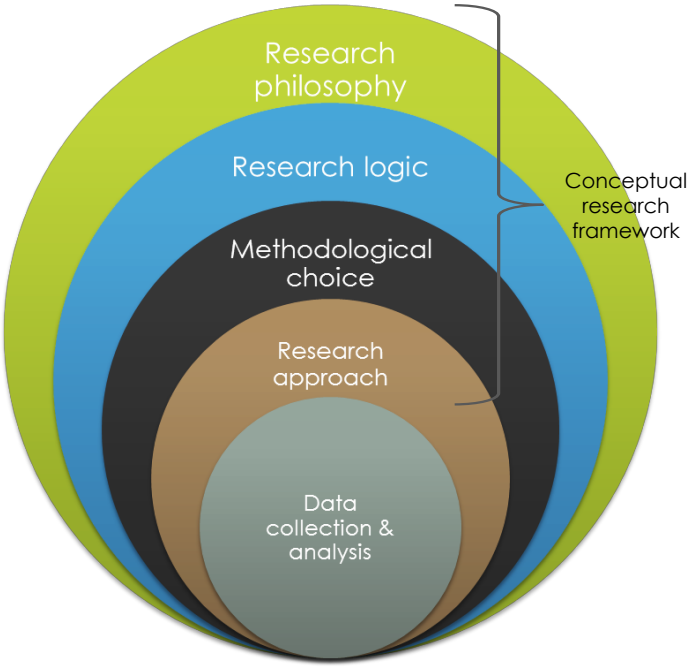


Figure 3-1: Research onion. Permission to reproduce in this form has been granted by Saunders

The layer ***Research approach*** considers different approaches that could be adopted in the research, and the ***Methodological choices*** focuses on the distinction of qualitative and quantitative research. The outer two layers ***Research logic*** and ***Research philosophy*** capture the difference between inductive and deductive research, and the latter includes the philosophical position of the ontological and epistemological research perspectives.

3.2 Research philosophy

The outermost layer of the onion describes the philosophy which positions the entire research and points out what are the acceptable knowledge and processes to develop it (Saunders *et al*., 2012). This is essential to consider, and particularly true within the built environment (Amaratunga *et al*., 2002a). Since philosophy underpins the whole research design and all inner layers of the research onion, this describes the way the researcher views the world (Saunders *et al*., 2012). Figure 3-2 illustrates that the research philosophy consists of the theoretical perspective, which is informed by the ontology and the epistemology (Crotty, 1998).

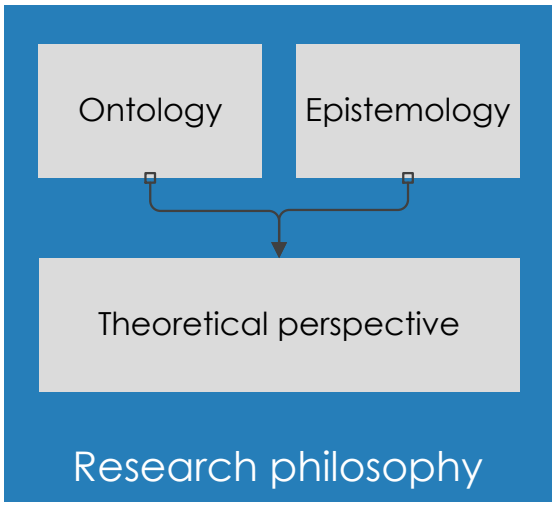


Figure 3-2: Content of the research philosophy inspired by Crotty (1998)

3.2.1 Ontology

Ontology is the underpinning assumption of the reality within the research, real world and the researcher. Since every theory of knowledge or epistemology presupposes an ontology (Bhaskar, 2008), the ontology relates to the real world and its characteristics (Creswell 2013). The term ***ontology*** or ***ontologia*** was first coined by the German philosophers Jacob Lorhard (Lorhardus) and Rudolf Goekel (Goecklenius) in 1613 (Smith, 2008a). Easterby-Smith *et al*. (2012) outline four different types of ontologies: (1) ***realism*** (the world is external and has only one truth), (2) ***internal realism*** (there is a single truth, but this truth is not directly accessible), (3) ***relativism*** (the truth is independent of the discovery process and there are many truths) and (4) ***nominalism*** (there is no truth as reality is created by humans). Another aspect of ontology is introduced by Saunders *et al*. (2012), who focus on the aspects ***objectivism*** and ***subjectivism*** and argue that both are able and accepted to produce valid knowledge for business and management research. Crotty (1998) further points out that ontology and epistemology emerge together and it is difficult to view one without the other.

3.2.2 Epistemology

Since ontology describes the understanding of 'what', epistemology must be perceived as the perspective of "what it means to know" (Crotty, 1998, p. 10). Hence epistemology describes the major way of thinking about the research philosophy and theory of knowledge (Saunders *et al*., 2007, Bryman, 2008). Epistemology is important for the research as it makes a distinction between objectivist/positivist research and subjectivist/constructionist research Crotty (1998).

The major concern about epistemology is 'what constitutes acceptable knowledge' in the research field (Saunders *et al*., 2012). Hence epistemology "[…] involves knowledge, therefore, and embodies a certain understanding of that what is entitled in knowing, that is, how we know what we know […]" (Crotty, 1998, p. 8).

This means the assumptions made by epistemology consider the possibilities of what kind of knowledge can be produced, how it can be produced and which criteria divide adequate from inadequate knowledge (Blaikie, 2010). Two contrasting epistemological aspects are ***objectivism*** and ***constructionism*** (Crotty, 1998). The first is described as: existing social entities in the form of meaningful reality which is independent of any consciousness, as for instance a "[…] tree in the forest is a tree, regardless of whether anyone is aware of its existence or not" (ibid., p. 8). This view of objective truth which is waiting to be discovered is rejected by constructionism as follows: no meaning without a mind, and meaning can only be constructed rather than discovered (Crotty, 1998). It can therefore be understood that constructionism uses an interplay between a subject and an object to identify patterns and generate a meaning (ibid.). Another stance of epistemology after Crotty (1998), is subjectivism which "[…] asserts that social phenomena are created from the perceptions and consequent actions of social actors" (Saunders *et al*., 2012, p. 132). In contrast with constructionism, the meaning in subjectivism is not produced as a result of an interplay between subjects and objects; rather, the meaning is created independent to the object, and is imposed on it (Crotty, 1998). Hence the meaning is attached to the object or phenomena within the subjectivist viewpoint (Saunders *et al*., 2012). In summary, the three epistemological stances are illustrated in Figure 3-3.

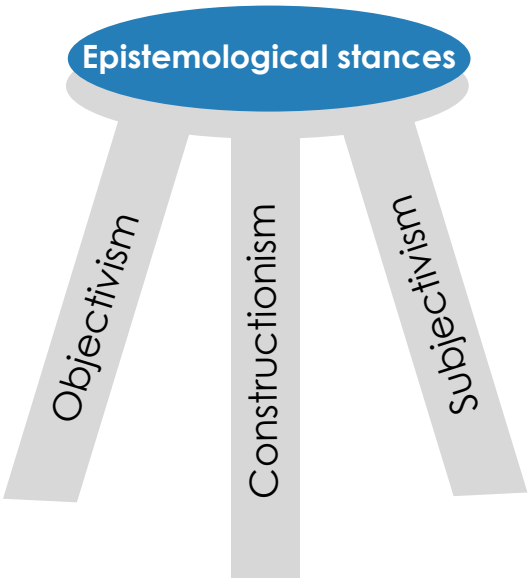


Figure 3-3: Epistemological stances inspired by Crotty (1998)

3.2.3 Theoretical perspectives

Theoretical perspectives are the assumptions that lies behind our research approach; hence these perspective are the fundament of the chosen approach and methods (Crotty, 1998). Easterby-Smith *et al*. (2012) for instance concentrate on two contrasting theoretical perspectives: ***positivism*** (the social world exists externally and its characteristics are best measured by objective methods) and ***social constructionism*** (the social reality is determined by people and not viewed as objective and exterior). It is important to note that theoretical perspectives of qualitative inquiries can be captured under an umbrella of the interpretivist tradition (Schwandt, 2001), see Figure 3-4. Grix (2010) reminds us that theoretical perspectives (research paradigms) are often labelled in different ways; however, the continuum of their positions moves in general from left (positivist) attempts to explain social reality to right (interpretivist) attempts which seek to understand or interpret social reality.

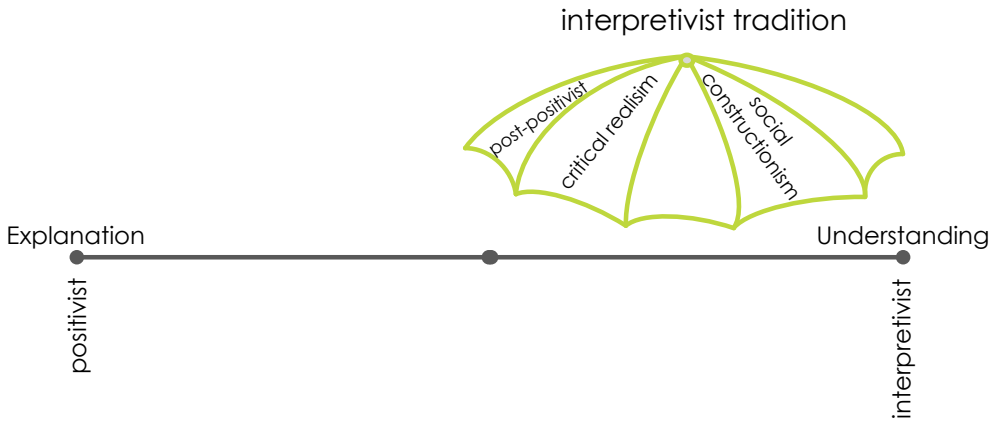


Figure 3-4: The continuum of theoretical perspectives inspired by Grix (2010) and Schwandt (2001)

Following Schwandt's argument, social constructionism is one of several perspectives under the interpretivist tradition. Social constructionism further focuses on the approach to how the meaning is constructed (Crotty, 1998), which is similar to the concept of 'verstehen' as a dimension of the interpretive tradition explained by Schutz (1962 cited in Denzin and Lincoln, 2003).

Saunders *et al*. (2012) extend this when they argue that positivism produces credible data only through clearly observable phenomena, in order to confirm/disclaim hypotheses which can be developed through existing theory. Additionally, it is claimed that researchers must strictly declare themselves as value free and completely objective (Crotty, 1998). On the other hand, is social constructionism considered as a new theoretical perspective that takes account of the contribution to the scientific revolution of Galileo or Einstein (Easterby-Smith *et al*., 2012). This new theoretical perspective focuses on the constructions of meaning evolved from different experiences of people, which contrasts with collecting facts (ibid.).

Another theoretical perspective is the ***realism*** within business and management research, which is subdivided into ***direct realism*** and ***critical realism*** by Saunders *et al*. (2012). The latter is arguably frequently used by business and management researchers to find the middle ground between positivist and social constructionism theoretical perspectives (Easterby-Smith *et al*., 2012). The critical realism in particular claims to understand reality through understanding the social condition which combines the development of knowledge by collecting data and understanding its meaning (Saunders *et al*., 2012). This is somewhat similar to the epistemology stances of constructionism, which establish an interplay between the object and the subject. The originator of this philosophical position, Bhaskar (2008), argued that critical realism accepts that real structures exist independently of patterns or events (Bhaskar, 2008). Therefore, this position considers social conditions constructed by humans and their real consequences, whether these conditions are gathered by experiments or not (Easterby-Smith *et al*., 2002).

It is important to note that there are other philosophical positions as well and there is no single philosopher that addresses all aspects of only one philosophical/theoretical perspective (Easterby-Smith *et al*., 2012). One theoretical perspective that must be mentioned is ***postmodernism***, which shows the critical and total rejection of any objective view of positivism (Denzin and Lincoln, 2003). This perspective is described as the jettisoning of totalising distinctions and the fragmentation of culture, art, life and architecture (Crotty,

1998). Figure 3-5 illustrates how the philosophical assumptions about ontology, epistemology and theoretical perspectives can be combined.

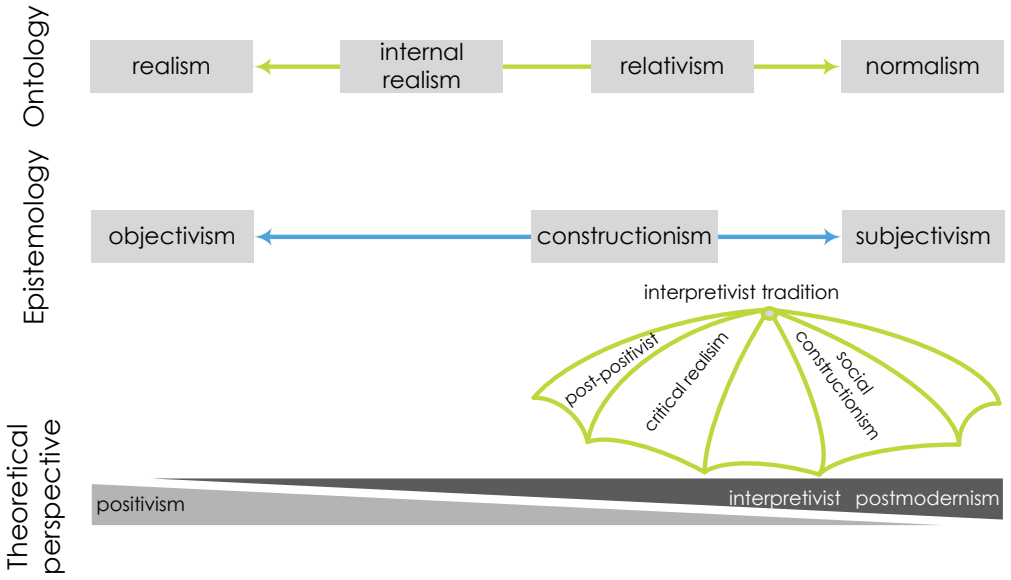


Figure 3-5: Combined philosophical assumptions inspired by Easterby-Smith *et al*. (2012), Grix (2010) and Johnson and Duberley (2003)

This research is positioned along this continuum between positivism, objectivism and realism on the left side and postmodernism, subjectivism and normalism on the right side. However, this requires some more considerations regarding the combination of those three elements. First, the ontological and epistemological stances cannot be considered separately or parallel to each other; as Crotty (1998) shows, realism in ontology and constructionism in epistemology are compatible and represent the emerging of both sides. Crotty (1998) further emphasised that social constructionism is not only compatible with ontological relativism.

Finally, it is important to consider that social constructionism is an ***interpretivist tradition*** within qualitative inquiry (Schwandt, 2001), which does justice to this call for interpretive traditions within the discipline of construction management.

3.3 Research logic

Research logic involves the adopted reasoning for the research (Saunders *et al*., 2012, Creswell, 2013). According to Ketokivi and Mantere (2010) the understanding of the

different reasoning is important to build transparency and consistency into the justification of the research. Three different types of reasoning are considered: deduction, induction and abduction.

3.3.1 Deduction

Deductive research starts with a theoretical argument/hypothesis which is tested through empirical observations (Järvensivu and Törnroos, 2010, Saunders *et al*., 2012). According to Ketokivi and Mantere (2010) deduction is "a form of reasoning where a conclusion is logically derived from a set of premises … and thus [the] conclusion … does not contain any new knowledge" (p. 330). In other words, deduction moves from theory to empirical observation (data), as illustrated in Figure 3-6.

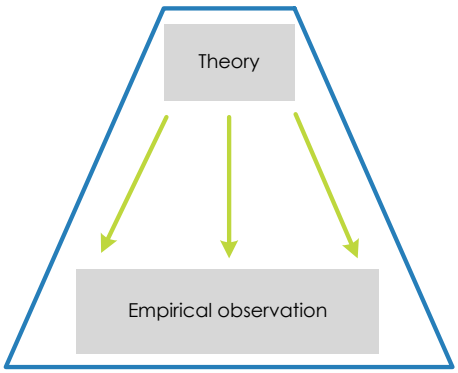


Figure 3-6: Deductive research logic

3.3.2 Induction

Unlike deduction, inductive logic generalises from data (empirical observation) to theory, as illustrated in Figure 3-7. Saunders *et al*. (2012) use inductive reasoning data to explore a phenomenon while identifying themes and patterns and formulate a theory by for instance creating a conceptual framework. However, it must be stressed that according to Blaikie (2010) the produced descriptions of the inductive logic are not a universal law. Nevertheless, the inductive strength is the production of an understanding about how the people regarding the phenomenon under investigation interpret their social world (Saunders *et al*., 2012).

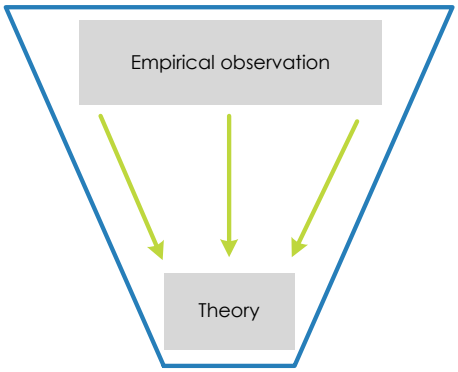


Figure 3-7: Inductive research logic

3.3.3 Abduction

The third research logic, abduction, was termed by Charles Sanders Peirce in 1934 (Van Maanen *et al*., 2007), as a result of the belife that new ideas and good theory do not emerge through sterile induction or deduction but through moving back and forth between both (Suddaby, 2006). The beginning of abductive research is often an "unmet expectation" to build a world or theory that makes this expectation meaningful (Van Maanen *et al*., 2007, p. 1149). Furthermore, it is a continuous interplay between concepts and data, where surprises can occur at any stage within the research part of abduction (Van Maanen *et al*., 2007). Abduction is illustrated in Figure 3-8.

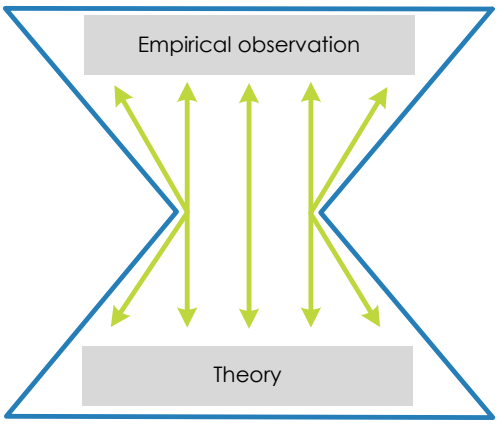


Figure 3-8: Abductive research logic

It is important to note that abduction is used in much business and management research (Saunders *et al*., 2012), and is incorporated within grounded theory (Suddaby, 2006);

nevertheless it is often not clear that the research uses abductive logic (Van Maanen *et al*., 2007). One reason for this could be the close relation to induction, as Bryman (2012) points out that abduction is broad in its approach but also worthwhile to distinguish from induction as it builds a theoretical understanding informed by context, people's worldview, language, meanings and perspectives. This could be true when we consider that Creswell (2013) avoids the term abductive but describes complex reasoning as an "inductive-deductive logic process" where the researcher works "back and forth between themes and the database" in order to establish the themes (p. 45). According to Järvensivu and Törnroos (2010) unlike induction, abduction accepts existing theory. Furthermore, it is argued that the theoretical perspectives of critical realism and constructionism are aligned with abduction (Blaikie, 2010, Järvensivu and Törnroos, 2010).

3.4 Methodological choice

Since the outer two layers of the introduced research onion have been peeled away and explained, the methodological choice is the third layer which has to be considered. The methodological choice is the choice between quantitative and qualitative research, which are both represented in the built environment (Amaratunga *et al*., 2002a). Each of those and its combination will be explained, in order to be able to justify which methodology is best suited for this research.

3.4.1 Quantitative research

Quantitative as an adjective indicates "that something is expressible in terms of quantity (i.e., a definite amount or number)" (Schwandt, 2001, p. 215). Hence quantitative data is numeric, which is often analysed in a statistical manner in order to examine relations amongst different variables (Saunders *et al*., 2012). This usually means developing testable arguments and theory for testing and generalisation through this numerical data (Amaratunga *et al*., 2002a). This follows the deductive logic which is in a strong relationship with quantitative data together with the positivism stance of philosophy (Saunders *et al*., 2012).

However, quantitative research is not restricted to positivism or deduction and may use philosophies such as realism and inductive research logic (ibid.).

Looking at common research approaches that are used within quantitative research these are principally experimental and survey approaches, which make use of questionnaires or structured interviews that allow the researcher to quantify the collected data (Saunders *et al*., 2012). It is important to note that a questionnaire is not restricted to quantitative data as it may involve open questions where the respondents give the answer in the form of words (non-numeric data) rather than a tick in a box.

Further, quantitative research often collects a large amount of data, which have to be reduced by different techniques before the researcher can analyse the relationships amongst the variables (Bryman, 2012). An example of a quantitative analysis is: descriptive statistics and its tests or the statistical packages, which is mostly performed by the software SPSS (statistical packages for social science) (Easterby-Smith *et al*., 2002).

Considering the advantages and weaknesses of quantitative research within the built environment, Amaratunga *et al*. (2002a) draw our attention to a list of strengths:

- "Comparison and replication are allowable;
- independence to the subject observed from the researcher (observer);
- subject under investigation is objectively measured;
- reliability and validity may be determined more objectively than in qualitative research;
- strong in measuring in descriptive aspects; and
- emphasises the need to formulate hypothesis for subsequent verification" (p. 22).

On the other side there are some weaknesses which are not only related to the built environment or business and management research. It is criticised that the quantitative researcher would fail "to distinguish people and social institutions" from the natural world

and natural science, and that "the measurement process possesses an artificial and spurious sense of precision" (Bryman, 2012, p. 178). More specifically within the built environment are the arguments that quantitative research only takes a quick informal picture of the situation while measuring the variables and it fails to understand and explain the meaning behind the numeric-data (Amaratunga *et al*., 2002a).

3.4.2 Qualitative research

The adjective qualitative is "attached to a variety of social inquiry" while it refers to "all forms of social inquiry" which "rely on qualitative-nonnumeric data" (in the form of words, etc.) and broadly aim to understand "the ***meaning*** of human ***action***" (Schwandt, 2001, p. 213). According to Schwandt (1999) "the aim of qualitative research is to understand what others are doing and saying" (p. 451). Hence qualitative research concentrates on exploring and understanding the meaning of people, individually or as a group in terms of the phenomenon under investigation (Creswell, 2009). In doing so, qualitative research delivers new discoveries and understanding. As Suddaby (2006) reminds us, this has a long tradition as "new discoveries are always the result of high-risk expeditions into unknown territory", such as by Darwin, Columbus, and Freud, who all conducted qualitative inquiries (p. 633).

Since qualitative research considers the understanding by making sense out of the subjectively expressed and socially constructed meaning, it is not surprisingly that it is generally (though not exclusively) referred to in association with the interpretive philosophical umbrella (Saunders *et al*., 2012). However, there is a consensus in the literature that qualitative research is a naturalistic inquiry because it focuses on people in their natural setting, who attach meaning to the phenomenon under investigation within their social world (Snape and Spencer, 2003, Saunders *et al*., 2012). Hence qualitative researchers are concerned about the "socially constructed nature of reality, the intimate relationship between the researcher and what is studied, and the situational constraints that shape the inquiry" (Denzin and Lincoln, 1998, p. 8). Qualitative research however includes several different characteristics which clearly distinguish it from quantitative research.

Snape and Spencer (2003) illustrate these commonly agreed and reported distinctive characters with the following examples:

- "Aims which are directed at providing an in-depth and interpreted understanding of the social world of research participants by learning about their social and material circumstances, their experiences, perspectives and histories;
- samples that are small in scale and purposively selected on the basis of salient criteria;
- data collection methods which usually involve close contact between the researcher and the research participants, which are interactive and developmental and allow for emergent issues to be explored;
- data which are very detailed, information rich and extensive;
- analysis which is open to emergent concepts and ideas and which may produce detailed description and classification, identify patterns of association, or develop typologies and explanations; and
- outputs which tend to focus on the interpretation of social meaning through mapping and re-presenting the social world of research participants" (p. 3).

Qualitative research is often reported in relation to the inductive logic through building a rich theoretical description of the meaning of the collected and analysed data and therefore moving from the particular to the general (Creswell, 2009, Saunders *et al*., 2012). However, it is important to note that it is argued that in practice the qualitative researcher commonly takes advantage of the abductive logic and its interplay between inductive and deductive logic (Saunders *et al*., 2012). Furthermore, there are some commonly used research approaches for qualitative inquires such as: phenomenology, ethnography, grounded theory, case study and narrative research (Denzin and Lincoln, 1998, Saunders *et al*., 2012, Creswell, 2013).

As we have seen so far, the starting point of qualitative research is non-numeric data, which must be collected within the natural setting of the participants in a way that allows the researcher to interpret the meaning (Creswell, 2009). Therefore, the qualitative researcher uses a variety of data collection methods. These methods in general are not standardised in order to explore emerging interesting issues in the naturalistic and interactive environment (Saunders *et al*., 2012), and allow close contact with the research participants, as pointed out earlier from Snape and Spencer (2003). The main data collection methods within qualitative research can be subdivided into naturally occurring data such as: observation, documentary, conversation and discourse analysis; and into generated data collection methods as for instance: individual interviews and group discussions (group interviews and FGs) (Easterby-Smith *et al*., 2002, Snape and Spencer, 2003, Bryman, 2012). To develop and interpret the meaning researchers have to analyse the collected data and these analysis procedures differ from the analysing of quantitative numeric data.

Qualitative analysing of data involves five major interconnected steps: (1) storing and organising of the data, (2) conducting of a preliminary read-through and memoing, (3) describing, classifying, and interpreting data into codes and themes, (4) interpreting the data and (5) representing and visualising the data (Creswell, 2013).

According to Amaratunga *et al*. (2002a) the use and focus of qualitative research is growing in the built environment. Supporting evidence for this can be found in Knight and Ruddock (2008) as they analysed a completed volume of the peer-reviewed articles and reported that more than three-quarters of the published studies employed qualitative methods and the single most-used data collection method is the individual interviews followed by FGs and group interviews. In addition, Amaratunga *et al*. (2002a) demonstrate the claimed benefits of qualitative research in relation to the built environment. These are:

- Qualitative research is powerful and flexible in studying any process;
- the flexibility of the data collection establishes confidence in terms of understanding the phenomena under investigation;

- it delivers a systematic and good connection of the meaning to the social world;
- qualitative research is the best strategy for discovering and exploring a new area;
- there is a strong potential for testing hypotheses; and
- data which need to be supplemented, validated, explained, illuminated or reinterpreted from the same setting are best collected by qualitative research.

Reported criticism of qualitative research focuses on issues such as the subjectivity of the findings due to the personal relationship between the researcher and the participants of the study; and its difficulty to replicate the study because of its unstructured nature (Bryman, 2012).

3.4.3 Combination of methods

Since both methodologies have strengths and weaknesses as pointed out above, there are good reasons for combining them in order to neutralise or reduce the bias of one methodology (Amaratunga *et al*., 2002a, Creswell, 2009). As this is a broad field with many terms used interchangeably, Figure 3-9 offers one possible distinction between the methodological choices.

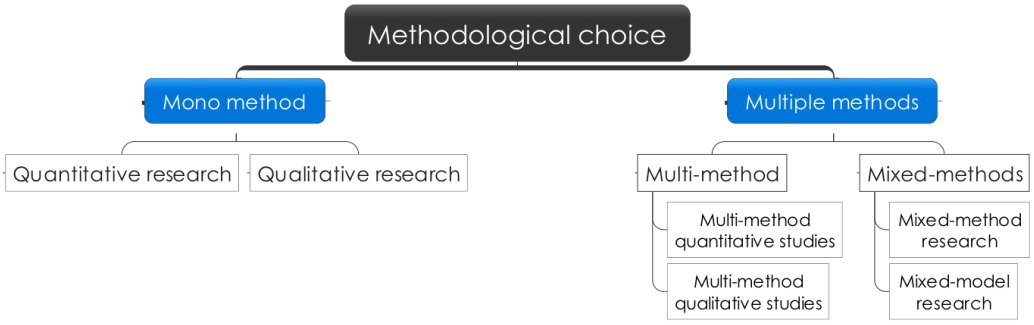


Figure 3-9: Methodological range. Permission to reproduce this Figure has been granted by Saunders.

Considering that the term mixed-methods is used interchangeably, it is deceptive that authors, for instance Morse (2003, 2010), define mixed-method design as the use of one complete method for a single study which consists of one core component and one or more supplementary component(s) which are either all qualitative or quantitative in nature but can be mixed. Therefore, the used terminology 'mixed-methods' does not presuppose that quantitative and qualitative methods have been used and mixed within one single study.

Considering this, a mixed-method design involves a primary (core) method (QUAL or QUAN) and one or more supplementary component(s) (qual or quan) that provide insights and explanation for the core component of the research through separate data such as interviews (Morse, 2010). The primary method and the supplementary components can be paced simultaneously (which is illustrated as +) or sequentially (illustrated as →) (Morse *et al*., 2006). An example of a simultaneous mixed-method design within a phenomenological study would be: QUAL $^{\text{(phenomenology)}}$ + qual $^{\text{(semi structured interviews)}}$. This describes precisely that the study uses a qualitative primary phenomenological approach and semi-structured interviews as a qualitative supplementary component. Figure 3-10 illustrates the example.

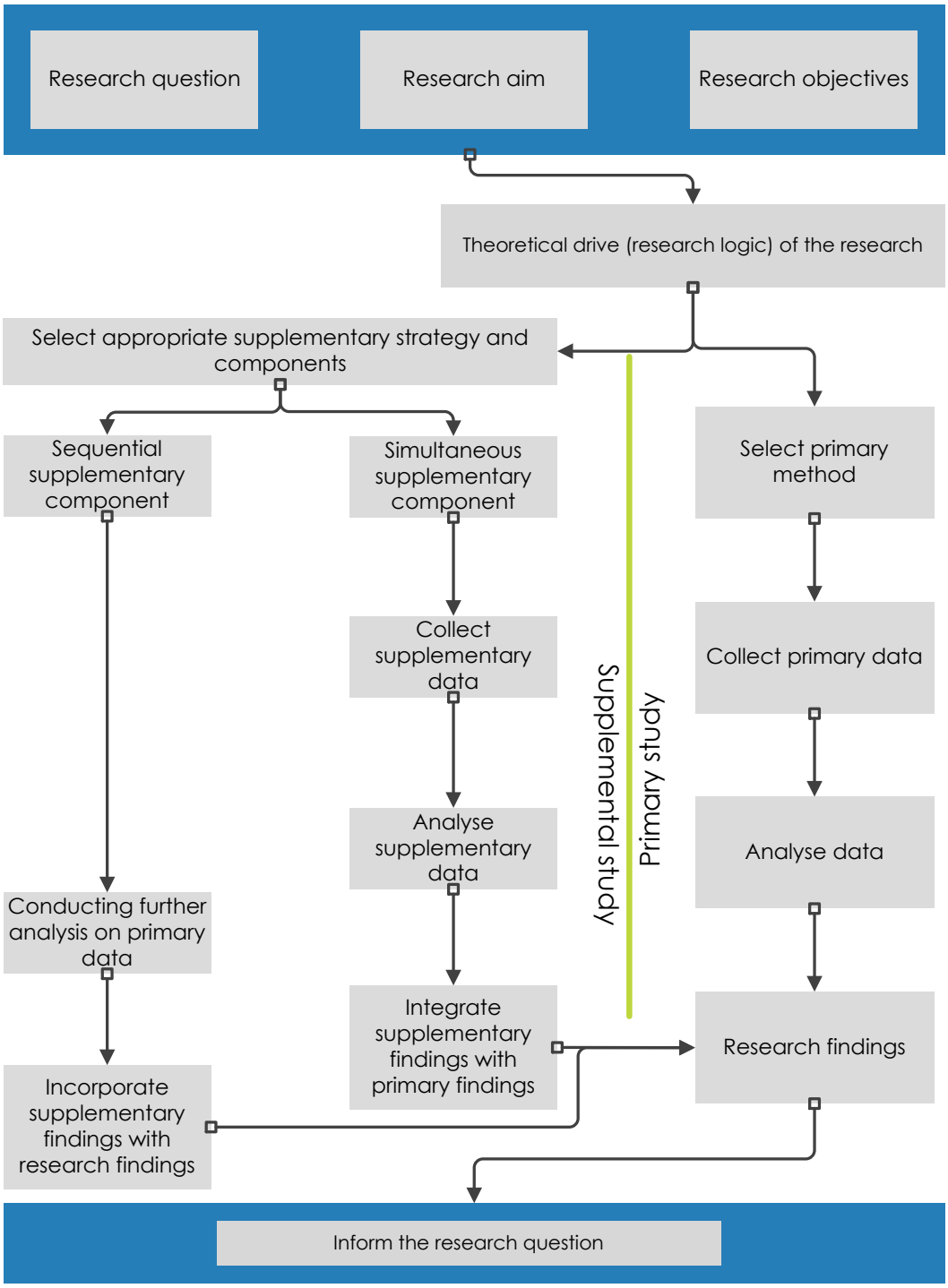


Figure 3-10: Mixed-method design, adapted from: The role of the theoretical drive in maintaining validit in mixed-method research, Morse *et al*. (2006), Qualitative Research in Psychology, reprinted by permission of Taylor & Francis LLC (http://www.tandfonline.com).

Morse (2010) further outlines reasons for using a simultaneous or sequential pace:

Simultaneous pace will be best:

- To answer the research question more completely and comprehensively with broader scope or increased depth to make the research richer and more useful;
- to gather another perspective while using more than one data set and sample; and
- to include information which would not be accessible within one method, or to answer sub-questions and move the research project along.

Sequential pace will be best:

- To answer minor questions that come up within the primary method; and
- to move the research programme towards implementation.

It is important to note that the primary data and the supplementary data may overlap or be separate but they cannot be merged together for analysing (unless formally transformed) (Morse, 2003, Morse, 2010). The participants of the primary method and the supplementary component may or may not be the same, but they are from the same population (Morse, 2010).

3.4.4 Sampling

Whether the research is qualitative, quantitative or a form of mixed-method design it needs to select a sampling technique (Ritchie *et al*., 2003a). However, in general samples are omnipresent, for instance when we read an article in a newspaper that was created through interviewing a group of people (Saunders *et al*., 2007). Therefore, sampling means simply that we collect a reduced amount of data from a sub-group rather than from the whole population - see Figure 3-11, p. 88.

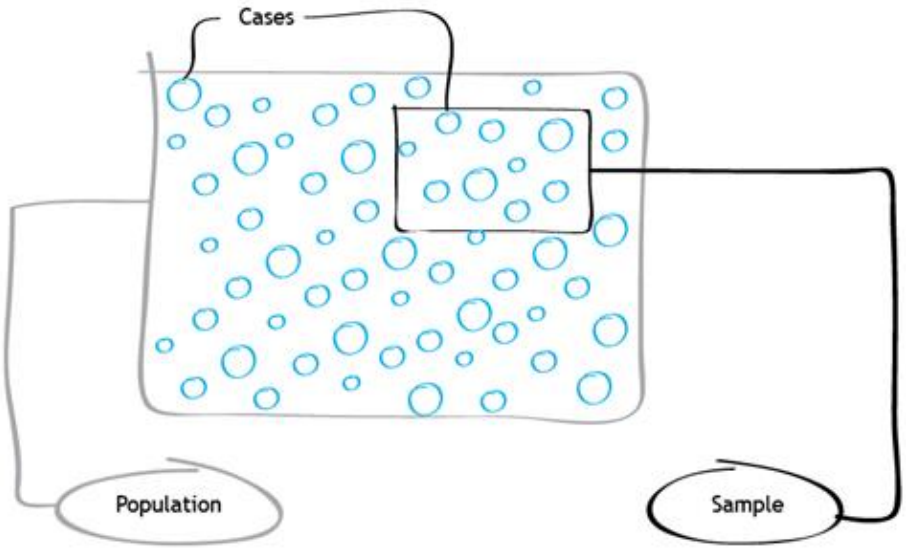


Figure 3-11: Sample, population and cases - explanation

However, the above-described qualitative and quantitative methodologies use two different sampling types. Saunders *et al*. (2012) point out that quantitative research usually uses probability sampling because of the targeted generalisability and qualitative research uses purposive sampling, which focuses on representative participants for the research. Purposive sampling is further known as purposeful sampling; which means that the individuals are purposefully selected because they have experienced the central phenomenon and can contribute to its understanding and help solve the research problem (Creswell, 2009). This means that the researchers do not desire to sample participants on a random basis; rather, they select people, organisations, documents, departments, etc., that can contribute to answering the research question (Bryman, 2012).

However, well-developed decisions in terms of samplings are crucial for the research (Marshall and Rossman, 2011). Hence the researcher has to make the following decisions: who or what should be sampled with which form of sampling and how much should be sampled (sample size) (Creswell, 2013). Following the description of Miles and Huberman (1994 cited in Creswell 2013 and Ritchie *et al*., 2003) Table 3-1 shows selected and possible sampling strategies that could be relevant for this research.

Table 3-1: Sampling strategies

Form of sampling	Reason to choose sampling
maximum variation	diverse variations of individuals or sites based on specific characteristics
homogeneous	focuses, reduces, simplifies and facilitates group interviewing
snowball or chain	identifies cases of interest from people who know what cases are rich in information
intensity	information-rich cases that show that they have experienced this phenomenon intensively
criterion	All cases that meet some criteria; useful for quality assurance
combination or mixed	triangulation, flexibility; meets multiple interests and needs

Source: Adapted from Miles and Huberman (1994) and Miller and Salkind (2002). Permission to reproduce this information has been granted by SAGE PUBLICATIONS INC.

Finally, any inquiry needs to decide on its sample size (Saunders *et al*., 2007). In a general manner, the sample size of qualitative research is usually small because qualitative data is rich in detail (Ritchie *et al*., 2003a). In this way there are suggestions for sample size of different research approaches as for instance for phenomenological approaches that focus on one phenomenon with a small sample of three to 10 individuals (Dukes, 1984).

3.5 Research Approaches

The research approach of a study is very important since the selected and deployed approach will inform the whole research procedure and present the study in a sophisticated manner (Creswell, 2013). Furthermore, it is stated by Saunders (2007) that the approach guides the study, which makes it most important to select an approach that enables the researcher to fully answer the research question and meet the research objectives. Subsequently, a selection of commonly used research approaches is considered in this section.

3.5.1 Survey

A survey research approach is commonly associated with quantitative research or quantifiable data as it collects data – usually with questionnaires or structured interviews – on several cases and variables in order to examine patterns (Bryman, 2012). Hence this approach is usually used with deductive research logic and is very popular in business management research because of the ability to collect a large amount of data (Saunders *et al*., 2012).

3.5.2 Case study

A case study approach consists of an in-depth exploration of a programme, event, process or individuals (Creswell, 2009). In other words, it explores in detail one or more cases in real-life over a period of time by using multiple sources of information (Creswell, 2013). Case studies can be conducted as qualitative or mixed-method research and it is common to triangulate the results (Saunders *et al*., 2012). The challenge within a case study approach is to identify a suitable case and decide if one or more cases are studied, which involves further issues to consider such as how many cases are enough (Creswell, 2013).

3.5.3 Phenomenology

The phenomenology approach identifies and holistically understands the meaning of human experience as described by the research participants (Amaratunga *et al*., 2002a, Creswell, 2009). In this light, phenomenology "sees social phenomena as socially constructed, and is particularly concerned with generating meanings and gaining insights into those phenomena" (Saunders *et al*., 2007, p. 606).

Phenomenology builds on the work of the German philosopher Edmund Husserl (1859-1938) from a philosophical perspective as well as the work in social phenomenology of the Austrian social scientist Alfred Schütz (1899-1959) (Schwandt, 2001, Outhwaite, 2003). Furthermore, it must be pointed out that the German philosopher Georg Hegel (1770-1831)

earlier argued that phenomenology would refer to "knowledge as it appears to consciousness" (Moustakas, 1994, p. 26).

According to Moustakas (1994) phenomenology studies a phenomenon as it appears to individuals in their consciousness. Moustakas (1994) further argued that the "very appearance of something makes it a phenomenon", and any phenomenon can be the start of a study (p. 49). This approach is commonly used in qualitative research (Amaratunga *et al*., 2002a, Creswell, 2013), which aims to identify, deeply understand, explain and describe a common or shared subjective experience of several individuals in terms of a phenomenon (Easterby-Smith *et al*., 1991, Schwandt, 2001, Creswell, 2013). This description, then, is different to explanations of analyses and keeps as much originality as possible and results in, e.g., "ideas, concepts, judgement and understanding" (Moustakas, 1994, p. 52).

However, phenomenologist are further concerned to deliver a reinterpretation, new and fuller meaning, while looking at a phenomenon from new perspectives and, most importantly, question the current meanings. Hence phenomenology is characterised by objectivity and as a critical approach that "calls into question what is taken for granted" (Crotty, 1998, p. 83). Phenomenological studies usually consist of collected data from individuals who have experienced the phenomenon, which then will be analysed to extract the meaning and the essence of collected experience in order to describe the phenomenon (Moustakas, 1994). Consequently, this approach is best suited for studies that seek to develop practices, policies and deeper understanding of a phenomenon through experiences of it that are shared by several individuals (Creswell, 2013).

3.5.4 Ethnography

The aim of the ethnography approach is to describe and interpret the shared patterns such as behaviour, language and beliefs of a group of interacting individuals (Creswell, 2013). It is important in this approach that the cultural group of individuals has to be studied as an intact group in its natural setting (Creswell, 2009). This requires often extensive participant

observations, trust of the participants and a strong strategy to deal with the fact of being a researcher and being involved in the social life of the participants (Saunders *et al*., 2012).

3.5.5 Comparison of the approaches

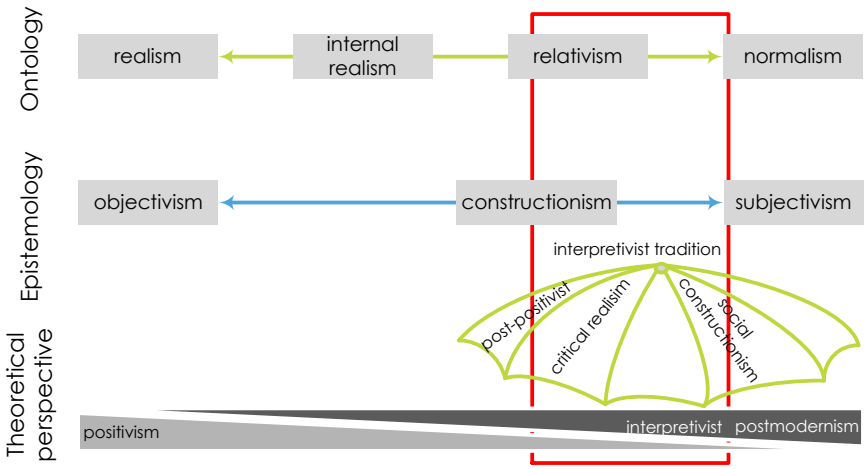
The four approaches that were selected have been summarised and compared in terms of five characteristics in Table 3-2.

Table 3-2: Comparing the approaches

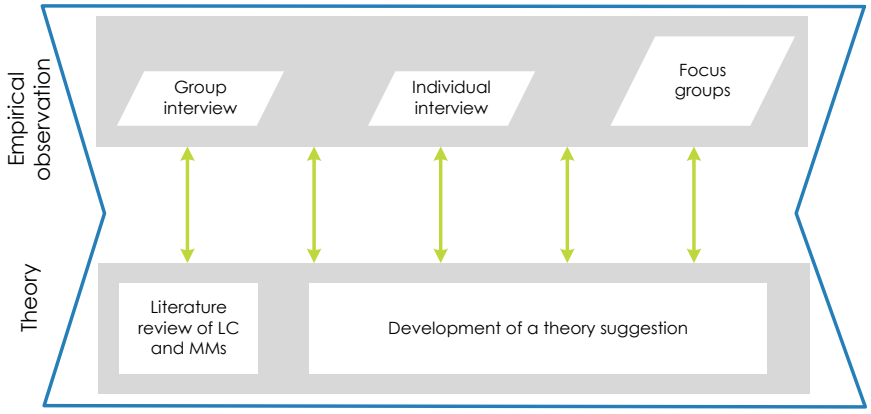
Character	Survey	Case study	Phenomenology	Ethnography
Aim	Describe or compare a population	Describing in-depth one or more cases	Describe and understand the essence of an experienced phenomenon	Describe and interpret shared patterns of a social group
Research logic	Deductive	Deductive / Inductive / Abductive	Abductive and inductive	Inductive
Research purpose	Exploratory / Descriptive	Explanatory / Exploratory	Exploratory	Explanatory / Descriptive
Sample size	large	small	small	large
Qual. /Quan.	Quantitative	Quan. /Qual.	Qualitative	Qualitative

3.6 Chapter summary

Table 3-3: Justification of the components of the conceptual research framework

Framework part	Selection rationale
Research philosophy	Within the context of the argument of Easterby-Smith *et al.* (2012), this research cannot be positioned to satisfy all aspects of only one philosophical position. Considering further that the research aim requires understanding of the meaning of LC maturity to develop a framework, this research has to be positioned within the INTERPRETIVIST TRADITION. This further involves the ontological position of RELATIVISM and an epistemological stance of CONSTRUCTIONISM (see the red box in the figure). As pointed out earlier, this leads to the theoretical perspective that informs the research approach. Hence the research takes on the perspectives of SOCIAL CONSTRUCTIONISM and CRITICAL REALISM. This derives from the focus on the experience of the objects (practitioners in LC) and the subject (LC maturity) within an interplay to construct a meaningful reality in this study (Crotty, 1998). 

Continued on next page

Framework part	Selection rationale
Research logic	As pointed out in the literature review, there is a gap in our knowledge about LC maturity, so defining arguments or hypotheses in order to test these within a deductive sterile logic is difficult to deploy in this research. In contrast, an inductive logic is useful for new research topics with little literature; however, abductive logic, which is best suited for new research topics with little literature in its actual context but with a wealth of literature in another context (Saunders *et al*., 2012), seems most appropriate for this research. Therefore, abductive logic is adapted as it allows the researcher to modify and develop an existing theory in another context. This in particular precisely matches this research, because there is much literature about maturity and MMs in other areas but very little within the area of LC, as pointed out within Chapter two. Furthermore, the abductive logic allows a continuous interplay between empirical observation and theory, and supports the generation of new ideas and surprises (Van Maanen *et al*., 2007). This is shown in the figure. Above all, positions in this research such as critical realism and social constructionism are both aligned with abduction (Järvensivu and Törnroos, 2010, Blaikie, 2010). 

Continued on next page

Framework part	Selection rationale
Methodological choice	Since qualitative research explores the meaning of individuals and groups in terms of a phenomenon (Creswell, 2009) it seems best suited for this inquiry. Additionally, the qualitative methodology is well known in the built environment as a powerful, flexible and systematic method to understand the meaning of the social world and discover or explore new areas (Amaratunga *et al.*, 2002a). Furthermore, the researcher expects individuals who practice LC over time to attach their meaning to the understanding of LC. Hence they attach meaning to the phenomenon 'LC maturity',and qualitative research focuses precisely on this kind of inquiry (Snape and Spencer, 2003, Saunders *et al.*, 2012). Considering the aim of this research, it is further important to get an in-depth understanding of the phenomenon of LC maturity and this is provided with a qualitative methodology that blends well with an abductive research logic, as pointed out by Saunders *et al*. (2012). As it is clear that this research has to be conducted with a qualitative methodology, there is a decision necessary in regards to a mixed-method design or a mono method design. Derived from the strength of the mixed-method design research such as obtaining a more complete picture of human behaviour and experience (Morse, 2003), or answering the research question more comprehensively, with broader scope and increased depth while making the research richer and more useful (Morse, 2010), this study will be performed as QUALITATIVE MIXED-METHOD DESIGN. The rationale for selecting a qualitative mixed-method design for this study was the strength to discover and achieve a rich understanding of LC maturity and therefore best answer the research question. In doing so this research uses a primary phenomenology approach with FGs as the primary method, so-called **QUAL** (phenomenology-FG) and a group interview as well as individual interviews as two qualitative supplementary components so-called **qual** (group interview) and **qual** (individual interviews) simultaneously. The chosen methodology is therefore: **QUAL** (phenomenology-FG) **+ qual** (group interview) **+ qual** (individual interviews).

Continued on next page

Framework part	Selection rationale
Research approach	As mentioned earlier, this research is best carried out with a phenomenology approach. The rationale for choosing this approach considers the decisions made before such us the qualitative methodology, with an abductive research logic and the fact of studying the phenomenon 'LC maturity'. In this light the phenomenology approach is best suited as qualitative exploratory research with an abductive logic in order to deeply understand LC maturity and develop a framework for a LCMM. Further, the phenomenology approach is characterised by gathering data through for instance interviews of a small sample of individuals who have experienced the phenomenon (Moustakas, 1994).

In summary, this means the conceptual research framework for this inquiry consists of a relativistic ontology with a constructionism epistemology and the theoretical perspective of social constructionism and critical realism. Further, as is described within this framework, an abductive research logic is embedded in a qualitative mixed-method design [QUAL $^{(phenomenology)}$ + qual $^{(group\ interview)}$ + qual $^{(individual\ interviews)}$] with a phenomenology approach. Table 3-4 illustrates this in short.

Table 3-4: My conceptual research framework

Research philosophy			Research logic	Methodological choice	Research approach
Ontology	Epistemology	Theoretical perspective			
Relativism	Constructionism	Social Constructionism & Critical Realism	Abductive	Qualitative Mixed-Method	Phenomenology

CHAPTER FOUR

RESEARCH METHODOLOGY

4 Research Methodology

4.1 Introduction

The term 'research' means different things to different people; there is however an agreement that research does increase knowledge through a process of enquiry and investigation in a systematic and methodical way (Amaratunga *et al*., 2002a). Further, Remenyi *et al*. (1998) show us that "[…] research methodology refers to the procedural framework with which the research is conducted" (p. 28).

Hence the research methodology is important and builds the backbone of the investigation. Considering the conceptual research framework presented in the previous chapter, this research is positioned as a phenomenology approach adopted through the primary method. Moustakas (1994) reminds us that phenomenological studies commonly involve in the methodology: the methods and procedures adopted in the study; and data collection, organisation, analysis and synthesising procedures. Therefore, this will be captured in this chapter together with a focus on the validation and reliability of the research and its findings. The final section then demonstrates compliance with the ethics.

4.2 Selected research methods

This section explains the selected data collection methods which are utilised and adopted within this research. Table 4-1 p. 99 illustrates an overview of the selected data collection methods; and the rationale for selecting these for this study.

Table 4-1: Overview and justification of the selected methods

Selected Method	Justification for selection
Literature review	The rationale for the literature review (LR) lies mainly in the first objective: to integrate the LC and MMs literature. Further, the LR was necessary to summarise the existing research within both domains and identify patterns, themes and issues (Meredith, 1993), and define the knowledge gap. The LR further supports the other objectives of this research through identifying characters and concepts in both fields (ibid.). Finally, the LR is utilised to contribute to the development of a LCMM framework.
Group interview	The group interview was chosen to test the ideas of this research (Frey and Fontana, 1993). As a result, the feasibility was emphasised and new ideas have emerged so that the understanding of the social context was enhanced, the picture of the planned methodology became clearer, and precision in the form of key information and nuances were added to the research. Further, through determining opinions and meanings about MMs in terms of LC, a contribution to the first and second objectives was achieved. Therefore, characteristics, conceptions and attitudes towards maturity in LC and new sub-areas for the synthesis of the LR were identified.
Interviews	The rationale for selecting the individual interview method is driven by the statements that interviews are one of the best methods by which to collect rich information (Easterby-Smith *et al.*, 1991) and doubtless the most used method in qualitative built environment research (Amaratunga *et al.*, 2002a). Furthermore, interviews enhance the understanding of the world of (LC) practitioners (Kvale, 2007), because it is consequently assumed that these practitioners have experienced the phenomenon of LC maturity over time. As a final point, interviews are particularly useful in the construction industry to enhance the depth and breadth about the phenomenon under investigation (Shehu and Akintoye, 2010). Hence 11 LC practitioners in three continents and six different countries were interviewed.

Continued on next page

Selected Method	Justification for selection
Focus groups	The FGs have been selected because they enable the researcher to develop an understanding which is adequate to those of the participants and their experiences and beliefs regarding the phenomena. Consequently, FGs enable: the development of an enhanced understanding and insights through group interactions (Smithson, 2008), and access to the concepts, language and concerns (Wilkinson, 1998) of the participants. Furthermore, FGs allow the researcher to observe precisely how views are constructed, expressed, defended, and modified, and a collective sense regarding the phenomenon is produced by the participants (ibid.). In addition, in this research FGs provide: the ability to answer the research question (Morgan and Krueger, 1993), and the efficiency of producing a concentrated amount of rich data of the phenomena under investigation (Fern, 2001, Morgan, 1997). Moreover, Smithson (2008) reported that in fact interviews in conjunction with FGs provide a strong research methodology. In addition, they are most appropriate to explore experience and opinions of a phenomenon, through the production of a consensus by a group that experienced the phenomenon (Morgan and Krueger, 1993). Hence two FGs are conducted with five and six LC practitioners who have experienced LC over time. Since the participants have many years of experience in LC they have attached meaning to the phenomenon of LC maturity through their experience and the FG method is chosen to access their experience and meaning of LC maturity.

4.3 Literature review

Since the LR itself is a library or desk-based research method that involves the analysis of secondary and explicit knowledge (Jesson *et al*., 2011), it cannot be neglected as a method within this study.

Seuring and Müller (2008) argued that a LR usually has two objectives: (1) summarising of existing research and identifying of patterns, themes and issues and (2) supporting the identification of the conceptual content of the research field (Meredith, 1993), and may be a contribution towards a theory development (Harland *et al*., 2006). However, this study extends these through a third objective: (3) emphasising the findings of the study.

4.4 Group interviews

The group interview in this study was conducted in the form of a natural group with leading academics and specialists in LC brought together from the IGLC, to test the ideas of this research.

4.4.1 Why use group interviews?

Group interviews originated in sociology and were described by Bogardus in 1926 (Merton and Kendall, 1946). They have been identified as a research technique that uses the advantage of group interaction (Frey and Fontana, 1993), and these interactions amongst the respondents can establish a cohesive consensus (Fellows and Liu, 2008).

Group interviews are part of the interview family (Bryman, 2012), and thus the collective name hosts different types, which have been identified by Frey and Fontana (1993) – see Figure 4-1. Some use group interview interchangeably with FGs, which is further distinguished in the figure.

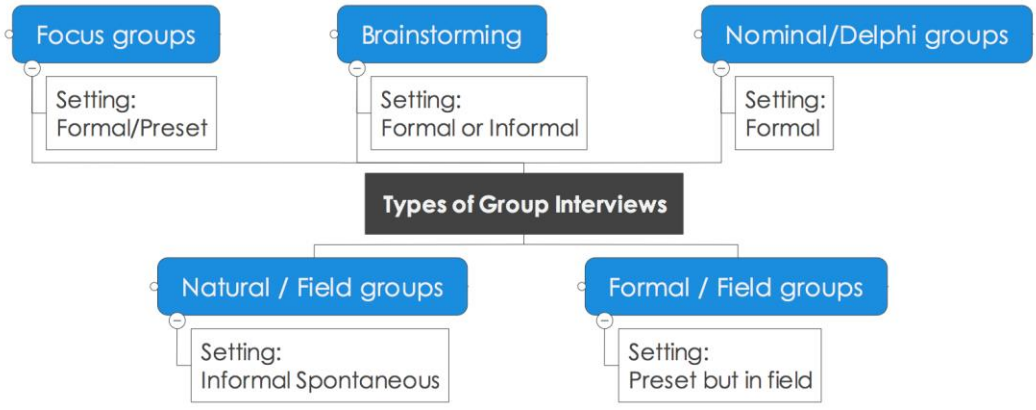


Figure 4-1: Overview of group interview types

Group interviews are utilised as a testing ground for new ideas, and to bring the researcher closer to the social context (Frey and Fontana, 1993). Babbie (2012) further points out that

group interviews are often used for the initial or exploratory phase of a research project such as:

- To satisfy the curiosity of the researcher;
- to increase the researcher's understanding of the social context;
- to test the feasibility of a the study;
- to become a clearer picture of the methodological techniques;
- to identify nuances of the research setting that could impact the investigation; and
- to identify key informants to add precision to the research problem.

Additionally, they are useful for pre-tests and pilot studies, inform of less structured and formal approaches to generate hypotheses, respond to scenarios or ask representatives of a field about their interpretation (Frey and Fontana, 1993).

4.4.2 How to conduct group interviews

Conducting group interviews requires attention to several dimensions and settings such as: the chosen purpose, the role of the interviewer, the structure of the question and the extent of their preplanning, and the setting of the group interview (Frey and Fontana, 1993). In contrast, participants are explicitly selected and invited to the FGs (Khan and Manderson, 1992); there is no control about the group composition in natural groups (Beckerleg *et al*., 1997). A style for such a natural group setting would be a passive and non-directive approach with open-ended questions (Frey and Fontana, 1993).

There are two main forms of analysing data from a group interview: the whole group as a unit of analysis, which sees all data as one unit, and the participant-based group analysis, which treats each individual within the group interaction as a unit (Ritchie *et al*., 2003b). One appropriate way to analyse such data is the Framework Method©, which is a matrix-based method to analyse data through the generation of themes and sub-themes within a matrix (Kvale, 2007).

Nevertheless, group interviews have some inconvenience compared to individual interviews, such as the risk of producing irrelevant data and the bias that the interviewer may influence the outcome (Frey and Fontana, 1993).

4.4.3 Mode of deployment in this research

With the aim of exploring the feasibility of this study and to collect the thoughts and perception of leading academics and specialists in LC, a group interview was held in a natural informal setting in the form of a panel meeting (Summer School) of senior academics and widely recognised specialists who were from three countries: the US, UK and Brazil. The group was brought together under the auspices of the IGLC, and the researcher could not influence the group's composition. Further, the role of the interviewer in this setting was non-directive with one open-ended question. The group interview lasted forty-five minutes, which included a fifteen-minute presentation of the research, background, idea, and steps, and an approximately thirty-minute discussion. Contemporaneous notes were taken of the comments of the participants as a basis for the construction of detailed notes afterwards, which is a data collection method appropriate for group interviews (Mcdonald *et al*. 2007, Greenhalgh *et al*. 2008). The construction of more detailed notes took place during the follow-up discussion. To clarify the veracity of the taken notes, each of the seven LC key informants were sent a copy after the discussion. All interviewees confirmed that they were an accurate reflection of the discussions and further gave written consent to use their comments in this thesis.

4.4.3.1 Sampling strategy

The sample including seven LC academics and specialists was not in the direct control of the researcher because it contains the setting of the summer school from the 20th Annual Conference of the IGLC in San Diego, USA - which is targeted to assist PhD research in LC.

4.5 Individual interviews

4.5.1 Why use individual interviews?

Much qualitative research is interview-based (Britten, 1995), and in addition it is claimed that interviews provide 'the best' method to collect information (Easterby-Smith *et al*., 1991). Amaratunga *et al*. (2002a) analysed qualitative built environment research and found that Interviews are doubtless the most used research method. Furthermore, numerous authors have identified interviews as one of the most powerful and flexible ways to understand other individuals (Fontana and Frey, 1994, Britten, 1995, Kvale, 2007). Hence interviews in qualitative studies are seen as a construction site for knowledge (Kvale, 2007). Kvale (2007) defines an interview as "[…] a professional interaction, which goes beyond the spontaneous exchange of views as in everyday conversations, and becomes a careful questioning and listening approach with the purpose of obtaining thoroughly tested knowledge" (p. 7).

Today's known interview methods were traced back by Fontana and Frey (1994) to opinion polling, which is the earliest form of interviewing, which took place before the 19th century. A widely recognised early study which clearly used a combination of observation, personal documents and informal interviews is the work of the Chicago School in the 1920s (Fontana and Frey, 1994).

Several authors such as Britten (1995), Easterby-Smith *et al*. (1991) and Kvale (2007) have reported reasons to use interviews in qualitative studies, such as:

- It is necessary to understand the constructs used by the respondents as a basis for their opinions and beliefs about a particular situation or matter;
- the aim is to develop an understanding of the respondent's world;
- to go below the surface of the phenomenon in order to explore new areas and ideas of the research;

- to clarify the purpose of a study and obtain knowledge and experience of the phenomena or subject;
- to pursue knowledge of a social situation or life history;
- to critically examine personal assumptions and general ideologies of persons that experienced the phenomena; and
- to deductively test implications of a theory or to seek background material for further research.

There are a wide range of different types of interviews such as: structured interviews, unstructured interviews, focused interviews and in-depth interviews (Bryman, 2012).

The three main types regarding the structure are: structured, semi-structured and unstructured interviews (Fontana and Frey, 1994, Britten, 1995). The most common type in qualitative studies, however, is the semi-structured interview, which has a sequence of themes with some prepared questions that it covers, yet there is still space for changes to follow interesting responses (Kvale, 2007). Furthermore, this type is identified and recognised as particularly useful in the construction industry because it increases the depth and breadth of the knowledge about the studied phenomenon (Shehu and Akintoye, 2010). Additionally, semi-structured interviews are well known as the most frequently used form of interviews in the research field of the built environment (Fellows, 2009, Baiden and Price, 2011).

Kvale (2007) defines semi-structured interviews as “an interview with the purpose of obtaining descriptions of the life world of the interviewee with respect to interpreting the meaning of the described phenomena” (p. 8). Further important for this research is the fact that interviews in conjunction with FGs provide a strong research methodology (Smithson, 2008).

4.5.2 How to conduct individual interviews

Semi-structured interview ideally consists of a structure in a general fashion with open-ended questions covering the research topic, while it tolerates the pursuing of an idea in greater detail (Britten, 1995). Qualitative studies usually conduct face-to-face interviews with individuals (Fontana and Frey, 1994, Creswell, 2009); however, they are not restricted to this (Sweet, 2002), as qualitative interviews can be conducted by telephone for equally rich data gathering (Sweet, 2002, Sturges and Hanrahan, 2004, Novick, 2008, Creswell, 2009). Crucial to conducting semi-structured interviews are the social interaction between the researcher and the interviewee, the posed questions, and the researcher's reaction after the interviewee's answers (Kvale, 2007). An interview guide is further important in order to ensure that all themes are covered within the interview (Baiden and Price, 2011). According to Patton (1987), typical interview questions are based on: behaviour or experience, opinion or beliefs, feelings, knowledge, senses, or background or demographic information.

4.5.2.1 Designing and conducting interviews

The planning and conducting of interviews can be illustrated by several steps (Creswell, 2013). Creswell (2013) focuses on the data collection process through qualitative interviews embedded in a wider research project in the form of nine steps - see Figure 4-32

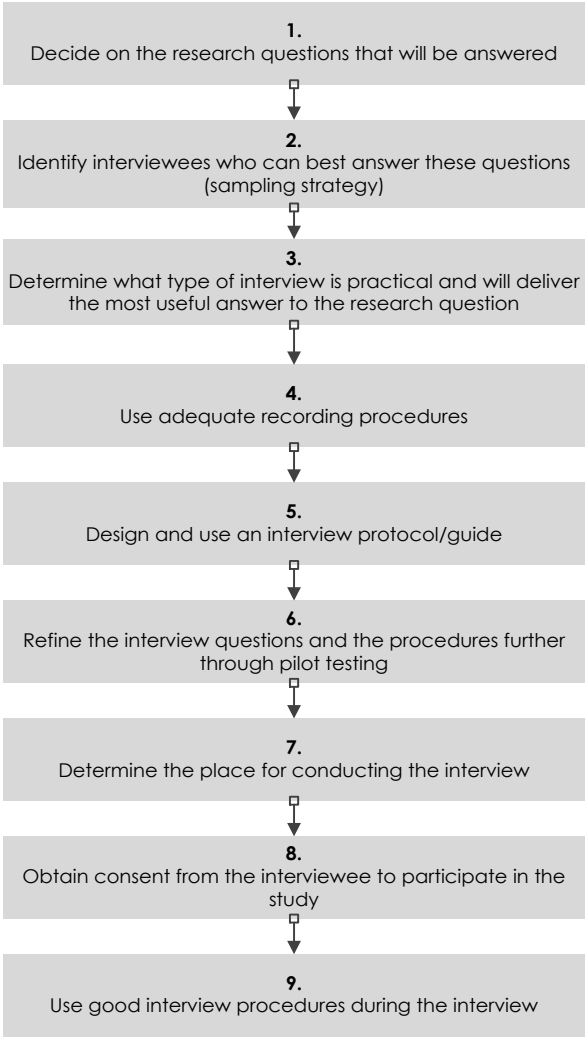


Figure 4-2: Steps in conducting qualitative interviews, inspired by Creswell (2013)

Creswell's (2013) approach starts with the questions that the interview should answer, and these should focus on the understanding of the central phenomenon.

The second step concentrates on the sampling process to recruit the best interviewees for the study, before the next step chooses the appropriate interview type. The fourth step encourages the use of sufficient voice recorders to record the interviews. As pointed out earlier, guidelines are important. These usually consist of five to seven brief and simple open-ended questions with space under each question to make notes (Kvale, 2007).

The sixth step uses a pilot test to refine these questions and the guidelines. Further, a pilot test helps to identify problems as well as issues such as ethics (Sampson, 2004). The location to conduct the interview is considered in the seventh step, and Creswell points out

that a quiet location, free from distraction and which allows good-quality audiotaping, is suitable. This seems simple; however one has to consider that the site is an important choice with wide-reaching implications such as: interviewees will speak more freely when they feel comfortable (Elwood and Martin, 2000). Ethical issues are part of the eighth step, such as the completion of a consent form and brief introduction to the study situation, purpose, use of a voice recorder (Kvale, 2007), an estimate of the duration, and what will happen with the results (Creswell, 2013). The last step considers the interaction between the interviewer and the interviewee. These procedures are: finish within the estimated time, stay close to the questions, treat the interviewees with respect and honesty and, most important, be a good listener rather than a frequent speaker during the interview. Additionally, Creswell (2013) suggests taking notes on the interview guidelines as backup if the audio-recording does not work. The number of interviews that need to be conducted is also important, and suggestions on time and available resources vary, so it is common for qualitative studies to conduct between five and 25 interviews (Kvale, 2007).

4.5.2.2 Quality of interviews

When it comes to the interview quality, it is crucial to have good equipment to record the interview (Britten, 1995), because quality is driven by the interaction between the researcher and the interviewee (Kvale, 2007). Additionally, there are three general criteria in terms of quality: (1) the richness of the answers; (2) the length of these answers; and (3) the clearness of the answers (Kvale, 2007).

The transcription of interview records can be described from a linguistic point of view as the translation from an oral language to a written language, which is important for the quality of the interviews (Kvale, 1996, Kvale, 2007).

Hence Kvale (2007) argues that the following points are important factors for transcribing the interview records:

- Researchers who do their own transcription obtain several advantages, such as: learn about their own interview style, remember the social and emotional aspects and start immediately with the analysis of the meaning;
- one basic rule is important: state explicitly how the transcript was made; and
- the form of the transcript depends strongly on: purpose of the investigation and resources available.

Although there is not one correct valid style or standard of the degree of detail of transcripts (Kvale, 1996), the style of transcribing depends on the purpose (Kvale, 2007). Hence it is argued that, if the transcript is used for sociolinguistic or psychological reasons, a word-by-word verbatim style is necessary (Kvale, 1996). Kvale further suggests that it is desired and appropriate for transcripts which are used to gain impressions and understanding about a phenomenon to rephrase and condense parts with little relevant information.

4.5.2.3 Analysing interviews

The analysis of interview data in the form of transcripts focuses on the meaning and meaning condensation, categorisation, as well as interpretation of meaning (Kvale, 2007). Therefore, preparing and organising of the text; reducing it into themes by coding and condensing of the codes; and lastly presenting the data as discussion, figures or tables are required (Kvale, 2007, Creswell, 2013). It is important to note that there is no standard mode of analysis but a common approach is thematic analysis which is incorporated and well known as the Framework Method© (approach) (Bryman, 2012), which is focused on the meaning. However, regardless of the mode of analysis, the quality of the interview analysis must be ensured. This can be achieved through the researcher's knowledge of the topic investigated, the sensitivity for the language and the confidence about the analysis tools (Kvale, 2007).

4.5.3 Mode of deployment in this research

The individual interviews for this research were prepared and conducted following Creswell's nine steps, to achieve the aim to contribute to the understanding of the findings of

the group interview, and deliver a depth and breadth of understanding of the phenomenon 'LC maturity'.

4.5.3.1 Sampling strategy

The developed sampling strategy aims to get the most suitable participants to achieve the aim of this research. Hence a purposive sample as criterion sample form was adapted – see Figure 4-3.

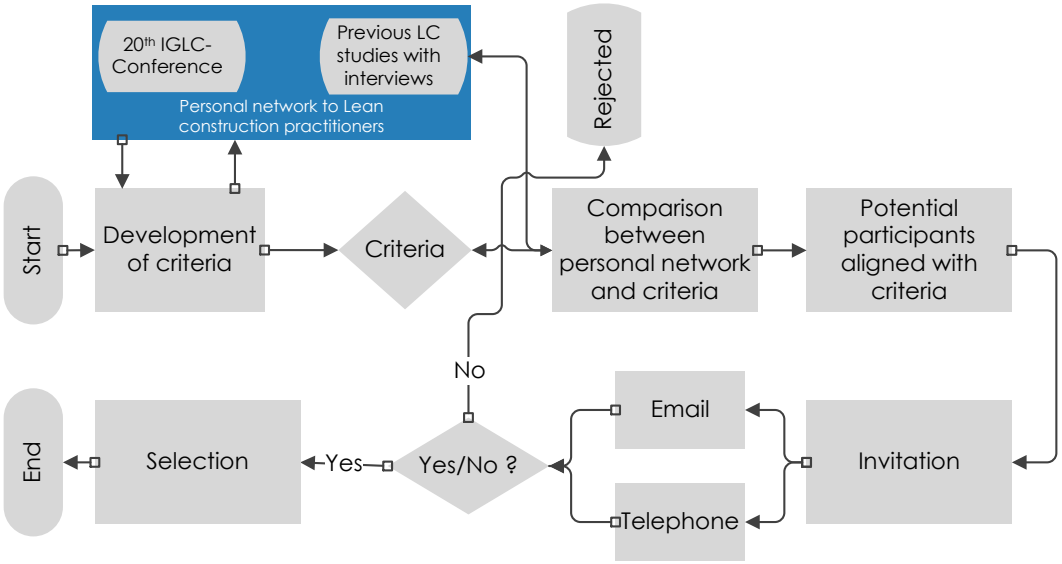


Figure 4-3: Sampling strategy individual interviews

First, the researcher developed the sampling strategy with the aim of increasing the quality of the chosen cases in the sample; on the basis of literature and personal expertise from previous LC research, two types of characteristics were defined: (1) the mandatory characteristics; and (2) the desired characteristics. All characteristics are illustrated in Table 4-2.

Table 4-2: Characteristics of the interviewee sampling

	Characteristics
mandatory	-2 years of practical experience in LC; -experience in a senior management position; -cases from at least the following continents which are well-known in practising LC: North America, South America and Europe; and -5 years of working experience in the construction industry.
desired	-As much experience with the phenomenon of *LC maturity;* -experience in the top management level; -experience in implementing and continuously improving the understanding and effective use of LC.

The mandatory characteristics were developed to ensure that the participants have experienced the phenomenon 'LC maturity'. The working and the senior manager experience will help to ensure that the participants are able to express themselves in a language that is easy for the middle and top management to understand. Further, the desired characteristics serve as additional quality assurance to make sure that quality participants are recruited.

Once the criteria were determined, they were compared with the personal network consisting of contacts from the 20th ICLC conference in 2012, and LC professionals through previous studies conducted by the researcher. The professionals fulfilling the criteria were then invited, either via telephone or email, and given information about the research. Those who agreed to participate were again compared with the characteristics, to select the most suitable participants to answer the research question. The result is shown in Table 4-3.

Table 4-3: Selected participants for the individual interviews

Partici-pants	Country	Experience in LC (years)	Total work experience (years)	Current role/position
LP#1	Germany	5	11	SM
LP#2	United Kingdom	10	37	MD
LP#3	Spain	2	20	SM
LP#4	Chile	5	5	SM
LP#5	USA	14	43	DL
LP#6	USA	2	17	SM
LP#7	USA	18	37	MD
LP#8	Germany	6	32	MD
LP#9	Peru	12	14	MD
LP#10	USA	5	17	SM
LP#11	United Kingdom	8	15	DL
Sum		87	248	

Semi-structured interviews were chosen as the interview types because of the advantage for investigate arising ideas. To ensure high quality, a quality voice recorder and an interview guideline with six open-ended questions were used to conduct the interviews. The developed interview guideline was piloted by a fairly informal approach to test the open-ended questions with the research team (Remenyi *et al*., 1998). The guideline is shown in APPENDIX C.

The researcher considered techniques and locations to conduct the interviews and the reported disadvantage of telephone interviews such as losing non-verbal data (Novick, 2008), and, contrarily, arguments about the huge advantages of telephone interviews, such as the geographical distances, being judged as rich on quality, and vivid (Sweet, 2002). Considering this and the motivation to take advantage of the existing technology and the power of the internet (Crichton and Kinash, 2003), the interviews were conducted via video phone calls. This brought with it the following advantages: the interviewees were in their usual location which is comfortable for them, the video provided access to the non-verbal behaviour, and the interviews could take place regardless of place or time.

Prior to the interview, the participants received an information sheet about the research, a consent form and a one-page written summary of MMs to ensure a base level of understanding about MMs. Each participant confirmed at the beginning of the interview that

they had read and understood this summary. Additionally, the summary was outlined verbally by the interviewer before commencing the interview.

Each interview lasted approximately forty-five minutes and immediately afterwards was transcribed by the researcher. Hence the transcripts take advantage of the non-verbal behaviour which was observed (whenever possible). This process followed an approach by Kvale (1996) in which the interview contents were partly rephrased and condensed in non-relevant parts to a briefer form of text. The transcripts have been created in the form of Mind Maps® because they provide a powerful thinking tool and simple graphical technique to arrange and present each interview (Vidal, 2006). This includes its structure and the thought processes of the interviewees. Tony Buzan, the originator of Mind Maps®, describes this tool as full brain thinking with both the intellectual right side (the creative side) and the dominant range of the mental skills from the left brain hemisphere (the logical side) at the same time (Buzan and Buzan, 2006). Further, Mind Maps® are widely used within operational research (Vidal, 2006)

4.6 Focus groups

4.6.1 Why use focus groups?

FGs are an important and useful research method for a wide range of purposes (Albrecht *et al*., 1993). The FG interview, which is principally seen as a type of group interview (Morgan, 1997, Bryman, 2012), has been used as a research method since the 1920s (Merton and Kendall, 1946) and the sociologist Robert Merton and his colleagues are usually cited as their inventor (Wilkinson, 1998) The establishment of FGs was strongly driven by the communication research and propaganda analysis in the applied social research programmes during World War II (Merton and Kendall, 1946, Mulvihill, 1956). Since 1946 FGs have been in the tool kit of social scientists (Stewart *et al*., 2006), as well as marketing research (Morgan, 1997, Fern, 2001). However, FGs are defined as a research technique which gathers data through actual group interaction on a defined topic (Morgan, 1997).

Furthermore, they are different to a constrained group interview with a set of questions, because FGs allow insights that would be not accessible without the group interaction and therefore by other methods (Smithson, 2008).

Wilkinson (1998) highlighted three key features of FGs: (1) providing access to the participant's own language, concepts and concerns; (2) encouraging the production of more fully articulated accounts; and (3) offering an opportunity to observe the process of collective sense making. Furthermore, it is suggested that FGs can be defined as a controlled group discussion built on a group interaction which is initiated through a discussion (Smithson, 2000).

4.6.1.1 When to use focus groups

In recent years, FGs have been increasingly used as a widely recognised method in social science research for collecting qualitative data (Morgan, 1997, Smithson, 2000, Stewart *et al*., 2006). The main purpose of using FGs is as a stand-alone research method (Frey and Fontana, 1993) for answering the research question (Morgan and Krueger, 1993). Furthermore, they are suggested as a method to explore understanding and opinions of individuals in a particular social context (Wilkinson, 1998). In addition, FGs offer an efficient ability to produce a concentrated amount of data on exactly the topic of interest (Morgan, 1997, Fern, 2001), while they enable access to data which are difficult to obtain with other qualitative methods (Morgan, 1997). Therefore, FGs are widely accepted, and appropriate for building theory (Fern, 2001). However, the most appropriate use for FGs is the purpose to learn and explore the opinions and experiences about a subject through an amount of consensus of a targeted group of people (Morgan and Krueger, 1993).

Morgan (1997) identified that FGs have three traditional ways of practice: (1) as a self-contained method; or (2) a supplementary source; and (3) as a multi-method study. Further, FGs can be used to generate preliminary as well as follow-up data to clarify findings (ibid.).

Certainly, FGs are able to produce different types of information such as personal, impersonal and shared or unshared information (see Table 4-4); which makes them suitable for a wide range of research purposes (Fern, 2001).

Table 4-4: Information output of a focus group

	Shared information	Unshared information
Personal information	Self-relevant information that the participants of a FG may have in common	Self-relevant information that is unique as it is not shared with others
Impersonal information	Not self-relevant information that the participants of a FG may have in common	Not self-relevant information that is unique and not shared with others

Source: Adapted from Fern (2001). Permission to reproduce this Table has been granted by SAGE PUBLICATIONS INC.

4.6.2 How to conduct and design focus groups

The design of FGs and how they are conducted depend strongly on the purpose of the research (Knodel, 1993, Fern, 2001). Furthermore, the group interaction and setting as a focus is the essence of this method (Morgan, 1997). To set this focus a precise design, accurate planning, and wise thoughts are important considerations (Knodel, 1993). Knodel (1993) offers a framework containing four steps to address this (see Figure 4-4).

Figure 4-4: Framework to conduct and design focus groups inspired by Knodel (1993)

4.6.2.1 Discussion guideline and structure

A starting point for designing a FG study is to consider the purpose of the study and define a FG discussion guideline (ibid.). Krueger (1998a) distinguishes between two types of guidelines: (1) Topic Guide, which is a list of issues or topics with words and phrases; and (2) Questioning Route, which consists of a sequence of questions in a complete sentence style. Both help the moderator to remember the themes and set a focus, whilst they have advantages and disadvantages – shown in Table 4-5.

Table 4-5: Advantages and disadvantages of guidelines

	Topic Guide	Questioning Route
Advantages	Quickly developed More conversational Allows spontaneity	Address topics precisely Quality analysis Enhanced consistency
Disadvantages	More difficult to analyse Difficult to pilot Include risk to ask questions differently	Less spontaneity Takes longer to develop

Source: Inspired by Krueger (1998a)

These guidelines set the order of the discussion and help to concentrate on a small number of themes, which allows more detailed and focused discussions (Knodel, 1993). The number of themes influences the structure; for a more structured group four to five themes are appropriate and for a less structured group two to three themes (Morgan, 1997). Further, Morgan (1997) pointed out that questions in general enable the moderator to control the content and the group discussion; this can be achieved with both guidelines.

The degree of a FG discussion is further influenced by the level of moderator involvement (Morgan, 1997). Hence FGs with more structure have higher moderator involvement to make sure that each FG discusses the same themes in a corresponding manner (ibid.). It has been suggested that a less structured approach is typical when the aim of the study is to understand the thinking of the participants (Smithson, 2008). However, similar to other qualitative methods, the FG questions in the guideline have to be tested/piloted (Wilkinson, 1998), and examples are stated by Krueger (1998a).

4.6.2.2 The targeted participants

The second step is to decide what are the characteristics of the desired participants for the FG sessions. Hence it is crucial to ask the right people to participate and it is further important to establish a strong strategy to achieve this (Sage, 2009). There are two types: (1) the homogeneous composition of participants; and (2) the heterogeneous composition of participants (Fern, 2001).

It is suggested to run small homogenous groups rather than one big session, because homogeneous groups deliver more in-depth information and share their common key expectations in a short period of time, which allows more time to share the unique expectations (Knodel, 1993, Fern, 2001). Another advantage of a homogeneous group is that the participants of the group feel more confident in voicing their views as they may share social background, level of education, knowledge and experience about the topic of interest (Sim, 1998).

An important component for the FG is the number of participants in the group discussion. Several authors have made suggestions about a general 'rule of thumb' size of six to ten participants (Morgan, 1996, Morgan, 1997, Greenbaum, 1998, Fern, 2001). Considering the used terminology of certain authors (Knodel, 1993, Morgan, 1997, Greenbaum, 1998, Fern, 2001), it is further acknowledged that small groups consist of two to six participants and big groups of seven to 12 participants. Further, this number depends on the desired amount of contribution to the topic of interest by each participant (Morgan, 1997), because small groups allow each participant more time to contribute to the topic than big groups do (Fern, 2001). In addition, it is argued that it makes more sense to run smaller groups if the topic of interest is in a specific segment (Fern, 2001). Effective small groups consist of participants who are very knowledgeable (highly involved) about the topic of interest and respectful to each other (Morgan, 1997). However, researchers must be aware that very knowledgeable participants are unmanageable in a big group, as they are more likely to start a conversation with their neighbours or talk simultaneously (ibid.). It is important to note that the role of the moderator becomes more critical as the number of participants in each group increases (Fern, 2001).

4.6.2.3 Number of focus group sessions

Knodel's (1993) third step is to determine the number of sessions; he argues that this number is strongly aligned to the complexity of the overall FG design. Hence the number of groups being conducted has a direct impact on the research team as it requires a large research team to conduct many FGs (Morgan, 1997). If groups have different characteristics and therefore diversity (break characteristics), the researcher has to run at least one session for each combination of diversity (Knodel, 1993, Morgan, 1997). Morgan (1997) points out that factors that affect the number of sessions are: the variability of the participants; the degree of structure; and the availability of the desired participants. Nevertheless, a researcher should only conduct the required number of sessions in order to provide a trustworthy answer to the

research question (Morgan, 1997). This can be achieved for instance by conducting two homogeneous groups (Knodel, 1993).

4.6.2.4 Analysing of focus group data

The last of Knodel's (1993) steps is the most challenging part: the analysis of the produced data from the FG. The analysing procedure for FG data is often viewed as equal to the analysing of other qualitative data such as individual interviews (Knodel, 1993, Morgan, 1997, Wilkinson, 1998). However, it is important to make a particular distinction between analysing data from FGs and other qualitative data (Kitzinger, 1995). Conversely, Morgan (1997) demonstrated that it is undeniable that the group influences the individuals; someone has to accept that both the group and the individuals cannot be separately treated as a 'unit of analysis'. Additionally, the analysis has to take into account that the data is a product of interactive nature which cannot be viewed as either 'right or wrong' or 'inaccurate or accurate' (Smithson, 2000).

4.6.2.5 Conducting and quality control of focus groups

Besides precise planning it is important to know how to conduct and control the quality of a FG; this will be considered in the following paragraphs.

Merton *et al*. (1990) identified four criteria that make FGs more effective: cover a maximum range of relevant topics, provide specific data, foster interaction that explores the feeling of the participants, and consider the context when the participants are generating their comments about the topic. Hence the moderating of FGs is very important and requires a different set of skills than moderating individual interviews (Krueger, 1998b). Krueger (1998b) further argues that when the moderator shares her/his opinions, this limits the range of information and should therefore be avoided. Krueger and Casey (2000) offer some practical tips for the moderator of FGs: practise questions, be aware of the timing, avoid any kind of feedback to the participant that signals approval, and carefully listen. Further, it is imperative to establish a relaxed atmosphere (Kitzinger, 1995), and to be prepared to

counteract and maintain the focus through asking and repeating questions when participants drift off into general discussions (Morgan, 1997).

In addition, the researcher has to deal with challenges such as: organising a room (site), meeting materials (flipcharts, markers), name badges and the managing of the arrival/departure of the participants (Wilkinson, 1998). This leads to the argument that the moderator is too busy to take field notes, observe the body language, record the sessions and keep the discussion flowing and therefore a 'moderator assistant' or 'observer' is extremely desirable (Krueger, 1993, Wilkinson, 1998). Krueger and Casey (2000) highlighted responsibilities for an observer of a FG session such as:

- The equipment; for instance the voice and video recorder, batteries and the arrangement of the chairs;
- sitting outside the discussion table, close to the door to be able to greet late arrivals outside before they join the discussion;
- take written field notes of well said quotes, interesting questions and non-verbal activities such as, for example: head nods, physical excitement and others that indicate agreement with what was said by others; and
- sketch the arrangement of the participants around the table.

As the quality of the data from a FG have the greatest impact on the transcripts and these directly affect the quality of the analysis and therefore the study, the use of good field notes, background information, and good recording equipment is crucial (Krueger, 1993). However, for rich and quality data the main attention has to be on a systematic and verifiable analysis; a proven systematic procedure is here the briefing of the moderator and the observer immediately after the session (Ibid.). Hence this improves the quality of the analysis and the importance of the study, and offers the first opportunity for both to review and consider what was the most important theme of the session (Krueger, 1993, Krueger, 1998b).

4.6.3 Mode of deployment in this research

Following the arguments in the sub-chapters above, this sub-chapter focuses on the approaches and critical issues regarding FGs which have been deployed in this research.

4.6.3.1 Design of the focus group

As the purpose of the study is crucial for the design of the FG, the researcher aligned the purpose of the study with the purpose of these FGs. This resulted in the following purpose for the FGs:

> *"To discover and collect experiences, attitudes and opinions about maturity in LC".*

4.6.3.2 The focus group guideline

The next step in planning and conducting FGs as the primary method was the development of a discussion guideline. This involved several choices such as:

- Type of discussion guideline (topic guide or questioning route);
- the number of concepts (themes) to investigate; and
- degree to which the group discussion will be structured.

This led to selecting the 'Questioning Route' as a guideline as it was crucial to support the quality of the analysis and to address the themes precisely. Next, three themes were selected as most appropriate because there was a need to investigate the themes with a strong focus and in more detail.

Following from the above, the degree of structure of the FG study was defined by the selected 'Question Route' (more structured), and the small number of themes (less structured). Further, the level of moderator involvement influenced the structure of the chosen approach. For instance, high moderator involvement increases the focus on the topic of interest, but on the other side enables less moderator involvement and a less structured group for the researcher to learn something new from the participants (Morgan, 1997). To

benefit from both advantages the researcher decided to use a funnel approach. Morgan (1997) defines a funnel approach as a compromised approach of both the less structured approaches that stimulates a free-flowing discussion and produces more data at the beginning of the discussion through less moderator involvement, and the more structured approaches at the end with more moderator involvement in order to allow a comparison of the FGs. To keep the group discussion continually flowing and produce a greater amount of useful ideas, the selected question type was 'open-ended'.

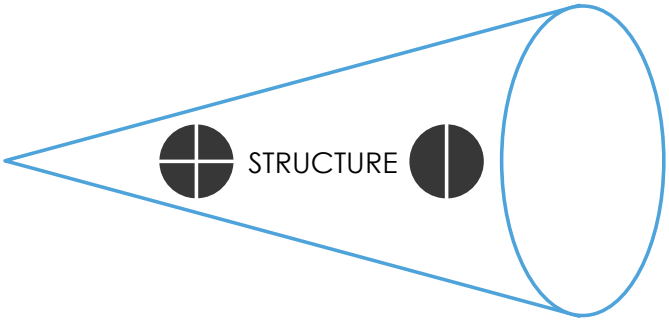


Figure 4-5: Funnel approach

4.6.3.3 Pilot of the focus group questions

To pilot the FG a piloting approach from Krueger (1998a) was adapted. This approach considers that it is usually difficult to pilot a FG because a 'true pilot' would be basically the first FG. However, Krueger's approach tests the developed questions with the research team that is familiar with the research programme (Krueger, 1998a). Hence the researcher developed a pilot test including eight questions that consider the developed questions for the FGs and the likely responses. This pilot followed the illustrated process in Figure 4-6 and ended with an improved Questioning Guide for the FGs.

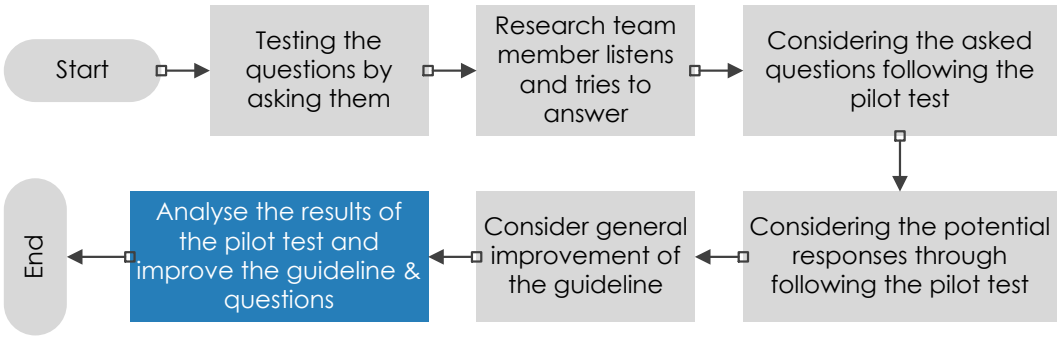


Figure 4-6: Pilot test process of the focus group guideline

4.6.3.4 Selection criteria

As it is important to recruit the right category of people for a FG study, the researcher defined the required characteristics for the participants of this study. So the researcher defined selection criteria (control characteristics) (Knodel, 1993). This follows the advantages of the homogenous group composition. The selection criteria are:

- Work experience in LC;
- leadership; and
- expert in the field of LC.

The criterion 'Work experience in LC' is concerned about that, the participants have worked within LC for at least two years. This was chosen to ensure that the participant covers a range of perspectives about the understanding and effective use of LC. For instance, this evolved through certain observation and handling of problems as they occur within the application of LC in practice. The 'Leadership' criterion is concerned about the way things are described and understood in a higher hierarchical position of an organisation. Hence experience in leadership in the form of at least a project management or senior management position was required. The final criterion 'Expert in the field of LC' ensured that the practical experience in LC is combined with knowledge and the ability to exert and share this knowledge. For instance, accepted experts are highly knowledgeable and skilled practitioners in their industry.

4.6.3.5 Focus group size and number of sessions

Since the numbers in homogenous FGs matters in terms of the data which are produced, the researcher decided that small groups are more suitable for this research. Firstly, the small groups were chosen because the participants have more time to contribute and share their perspective on the topic of interest. Secondly, the selection criteria deliver participants who are highly involved within the topic of interest, and therefore difficult to control, and the participants in large groups often break up into small conversations amongst neighbours around the table (Morgan, 1997). Thirdly, small groups reduce the importance and therefore the bias of the moderator role. Hence a small group size of five participants was defined and desired in this research. Following practical advice from Morgan (1997) the researcher had to recruit 20% more participants in order to cover participants who did not turn up.

The next step of the FG planning was then to define the number of group sessions which had to be conducted, considering the identified evidence in the literature: that the desired number of session is between two and five (Fern, 2001), and considering further the complexity of the research project (Knodel, 1993), and the availability of the participants in the special field (Morgan, 1997) of LC. The argument that a more structured approach needs fewer group sessions (Morgan, 1997), and the fact that an extension of the length of the discussion increases the amount of unique information which comes up in the discussion (Fern, 2001) were also considered. The researcher came up with the result that two homogeneous FG sessions with an extended length of two and a half hours would be most appropriate. To ensure a trustworthy answering of the research question, it was important that these groups are not too different from each other; hence, two groups without break characteristic are required Knodel (1993). As a result of this, the FGs for this research had to be two homogenous groups with a total of 12 homogeneous participants who are highly involved and interested in LC.

4.6.3.6 Sampling strategy

For the qualitative research nature and the premises to sample particular cases/participants relevant to this research, a purposive/non-probability form of sampling which samples in a strategic way was applied (Bryman, 2012). On the basis of two sampling strategies, a snowball strategy combined with an intensity strategy, a sample strategy under the premises of the quality of the participants' experience was developed. The participants for the two FG sessions were selected through this strategy, illustrated in Figure 4-7.

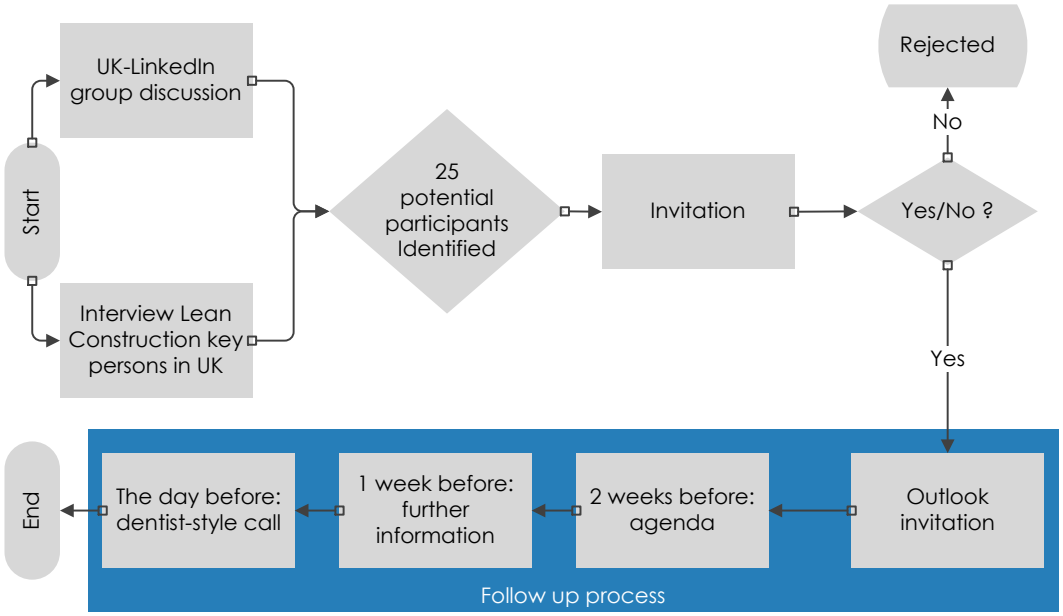


Figure 4-7: Sampling strategy focus groups

The recruitment strategy started with two tasks which enabled the researcher to identify professionals to select: (1) interviewing of key persons in the UK LC community and (2) a discussion in a professional social network. The motivation of the researcher to establish a LinkedIn discussion in a UK LC group was to engage the potential professionals who are interested and knowledgeable about the topic of interest in the FGs and are most likely to fulfil the defined characteristics. Hence this discussion was established with an easy to answer and related question about the topic (LC maturity) of the FGs. As group members then discussed this question the researcher could find out through their responses and their profiles if they are potential participants for this FG study. The second task identified

potential participants through interviewing two key persons in the LC community in the UK. Within these interviews the researcher explained the purpose of this research and the purpose of the FG, and introduced the defined characteristics which professionals as potential participants have to fulfil. Through a discussion the identification of potential participants evolved, together with their contact details. These two tasks resulted in a total of 25 LC practitioners as potential participants for the FG sessions.

To conduct the FGs at a reasonable distance to the participants, two facilities in the form of conference rooms were used, one in Liverpool for participants from the North West, and one in Nottingham for participants around the Midlands.

All selected professionals were contacted via email. Within this email they received information about the research and the purpose of the FG and were invited to participate as a selected professional in a unique group discussion on the topic of interest. Since it was important to recruit 12 homogeneous professionals for two FGs, it was desirable to extend the recruitment process with a follow-up process to achieve a stronger sampling strategy. This follow-up process is presented by Morgan in Sage (2009) who pointed out that a strong follow-up process has to take place if the researcher wants to ensure that the participants show up at the FG event. The first step of this follow-up procedure was to send all selected professionals an Outlook invitation with the details such as date, time and location; the second step was the sending of an Agenda to the participants; this was carried out two weeks before the FGs took place. One week later the participants received some further information such as: consent forms, participant information sheets, a profile template, and directions to the FG site including campus maps, information about the parking situation, walking distance to the train station and a mobile number to contact the researcher for any further questions. The last element of this follow-up process was a ‘dentist’-style phone call adopted from Krueger and Casey (2009). This phone call was carried out a day before the FG to remind participants who might have forgotten about it, and further to give them the feeling that this FG must be very important to the researcher.

The result of this strong sampling strategy and follow-up process was a total of 11 selected professionals with high-quality experience who participated in the two FGs, as shown in Table 4-6.

Table 4-6: Selected participants for the focus group study

Participant	Location	Experience in LC (years)	Total work experience (years)	Current role/position
PL#1	Midlands	7	22	MD
PL#2	Northwest	2	34	SM
PL#3	Midlands	11	37	MD
PL#4	Midlands	8	25	MD
PL#5	Northwest	5	26	OD
PN#6	Midlands	8	30	MD
PN#7	Midlands	36	40	AD
PN#8	Midlands	4	12	MD
PN#9	Midlands	5	26	R/PM
PN#10	Northwest	3	33	LTM
PN#11	Midlands	4	7	SM
MD=Managing Director; SM=Senior Manager; OD=Operations Manager; Associate Director; R/PM=Researcher/Project Manager; LTM=Lean Technical Manager CON=Consultant; PRA= Practitioner / PL=Focus group in Liverpool; PN=Focus group in Nottingham				

4.6.3.7 Recording and transcribing

Since qualitative studies with a phenomenology approach usually analyse text in the form of transcripts (Miles and Huberman, 1994), and the analysing framework for the FGs in this research described in the next section requires transcripts, the audio-tapes of the FGs had to be transcribed. Hence the following recording and transcribing procedure illustrated in Figure 4-8 below was developed and applied in this research.

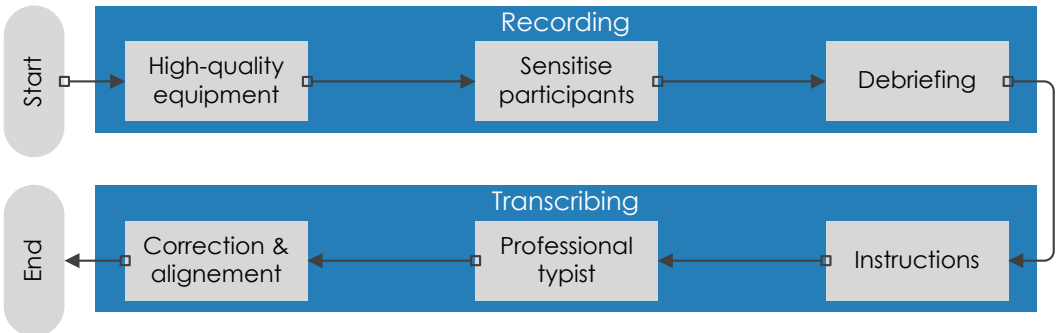


Figure 4-8: Recording and transcribing process of the focus groups

The procedure consists of two major steps: the recording of the FGs and the transcribing of those records. Both steps involved three processes which had to be carried out within this research. The first process follows Krueger's (1993) argument that 'quality data requires quality equipment'. Hence the researcher used two high-quality voice recorders (E) at two different positions (see the FG layout in Figure 4-9) on the table where the participants were sitting.

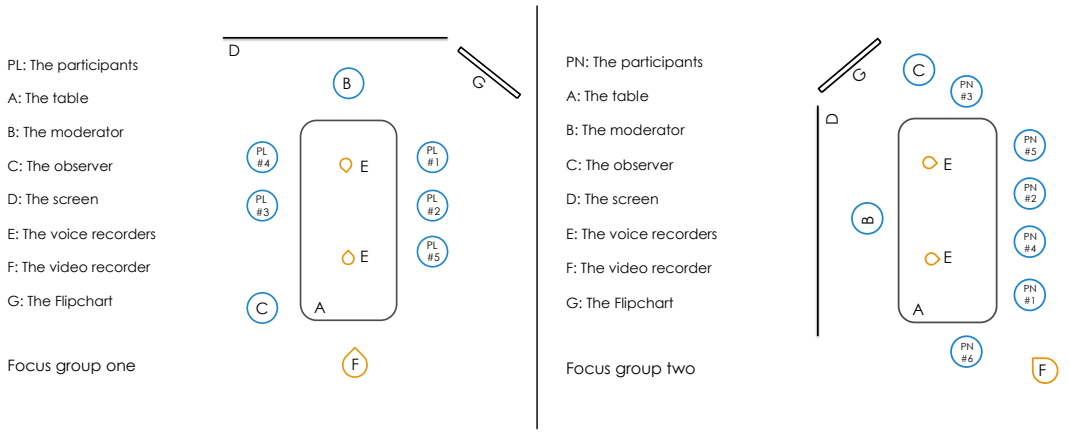


Figure 4-9: Sitting layout of the focus groups

Further, a video recorder (F) was used as a third source, to gather the lingual and non-verbal responses from the participants (Morgan, 1997). To enhance the quality of the recorded responses and reduce the disadvantage of a group discussion – that participants could speak simultaneously (Fern, 2001) – the participants of both groups were sensitised at the beginning of the session. This included raising awareness of speaking clearly so that the voice recorder is able to record them correctly and to voice everything, as nodding agreement is difficult to analyse; further, the participants were asked to avoid speaking simultaneously. The last process in the recording step was the recording of a debriefing between the observer and the moderator directly after the FG. Hence this systematic approach contributes as a first step to a higher quality of analysis (Krueger, 1993).

The transcribing then started with the development of clear instructions and templates about how the records of the FGs had to be transcribed (see APPENDIX G). This enabled the research to ensure that the quality of the first transcribing allowed an intense analysis of the

transcripts. Following this a professional typist transcribed both sessions in compliance with the researcher's instructions. The instructions and style of transcribing adopted used and combined ideas from the researcher and two authors (Kvale, 1996, Smith, 2008b).

Within the last process, 'Correction & alignment', a second transcribing was carried out by the researcher himself in order to correct the first transcripts and enhance their quality. Furthermore, this process involved a second reading of the transcripts to align them with the video records of each session, which enabled the researcher to check the logical consistency, correctness of the formatting and the underlying emphasis and correctness of the participant's assignment in the transcripts. As pointed out, the recording and transcribing provide the first contributions of the analysis, such as debriefing and several readings and watching of the video records. Therefore, the result of the process above delivered quality transcripts of the conducted FGs which were then extensively analysed as described in the next sub-chapter.

4.7 Analysis and organisation of the data

Whilst the core elements of qualitative data analysis have been demonstrated in section 3.4.2, this section first looks at the way the data in this research was organised and stored before the analysing method and procedures for primary and supplementary data in this research are presented.

4.7.1 Data organisation

The data storing and organising of this research followed a digital storing approach which is presented in the following paragraphs.

The following was all adopted from Miles and Huberman (1994): raw material such as field-notes, flipcharts, tapes and videos, partially processed data: write ups, Mind Maps® and transcripts, coded data, memos, data presentation, analysis episodes, and report text digitalised and stored. This required photocopying and transferring paper documents to PDF

format. Further, all those data were stored on a password-protected hard disk. As Fred Davidson (1996) additionally pointed out that backups should be made of the data in a research project, a backup plan was established. Furthermore, the researcher ensured that the identity of the practitioners participating in the interviews and the FGs, with the exception of the group interview (see section 4.4.3), was anonymised (Creswell, 2013). Furthermore, the researcher used the advantages of qualitative computer programs to support the storing and managing of the data in a simple way. The advantages of these computer programs are summarised by Creswell (2013); hence computer programs:

- Provide a quick and easy accessible file-storing system to store and organise the data;
- support the research by locating and searching of specific statements, a phrase, or a word;
- encourage the researcher to focus on the macro level such as text lines meanings, sentences, and ideas carefully; and
- enable the researcher to map and visualise relationships between codes, themes or documents.

Furthermore, computer programs in research projects in the construction management field provide an effective way of examining a phenomenon extensively and intensively (Blismas and Dainty, 2003). Blismas and Dainty (2003) pointed out that computer-aided analysis can enhance qualitative research through assisting the researcher in the data management, offering a 'facility to code and retrieve all data' (see also Kvale, 2007) and bringing the researcher closer to the phenomena under investigation through larger data sets.

However, the use of computer programs can involve some disadvantages and problems. These could be: the technical barriers in quality control and documentation of the data; the learning of the effective use of a program and maintaining a data management system to be effective can be a challenging task for the researcher; and data organising is often tedious, complicated, and time consuming (depends on the speed of the computer and the user's knowledge) and may slow down the analysing process (Miles and Huberman, 1994).

As there are many different types of programs to support qualitative research first a decision has to be made regarding the program type and a second one to choose the right program for this research. Since ***code-based theory builder*** programs usually involve a ***code-and-retrieve*** program (divide textual data into chunks, attach codes and find and display those codes) as well, those types are specially developed to make connections amongst the codes and results and classifications or categories of the whole, in order to interpret a structure or formulate propositions (Miles and Huberman, 1994). As the analysis of the data within this research focused on the understanding of the phenomenon 'LC maturity' it is desired to divide the amount of textual data into chunks and organise those chunks into themes. Hence ***code-based theory builder*** programs are the desired type of programs in this research.

Previous comparison of qualitative data analysis software from certain authors (Miles and Huberman, 1994, Miller and Salkind, 2002, Creswell, 2013) were considered to identify characteristics and evaluations of different programs. This resulted in seven criteria and functions that a program should satisfy, and these are:

- Type of data the program will accept: it is important that the textual data resulting from the interviews and FGs can be directly used with the program;
- user friendliness: it is easy to get started;
- data management: the program allows the researcher to manage the data;
- coding: the program supports the developing of codes and dividing the textual data into chunks, separate word, phrases, lines, sentences, paragraphs and then attaching codes or key words;
- reading and reviewing: searching and displaying of specific text passages;
- memoing: offers the opportunity to write memos and notes about the data; and
- data linking: can make links amongst different parts of data and show the relationship.

As it is argued that both ATLAS/ti and NVivo (NUD IST) are the best programs to support qualitative research (Lewis, 1998), these programs will be compared using the adopted criteria and functions above together with the results of previous comparisons and descriptions of these two programs from the following authors: Miles and Huberman (1994) and Miller and Salkind (2002) as shown in Table 4-7.

Table 4-7: Comparison of qualitative computer programs

Programs	Data type	User friendly.	Data Mgmt	Coding	Reading	Memoing	Data linking	Author of comparision
ATLAS/ti	S	C	O	S	O	C	C	Miles and Huberman
ATLAS/ti	S	C	S	S	S	S	S	Miller and Salkind
NVivo (NUD IST)	S	C	O	S	C	C	O	Miles and Huberman
NVivo (NUD IST)	S	C	O	C	C	C	C	Miller and Salkind
W=weak [worst result], O=ok, S=satisfied, C=Comfortable [best result]								

Source: Adapted from Miles and Huberman (1994) and Miller and Salkind (2002). Permission to reproduce this information has been granted by SAGE PUBLICATIONS INC.

The comparison resulted in the decision that the program NVivo is the most appropriate support for this research. In addition, it must be stressed that NVivo supports the Framework Method© in versions 9 and 10 (QSRInternational, 2012). Hence NVivo version 10 will be used within this research to support the analysis of the individual interview and FG data.

It is important to note that even though the computer programs have their advantages, support and functions for the analysing process of qualitative data, the process/tasks of the data analysing are exactly the same because the researcher and not the software does the coding and categorising of the data (Creswell, 2013).

4.7.2 Analysis of the collected data

Since the analysis of qualitative data in general was introduced in Chapter three, the following sections present the selected, prepared and performed analysis approaches for each deployed data collection method in this study.

4.7.2.1 Analysis of group and the individual interview data

Thematic coding is one of the most common analysis approaches of qualitative data and this approach is often referenced as 'thematic analysis', recently more often referred to as within the Framework Method©, which was developed in the 1980s from the largest, independent not-for-profit research institute in the UK – the National Centre for Social Research (NatCen) (QSRInternational, 2012). Article references were searched for relevant publications that have used the framework approach in order to justify the relevance and adaptation of this approach in this study. As a result this method of analysing qualitative data has been used in construction related research, as for instance in Baiden *et al*. (2006) and Whittock (2002); and it has been further used in qualitative health care research such as Pope *et al*. (2000); and in applied policy research such as Srivastava and Thomson (2009).

However, the major advantages which emerge from the use of a well-defined, documented and systematic analysis procedure such as the Framework Method© are: the more precise reworking and reconsidering of upcoming ideas in the analysing procedure (Ritchie and Spencer, 2002), the reduction of data through summarising and synthesising, and the retaining of the links to the original data (QSRInternational, 2011). Considering the advantages as well as the relevance of this method, it was selected for analysing the group interview data of this research.

Steps of the analysis

The Framework Method© was developed by Jane Ritchie and Liz Spencer, at NatCen (Ritchie and Spencer, 2002). The name of this approach is drawn from the 'thematic framework' which presents the central element of the method (Ritchie *et al*., 2003b). The approach involves a systematic ordering and synthesising of the data against key issues and themes which are developed from the data (Ritchie and Spencer, 2002). The key steps of this Framework Method© are illustrated in Figure 4:-13.

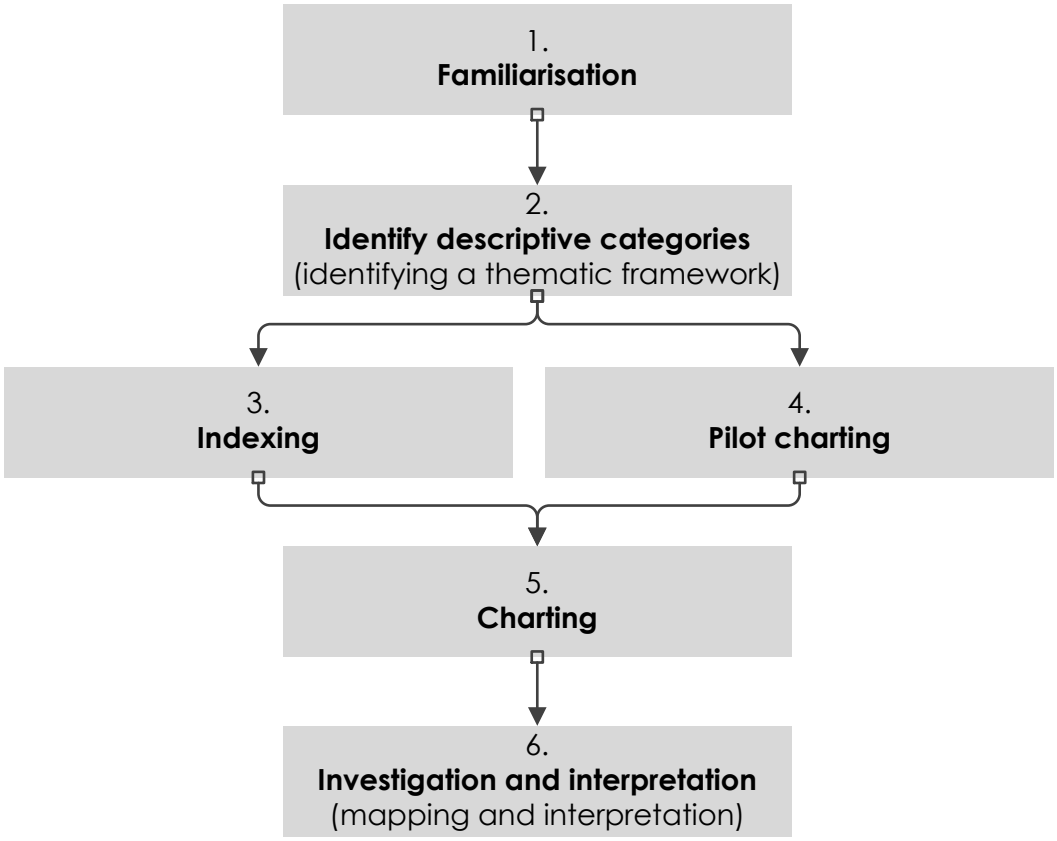


Figure 4-10: Key stages of the Framework Method©, adapted from QSRInternational (2011), Permission to reproduce this Figure has been granted by QSR International Pty Ltd

Familiarisation is the first step of the framework as the researcher must become familiar with the range and diversity of the gathered data (Ritchie and Spencer, 2002). During this step, the researcher is not only getting more familiar with the range and depth of the data, but identifying the thematic framework (which later organises the data) through recognising and note-taking of important themes and sub-themes (QSRInternational, 2011, Bryman, 2012).

Once this thematic framework is identified, it has to be tested to ascertain whether it is appropriate and able to manage the gathered data; this can be done by either indexing (coding the data with the thematic framework) or a pilot charting (chart a bit of the data to the framework matrix), and then revising the framework if necessary (QSRInternational, 2011). As soon as the thematic framework is appropriate to organise the data the next step, 'Charting', will follow. Charting is the process which summarises the key points of the data and sorts this distilled summary of meaning into the appropriate part of the framework matrix (Ritchie *et al*., 2003b). Hence a sensitive judgement of the researcher is important in this process to find the right balance between summarising the data in a way that retains enough context and essence of the comment being made and to not chart verbatim parts of transcripts (ibid.). For each theme there is usually a matrix with the corresponding sub-themes on a DIN A3 sheet of paper (Ritchie and Spencer, 2002, Ritchie *et al*., 2003b). The biggest difference between the content analysis and the Framework Method© is the charting process, which results in charts with a concentrated and distilled summary of the expressed views and experience, which is different to a simple cut and paste method of verbatim text (Pope *et al*., 2000).

After charting the data according to the thematic framework the charts are used for the last step, the 'investigation and interpretation'; this involves interpreting the data as a whole in order to define concepts, map the range and nature of phenomena, create typologies, find associations and provide explanations of the findings, the relation between the themes and the meaning (Ritchie and Spencer, 2002). Additionally, the interpretation of the meaning from interview data in particular goes beyond the structuring to a deep and critical explanation of the data (Kvale, 2007).

4.7.2.2 Analysis of focus group data

The procedures prepared and used to analyse FG data are aligned to the adopted research approach, phenomenology. Phenomenologists focus not on 'covering of laws' but on the meanings and actions in order to receive a 'practical understanding' (Miles and Huberman,

1994). The analysing approaches of phenomenology research have therefore developed specific structures and steps through especially the contribution of authors such as Colaizzi (1978), Van Manen (1990), Moustakas (1994) and Creswell (2013).

Analysing framework

The phenomenological analysing approach to analyse the data of the FGs in this study derived from the adaptations of Creswell (2013) analysing approach, which is a simplified version of Moustakas (1994) modification of the phenomenological STEVICK-COLAIZZI-KEEN method and Colaizzi's (1978) original seven-step analysing method of phenomenological data (see Figure 4-11).

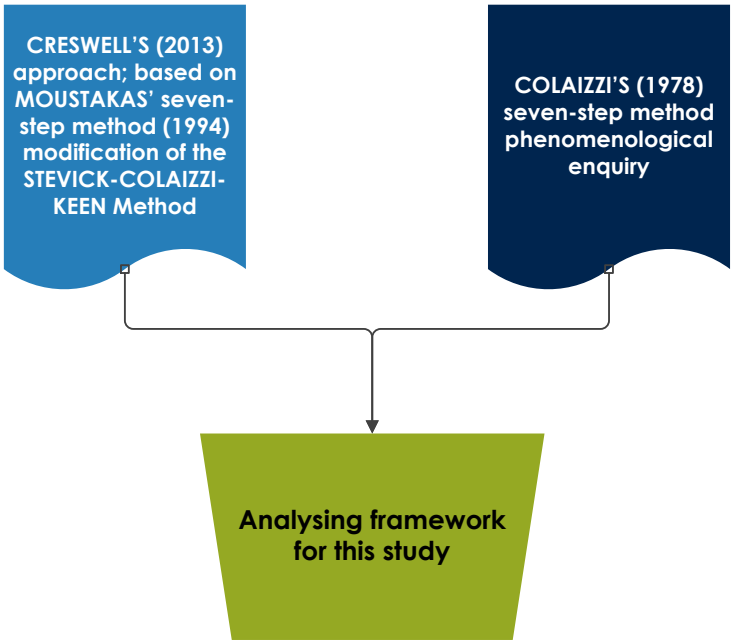


Figure 4-11: The adapted analysing framework

The framework therefore involves the following steps:

1) Transcribing of all data collected by audio-tapes. Those transcripts can be verbatim or in a condensed text format but they need to capture the essence of what the participant had to communicate (Colaizzi, 1978).
2) Describing the personal experience of the researcher and the phenomenon through epoche. Husserl developed the concept of 'epoché' which "[…] requires the

elimination of suppositions and the raising of knowledge above very possible doubt" (Moustakas, 1994, p.26). This then is an attempt towards an exclusion of the personal experience of the researcher and ensures that the focus is set on the experience of the participants in the study.

3) Reading all the textual data (transcripts and notes) to familiarise and develop a feeling for the data, and extracting significant statements (phrases or sentences) from the data sources which directly relate to the phenomenon under investigation.
4) Developing a list of non-repetitive and non-overlapping significant statements while treating each of them as equally important.
5) Grouping the significant statements into larger units of information, 'meaning units' or 'themes'. The statements that address similar meanings are grouped into meaning clusters (themes).
6) Developing an in-depth exhaustive description of the phenomenon that represents the 'essence' of the experience. This represents the culmination of a phenomenological study (Creswell, 2013). And identifying the fundamental structure of the phenomenon based on the rigorous analysis of the exhaustive description of the phenomenon through the participants.
7) Returning to some of the participants a second time for validation. A follow-up appointment is made to validate the findings (the essence of the phenomenon), and new meanings of the phenomenon that emerge will be integrated into the final description of the phenomenon (Colaizzi, 1978, Anderson and Spencer, 2002).

4.7.2.3 Uniqueness of the focus group analysis

The analysing of the FG data is underpinned by some uniqueness, as previously pointed out (Smithson, 2008); as FG data are produced in the form of a group interaction – 'performance amongst the participants in the group' – the analysis has to consider this fact (Kitzinger, 1995). Considering further the arguments and suggestions in terms of the analysis of certain authors (Morgan, 1997, Sim, 1998, Wilkinson, 1998, Smithson, 2000, Smithson, 2008), it is

important to analyse the discussion of all group members of each FG and take into account the viewpoint of individuals that differ from the majority of their group (dissenters). This was considered through different codes built into the analysis. Hence this allows analysing the individuals and the group, which enhances the richness of the data gathered by the FGs.

4.8 Validation strategy and reliability

In following the flow of data collection methods, sampling strategies, collecting and analysing the data, generating of meanings and interpreting the findings within a qualitative research, the next step is where the research has to be confronted with its validity (Miles and Huberman, 1994). Additionally, the research methodology would be incomplete without considering the validation 'evaluation' of the research (Amaratunga *et al*., 2002a). Further, it is important to note that the phenomenologists believe in the idea that there is no single reality to get 'right' - but cannot escape a sneaky feeling that, in fact, reasonable conclusions are out there somewhere (Miles and Huberman, 1994). There is further a blurred language in the context of evaluate quantitative and qualitative research in the literature (Amaratunga *et al*., 2002a). Several terms that have evolved over the last three decades regarding validity in qualitative research are from Lincoln and Guba (1985) who used terms such as ***credibility, transferability, dependability*** and ***conformability*** to reach the trustworthiness and correctness of a piece of research; these terms are translated from the conventional terms ***internal validity, external validity, reliability and objectivity***. Licoln and Guba's term ***transferability*** is often referred to as ***generalisability*** (Ritchie *et al*., 2003c). Eisner (1991) uses terms such as ***credibility*** (which will be achieved through multiple types of data 'structural corroboration' (triangulation), ***consensual validation*** (which pursues the agreement of competent others that the study is right) and ***referential adequacy*** (which focuses on the importance of criticism to reveal the subject in order to add understanding). Lincoln and Guba (1985) further state that the trustworthiness of a study is simply reached by convincing the researcher and his or her audience that the findings of the study 'are worth paying attention to' and to take account of them. Another context of trustworthiness within

interpretative research is described by Angen (2000) when validation is the 'Judgement of trustworthiness or goodness' of the research. However, following the evidence from Creswell (2013) and Whittemore *et al*. (2001), the term validation (validity) is accurate and is preferred in this research over historical terms such as 'trustworthiness' and 'authenticity'.

Therefore, validation in qualitative research is seen as the endeavour to evaluate the results regarding their accuracy (Creswell, 2013). This is doubtless in harmony with the general view of value in research within but not exclusively the built environment, which derives from valid results (which are the product of collection, interpretation, analysis and evaluation of data) and their contribution to knowledge and value (Amaratunga *et al*., 2002a). Further, validation in qualitative research is demonstrated by Angen (2000) as a process to evaluate the truth of the findings, and validity means the attempt to have something valuable that can be trusted and convincingly described within a human community.

The problem of qualitative research is the 'vertical monopoly' which results from a single performance of the research processes through only one researcher and the concentration on the findings (What) and not on the way to them (How) in their reports (Miles and Huberman, 1994). To cope with this problem it is recommended to use multiple validation strategies or at least two validation strategies for qualitative inquiries (Creswell, 2013).

4.8.1 Validation strategies

As there are numerous validation strategies for qualitative research a selection of often and frequently used approaches is reviewed to further choose from those strategies at least two that are most appropriate for this research.

Triangulation

The basis of triangulating is to confirm the findings through the use of multiple independent sources and different methods or investigators, which illustrates the self-consistency of the findings (Miles and Huberman, 1994). This process is known as providing corroborating evidence by different sources of data while triangulating information to a code, theme or

perspective (Creswell, 2013), and delivers at its best an in-depth understanding of the phenomenon under investigation (Denzin and Lincoln, 1998). However, there are some authors who neglect the view of triangulation as validation strategy, such as Fielding and Fielding (1986). More recently, Ritchie *et al*. (2003c) have stated that triangulation is arguably one of the most often-cited strategies of validation in qualitative research. Furthermore, Denzin and Lincoln (1998) first reported and identified four different modes of triangulation in relation to a single study: ***data triangulation*** (compare multiple and different sources of data; this is best done through data collected from different methods), ***investigator triangulation*** (the use of different investigators and through multiple analysis), ***theory triangulation*** (use of different theoretical perspectives to look at the data), and ***methodological triangulation*** (the use of multiple and different methods to collect data).

Peer review or debriefing

Peer reviews and debriefings deliver an external process to check the research findings and the way to them (Lincoln and Guba, 1985, Ely, 1991). Lincoln and Guba (1985) describe that a peer review session includes: hard questions about methods, meanings and interpretations of data from a disinterested peer reviewer who is trying to be the "devil's advocate", whereas both the peer reviewer and the researcher make notes within this session (p. 308). This approach is suggested to be useful to establish the credibility of the research (Ely, 1991). However, it is argued that too much criticism can extremely damage the research and further slow down the performance of the researcher through reducing motivation, enthusiasm and energy (Lincoln and Guba, 1985).

Negative case analysis

Negative case analysis or 'looking for negative evidence' as labelled by Miles and Huberman (1994): the basic of this approach is that working conclusions (hypotheses) are drawn, and the researcher refines those by looking for negative evidence (Lincoln and Guba, 1985), and might ask: are there any data that disconfirm this conclusion? (Miles and

Huberman, 1994, Creswell, 2013). Miles and Huberman (1994) used a statement by Albert Einstein to emphasise this approach: "No amount of evidence can prove me right, and any amount of evidence can prove me wrong" (p. 271). However, a problem of searching for negative evidence is the duration – how long to search for negative cases, as stated by Glaser and Strauss (1967).

Member checks

This approach involves the playing back of the research evidence to participants who were involved in the first place when the data was collected (Ritchie *et al*., 2003c). Hence the local informants judge the major evidence of the research; this is considered to be "the most critical technique for establishing credibility" (Lincoln and Guba, 1985, p.314). Therefore, it is an established technique in qualitative research (Miles and Huberman, 1994). In addition, Bronfenbrenner (1976) demonstrated the playing back of the feedback to the participants is a source of 'phenomenological validity'. This can be further emphasised through the demonstrated phenomenological analysing approach of Colaizzi (1978), which involves this approach. Member checks serve several purposes such as: intentionality assessment, correcting errors of collected and interpreted information of the participants, provide opportunity to collect additional information and agreement of correctness and accuracy of the research findings (Lincoln and Guba, 1985). Within this approach it is crucial to not present the findings in a too abstract or incomprehensible way, and to carefully select how and what is played back to the participants (Miles and Huberman, 1994). However, the researcher has not to "[…] honour all of the criticisms that are mounted, but he or she is bound to hear them and weight their meaningfulness" (Lincoln and Guba, 1985, p.315). Nevertheless, member checks are biased if all members share the same myth or perception of the phenomenon (Lincoln and Guba, 1985). It is suggested that this validation technique is conducted through a FG composed of members of the study (Creswell, 2013).

The Rich, Thick-Descriptions

A rich and thick-description delivers the important basis for the readers' judgement of transferability of the research (Lincoln and Guba, 1985, Erlandson, 1993). The term transferability is the preferred form of external validity. Hence the rich, thick-description involves multiple details of the database, to enable potential appliers to make a transfer of the study (Erlandson, 1993). This involves providing the greatest possible range of information so that the reader understands the findings (Lincoln and Guba, 1985). Hence the description should enable that the reader as well as the researcher are able to analyse; this can be done through the use of quotes and their like from participants within the research (Erlandson, 1993), and the description of ideas from the wider (general) to the detail (narrow) (Creswell, 2013).

4.8.2 Selecting the right technique to build a validation strategy

After reviewing a selection of techniques and considering the advantages of validation in qualitative research, such as the close relation between participants and researcher (Creswell, 2013), the most appropriate approaches are selected and combined into a validation strategy for this research.

Due to its outcomes and appropriateness for establishing a phenomenological validity and agreement of the correctness as well as accuracy of the research findings, three approaches were selected: triangulation, member checks and rich, thick-description. Triangulation was selected because of its contribution to an in-depth-understanding of the phenomenon. This will be adapted by a combination of methodological triangulation and data triangulation. Since member checks are aligned with the selected phenomenological analysis strategy (see step 6. of the analysis approach for the interview and FG data), this approach is grounded already in this research methodology and further delivers several contributions to the correctness and accuracy of the findings in this study. The rich, thick-description is chosen to be the third approach and will ensure the transferability of this research. The member checks will be deployed within this study through interviews and a FG to play the

interpretation and findings back to the participants in order to judge the major evidence. Following recent evidence that the combination of those three approaches is unquestionably reasonable and all three are the most commonly used validation approaches (Creswell, 2013), this validation strategy will ensure the validity of this research. The combination of all three approaches to the validation strategy is further illustrated within Figure 4-12.

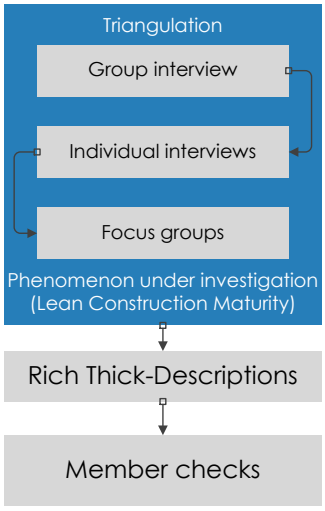


Figure 4-12: Combined and adapted validation strategy for this research

4.9 Compliance with the ethics

Prior to commencing the study, ethical clearance was sought as it involves human participants and the use of their data. Hence in August 2012 this research successfully received the ethical approval from the Research Ethics Committee of Liverpool John Moores University. In order to be transparent, Table 4-8 shows the ethical activities that have been implemented by the relevant research methods. In addition, the documents such as 'participant information sheet' and a template of the consent form can be found in APPENDIX A & B.

Table 4-8: Implemented ethical activities

Ethical activity	Group Interview	Interviews	Focus Groups
Written consent was obtained from the research participants.	X	X	X
Research participants were provided with an information sheet regarding the nature, purpose, risk and benefits of the study.		X	X
Research participants were provided with an extended abstract and a 15-minute presentation regarding the nature, purpose, risk and benefits of the study.	X		
Research participants gave their written consent for publication of their names together with the comments given to the researcher in this thesis.	X		
Research participants were provided with the contact details of the researcher.	X	X	X
Research participants were informed that taking part in the study will be absolutely confidential and anonymised.		X	X

4.10 Chapter summary

This chapter has introduced and established a holistic overview of the research, with those methods chosen to be appropriate to study the phenomenon of 'LC maturity'. The chapter has justified each selected data collection method while considering the research aim and objectives. Further it has demonstrated why those methods are appropriate, how they have to be used, and deployed in this research. This involved the cases and the sampling strategies developed and used for each method. Furthermore, the rationales have been presented regarding how and with what characteristics in relation to the phenomenon 'LC maturity' participants were selected. The chapter has provided the evidence of the appropriate and adapted data-analysing approaches in this research. Additionally, the appropriate steps of analysing the different data sets have been explained. The chapter has described different validation techniques and developed a validation strategy consisting of three different approaches to ensure validity. Finally, the chapter has pointed out how the ethical compliance is achieved within this research and the applied methodology.

CHAPTER FIVE

FINDINGS – SUPPLEMENTARY DATA COLLECTION

5 Findings – supplementary data collection

5.1 Introduction

This chapter shows the transparent execution and evidence of the analysis for the supplementary data collection in this research. Examples of the data for both the conducted group interview and the individual interviews are presented. Consequently, the synthesis of the two data sets, their meaning, and the findings are demonstrated. This was carried out to contribute towards achieving the first, second and third objectives of this research.

5.2 Group interview: Findings[4]

The group interview was undertaken to test the ideas of this research with a group of seven leading LC academics and specialists, brought together from the IGLC. Hence the purpose of this group interview was to garner rich information about the conception on maturity and MMs of these leading LC academics and specialists. The collected and verified textual data (see section 4.4.3 for details) were analysed through adopting the Framework Method© described in section 4.7.2.1. The applied key steps of this analysis approach are highlighted in blue within Figure 5-1.

[4] Parts of these findings and the related literature have been original published in Nesensohn, C., Bryde, D. J., Ochieng, E. G. and Fearon, D. J. (2014). Maturity and maturity models in Lean construction *Australasian Journal of Construction Economics and Building* V.14(1), pp.45-59. http://creativecommons.org/licenses/by/4.0/

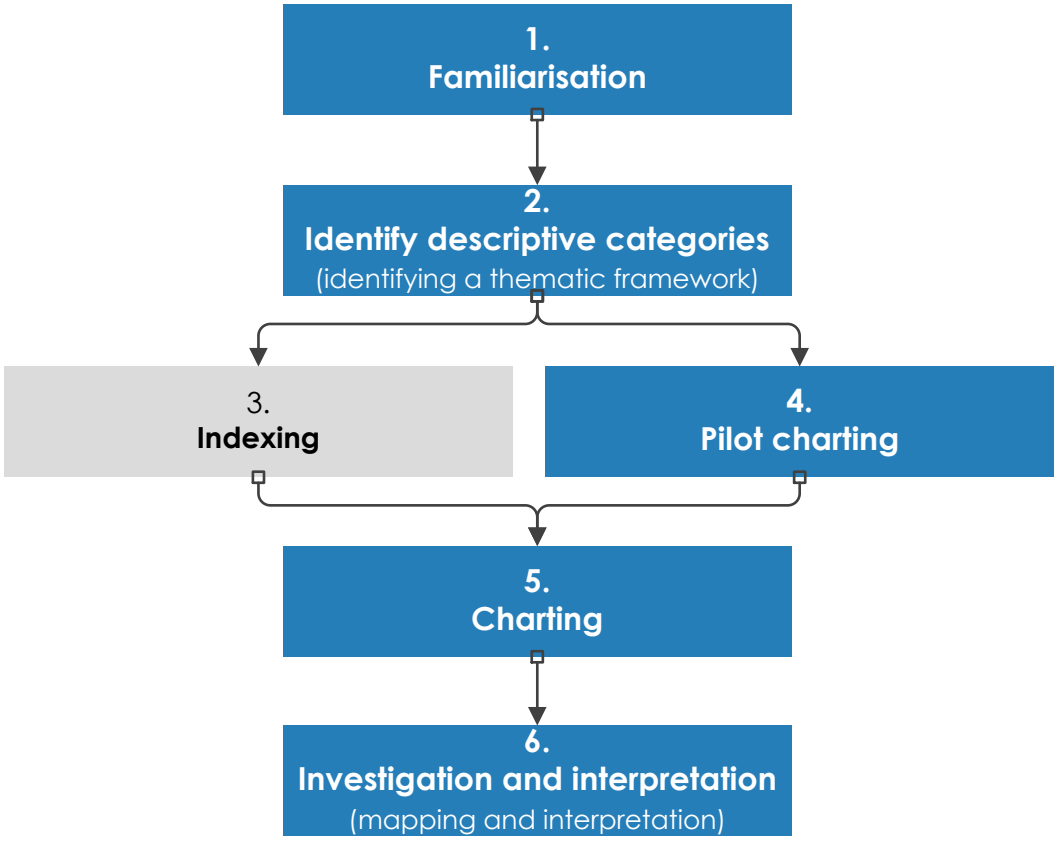


Figure 5-1: Key steps of the Framework Method©: Group interviews

Before the result of each step in this approach is presented, the next section provides an overview of the participants' profiles.

5.2.1 Group interview: Participants' profiles

A summary of the participants of the group interview is illustrated in Table 5-1 below.

Table 5-1: Participants: Group interview

No.	Participant type	Position
#1	Prof.	University of California at Berkley, USA
#2	Prof.	University of Salford, UK
#3	Assoc. Prof.	Michigan State University, USA
#4	Prof.	San Diego State University, USA
#5	Prof.	Federal University of Rio Grande do Sul, Brazil
#6	Specialist	Co-founder and managing director of the LCI
#7	Assoc. Prof.	San Diego State University, USA

5.2.2 First step: Familiarisation

Familiarisation by immersion in the textual data constructed from the contemporaneous notes and the follow-up process was achieved through reading and reviewing the contemporaneous notes a number of times.

5.2.3 Second step: Identify descriptive categories (thematic framework)

During the familiarisation process the thematic framework (descriptive category) was identified through recognising and note-taking of important themes and sub-themes. Hence an initial thematic framework of the data was developed. This conceptual thematic framework consists of two themes and concepts relating to the potential support for the research project and perceptions about MMs amongst the LC specialists and academics (see Table 5-2).

Table 5-2: Conceptual thematic framework: Group interview

Conceptual thematic framework: for the group interview
1. Potential support for the research project
1.1 Feedback and potential adaptation
2. Perceptions about maturity models
2.1 Conceptions of maturity
2.2 Attitudes towards maturity models

5.2.4 Third step: Indexing

This is not applicable as pilot charting (step 4) was carried out instead, due to the manageable amount of data.

5.2.5 Fourth step: Pilot charting

It was decided that it is more appropriate for this investigation to use pilot charting of the data and revise the themes and sub-themes, because the data was a manageable size. The pilot charting mapped examples of the textual data to the conceptual thematic framework. Through this the thematic framework and its appropriateness to organise all the data were confirmed.

5.2.6 Fifth step: Charting

The charting process was carried out in a DIN A4 matrix for each theme and its sub-themes on the top of the matrix and the seven participants on the left side of the matrix. The constructed charts provide a concentrated and distilled summary of the expressed views and conceptions within the group interview. The result of the charting process is illustrated within Table 5-3 and Table 5-4 below, which are the matrixes of the two main themes 'Potential support for the research' and 'Perception about maturity models'.

Table 5-3: Framework matrix-theme 1: Group interview

Participants	1. Potential support for the research
	1.1 Feedback and potential adaptation
#1	It would be interesting to ask how a company is mature in LC? How they progressed? And what does it mean to be mature in LC? There might be some useful pattern to share. Descriptive research is the right approach; the use of success stories as a tool to changing people might push you into Design Science research. Success stories situated in the real world using real cases would be interesting to adopt. Stories as means to induce companies and individuals to change their behaviour. However, you understood entirely perfectly how to do the research.
#2	Processual Innovation Research "what happens over time" as an idea to find patterns in the process of innovation to take into LC. Patterns to start with LC are: LPS, information technology (UK) & TPS (Brazil). But ensure for this research enough time and a case with excellent access.
#3	-
#4	-
#5	I would suggest to do something more prescriptive that helps companies to understand and consider the dynamic of the industry
#6	-
. #7	-

Table 5-4: Framework matrix theme 2: Group interview

Partici-pants	2. Perception about maturity models	
	2.1 Conceptions of maturity	2.2 Attitudes towards maturity models
#1	Term [is] problematic, because you don't get mature in LC as the journey never ends	-
#2	Problem: do we know the target situation and the way to that? Is the target situation good? As LC is still developing it could involve [into] something else in 5 years!	MM are a kind of target situation with a way to that. The assumption is the way is for everybody the same and we try to measure this way. LC starts in many companies we know with LPS, or information technology (UK) or the TPS (Brazil). A problem is, do we know the target situation and the way? The CMM was heavily criticised in addition from the software industry people -the PM2 MM seems based on the PIMBOK, which is criticised even from PMI members. The SPICE took 3-6 years to develop and wasn't very successful in its use.
#3	Is there a fulfilling answer to "how Lean are we?" I'm sure companies will ask this! But should this answer be there?	Companies that are done with the LPS might well ask what's the next level to go to. Toyota for example moves towards the ideal state of zero inventories.
#4	I won't phrase it "maturity of LC"! Do we know what maturity looks like? Can we say with certainty that is the endpoint where we are trying to get? Uncomfortable is for me a set of tools you should use it if not you are not mature. Understanding should be the metric even if it is much harder to measure than best practices	I'm a maturity model sceptic! Because I don't see they drive improvement. We have dog years: a 2-year-old dog is chewing a shoe - nothing can hold him back because he is still young. Later he behaves differently. This is not as much later as for humans. Spread out and convert to human lifecycle - we got a MM we all know with some value. It's not very accurate, but it has its uses. I don't know a successful MM in any industry. Contractors ask us: hand the box in with what we are supposed to do and we do it! We don't like to talk about LC as use a set of tools and you are mature. A MM that sees you are mature if you use certain practices or tools, rather than understand certain things, pushes people to: tell me what is the box. Understanding should be our metric.
#5		I don't like the idea of a standardised structure to achieve a LC implementation.
#6	More and more I see Lean as a philosophy, a way to see, understand and act in the world.	I don't doubt these models help people to find the next step; I see a greater danger that people get tranquillised by it. I don't say MMs has no value and I have never seen one used in action. Crosby's model is a nice generalised form. But I doubt the boundaries haven't any objective basis as definition. I encourage you to think more deeply about the efficiency and utility of a MM. My experience shows me that implementing LC is extremely surprising in what happens and it is not a standard.
. #7	Instead of the term maturity I would use evolution.	Defining a MM shows you the making path of the LC evolution. Make clear for whom - contractor or owner - is the model. It is important to define if the MM is something for the contractor to learn or the owner to assess potential contractors.

5.2.7 Sixth step: Investigation and interpretation

Within the last step of the Framework Method© the matrixes and the meaning of its mapped group interview data were interpreted. To facilitate this process the tool Mind Maps® was

utilised, which is widely used within operational research and other management-related disciplines (Vidal, 2006). As a result of this systematic analysis approach and the tool Mind Maps® around 60 contemporary notes have been grouped and synthesised into a thematic framework consisting of two main themes and three sub-themes. Those findings are presented and described as follows.

Note:

Because the group interview was mainly conducted as a pre-test of this research, the data is not only interpreted but in addition directly discussed to allow an enhancement of the subsequent data collection. Hence this is unique for the group interview data.

5.2.7.1 Theme 1: Potential support for the research project

The feedback of the specialists and academics to the research project was characterised by acceptance, suggested ideas for the research and the acknowledgment of a detailed research plan. The expressed ideas of both the specialists and academics have been considered within this research and the voiced acknowledgment in terms of the research is illustrated and captured in the Mind Map within Figure 5-2, p. 152.

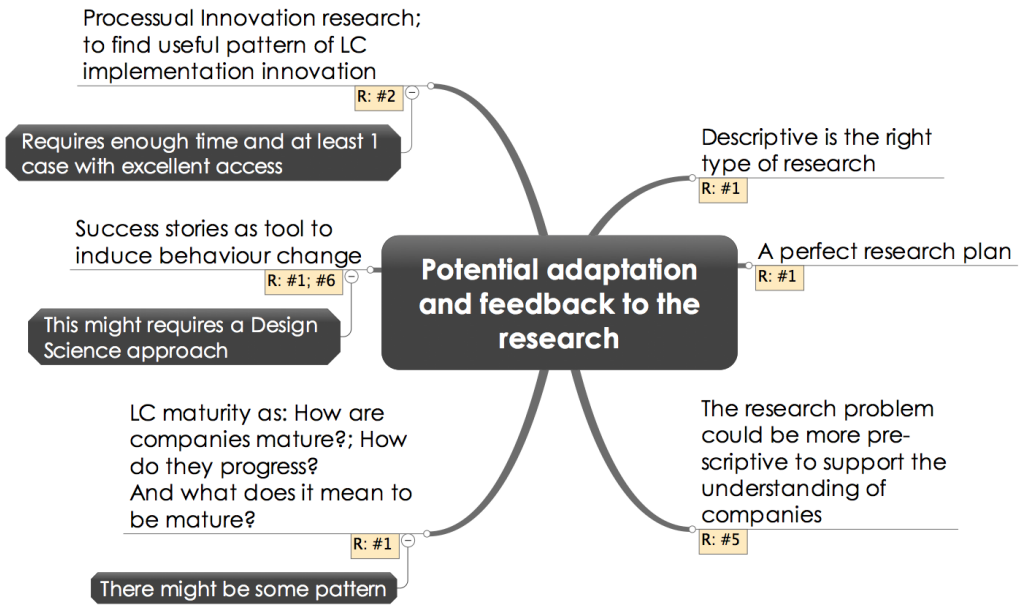


Figure 5-2: Mind Map -Feedback & potential adaptation

The idea from participant #2 was that 'Processual Innovation research' cannot be adopted, because of limited resources, although the literature about the processual innovation research was reviewed with the purpose of finding concepts that might contribute to this research. The ideas from participant #1 and #6 about 'success stories', the interest in 'how companies are getting mature in LC', and sharing of such patterns, were considered within the framework of this research through reviewing the relevant literature and adapting the data collection of the primary data to gather some insight into how companies improve their maturity in LC.

5.2.7.2 Theme 2: Perception about maturity models - Conceptions of maturity

Four major topics regarding this first sub-theme were derived. As illustrated in the Mind Map, within Figure 5-3 the topics are: (1) maturity is perceived as an *endpoint*, (2) maturity relates to a *set of tools* to measure it, (3) the term maturity could be replaced by a *substitute term* and (4) maturity in LC should be linked to the notion of *understanding and philosophy*. Figure 5-3 in addition shows example quotes from the LC specialists and academics in each of the topic areas. The next section discusses each of these four topic areas.

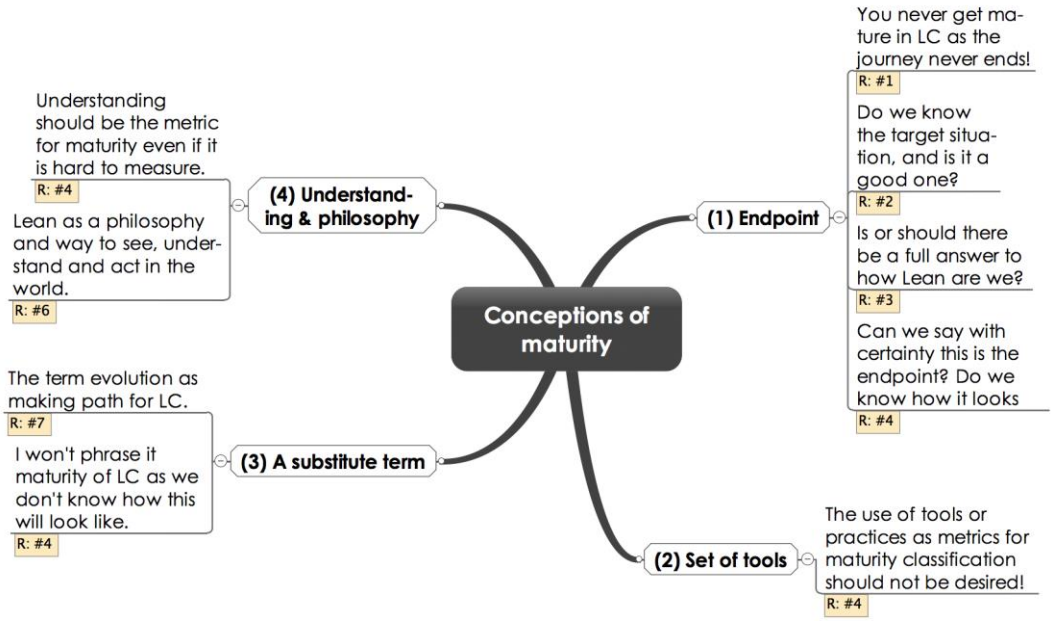


Figure 5-3: Mind Map-Conceptions of maturity

Topic 1: Endpoint

The first major topic, ***'endpoint'***, illustrates that participant #1, #2, #3 and #4 associate the notion of maturity with a defined endpoint by using phrases like *"end of the journey", "the target", "target situation"* and *"full answer"*. This raises the issue of the usefulness of knowing or having such an endpoint in mind. These conceptions of the specialists and academics imply a lack of knowledge considering: what is 'mature' in a LC context? Answering this introduces corollary questions: Is it useful to know what maturity in LC is? If yes, what does LC maturity look like? How would an organisation become more mature in LC? Is there really an identifiable endpoint in LC maturity? How Lean are we? From the large body of published work on maturity and maturity-related concepts, in the form of models and assessment tools, the contrary argument must be: how can it not be good to know what maturity in LC looks like? Additionally, we must refer to existing concepts of Lean maturity in other industries, such as aerospace, which are usefully applied to practice. However, these findings emphasise the gap in our knowledge as to what maturity in LC looks like. This is despite the fact that there has been work undertaken regarding the maturity in LC from industry policy makers such as the European Construction Institute (ECI) and the Highways Agency (HA) in the UK. The latter of these two organisations re-

contextualised the LESAT-Model to the HALMAT, with the aim being to determine the Leanness of the HA supply chain in relation to meet the objectives and goals of the HA (Highways Agency, 2010). Important to note is that the HALMAT is difficult to generalise because it is very specific for the HA.

Given the emphasis by authors such as Caffyn (1999) on the importance of approaches to assess the organisational transformation and further consider the fact that implementing LC is a transformation (in addition often stated as a journey) of an organisation (Mossman, 2009, Sage *et al*., 2012, Zimina *et al*., 2012), the transformation further can be seen as the movement towards maturity. However, as maturity is conceptualised as the movement towards an ideal point (Hogan and Roberts, 2004), and an organisation is mature when it is perfectly conditioned to reach its objectives and goals continuously, in the real world it would be impossible to find a fully mature organisation (Andersen and Jessen, 2003). This suggests that, contrary to the view of some of the LC specialists and academics's, being mature does not imply a tangible endpoint. Rather, it is more appropriate perhaps to illustrate the 'endpoint' of being mature in LC as an idealised vision that one is constantly striving to achieve. However, it is argued that the vision of an ideal endpoint provides a clear direction towards maturity, although it will never actually be achieved completely (Andersen and Jessen, 2003, Rother, 2010). Hence being mature in LC can be seen as interchangeable with a vision and the goal of a Lean transformation within the organisation. The statement of participant #1 reflects this analogy: *"the Lean journey never ends and you don't get mature in LC"*.

Another analogy is appropriate and that is with the concept of human maturity. The human maturity process is a circle without an end: "regardless of where we go we will get new experience" (Sams, 1999, p. 7). So humans never stop learning and becoming more mature as they interact with their environment. As articulated by participant #2: *"Lean construction is still developing and could involve something else in the next five years!"* Additional comments from participant #2 made explicit the link between the concept of maturity in management and that of human maturity: *"we as humans recognise that the more we learn,*

the more we discover that we have to learn". So learning is an important process in relation to LC maturity. Yet all these views do not align with the current literature on the topic. This emphasises that there is currently no completely satisfying answer to the question *"how mature are we?"* which provides added impetus for this research and its investigation into the phenomenon LC maturity.

Topic 2: Set of tools

The second major topic derived was that maturity in LC can be classified by a ***'set of tools'***. This can be related to published PM MMs, such as the OPM3 and the Berkley (PM^2), where maturity is measured with best practices and tools derived from the PMBOK® (Cooke-Davies, 2004). Nevertheless, the counter-argument that the metrics for LC maturity should be based on a deeper understanding of the topic, rather than just the tools and practices, is a moot point which ought not to be overlooked. Hence it must be recognised that there is a need for research to explore which metrics or dimensions are more or less appropriate for LC and how LC can be conceptualised through these dimensions.

Topic 3: A substitute term

The third topic, the use of ***'a substitute term'***, was neatly articulated by participant #4, who stated: *"I wouldn't phrase it 'maturity' of LC"*. The theme was taken further by participant #7, who suggested using the term "*evolution*". Taking into account the existing terminology of Lean 'maturity' in an aerospace context (LESAT), the work of the policy makers regarding LC 'maturity' (HALMAT-UK Highways Agency and CIRIA) and the increased volume of work using the term 'maturity' in the academic literature raise questions as to the desirability of adopting any substitute term for the domain of LC.

Topic 4: Understanding and philosophy

The final topic relates to the level of ***'understanding'*** of LC and whether a LC ***'philosophy'*** is followed; though in the words of participant #4 this is something that is *"hard to measure"*.

5.2.7.3 Theme 2: Perception about maturity models - Attitudes towards Maturity Models

The second sub-theme in the thematic framework was attitudes towards MMs and this was further broken down into six major attitudinal areas, as shown in the Mind Map in Figure 5-4. These are: (1) MMs are a kind of target situation; (2) a MM for LC requires a distinctive focus; (3) scepticism; (4) MMs involve a standard structure; (5) MMs show the next level; and (6) value of MMs. The next section discusses each of these in turn.

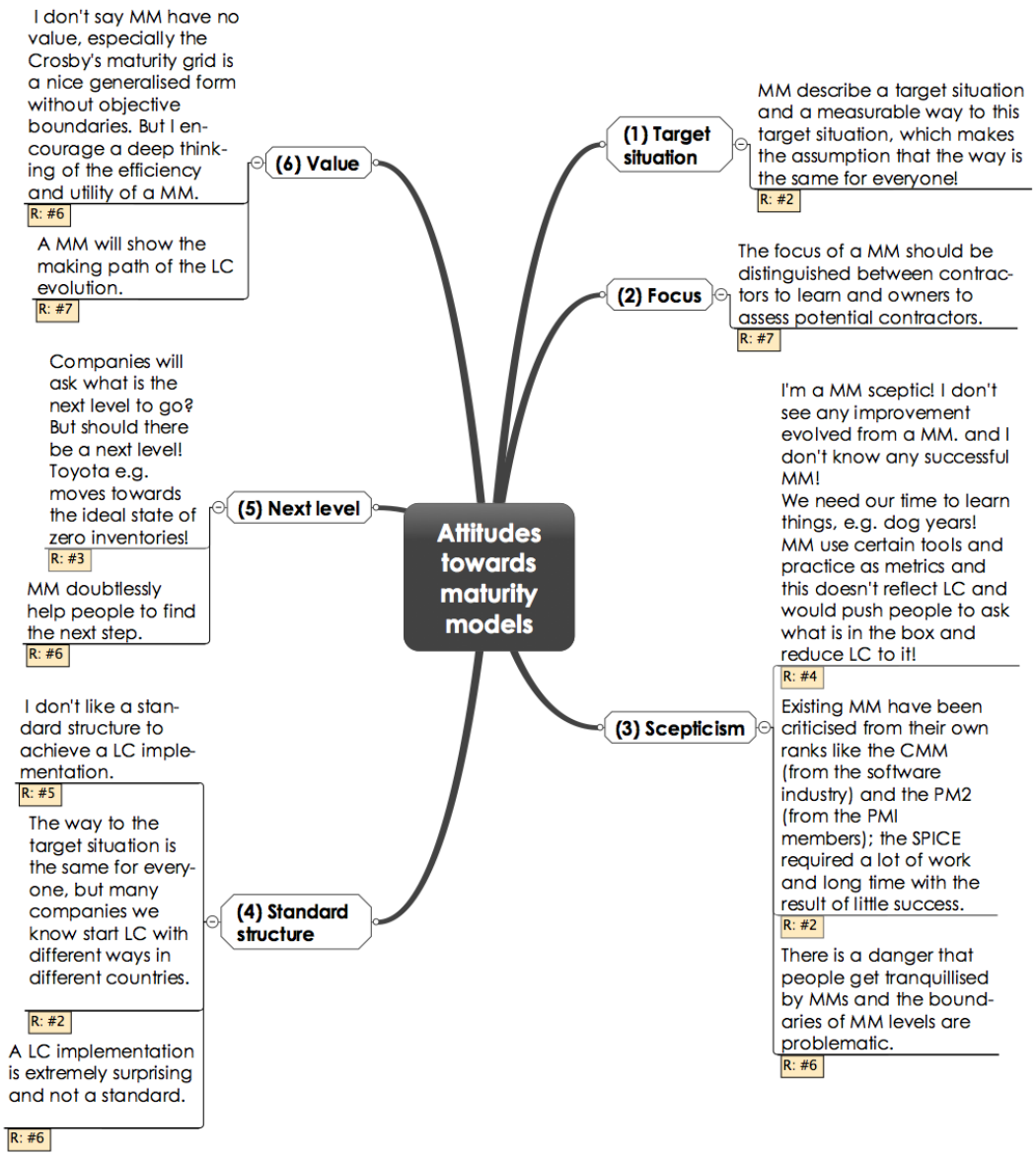


Figure 5-4: Attitudes towards maturity models

Attitudinal Area 1: Target situation

The first area of discussion sees MMs as "*a kind of **target situation** and a way to that, which will be measured through the model"* (#2). It was further implied that the route to this target situation in a MM is the same for everyone. This differs from the extant literature, for instance the UK Government report (OGC, 2010a), which argues that a MM supports organisations to implement their own unique change or improvement strategy in a managed way. Furthermore, MMs like the CMMI or the OPM3 do not prescribe how to improve specific areas; rather, they point out the priority for improvement actions which may be different for each individual (Project Management Institute, 2003, CMMI Product Team, 2010).

Attitudinal Area 2: Focus

One aspect of the data concerned what would be the ***'focus'*** of a possible MM in the context of LC. For example it was argued by participant #7 that "*the focus of a MM within Lean construction should be distinguished"*. The sense here is that it must be clear if the focus is on the clients using it as a form of assessment tool to evaluate contractors, or used by contractors as an improvement tool within their organisations. It is worth noting in this respect that several MMs in other industries are used in both situations.

Attitudinal Area 3: Scepticism

Some attitudes revealed ***'scepticism'*** towards MMs. For instance participant #4 questioned the existence of MM-driven improvement, stating that he "*never saw a successful MM"*. Linked to this was the opinion that the use of certain tools and practices within such MMs could lead to LC being reduced to a toolbox consisting of certain tools and practices. Participant #2 added to this scepticism, describing how "*existing MMs have been criticised"*, with the SPICE model gaining limited traction in the industry. Another point made by participant #6 was that MMs could "*tranquillise"* people, leading to complacency and a lack of focus. This scepticism must be addressed. We find in the PM literature on MMs, e.g. OPM3 and PM^2, the use of certain tools and best practice being the basis of the PMBOK®

(Richardson, 2010). In comparison to the domain of PM there is no combined body of knowledge in LC. The criticism of MMs – as for instance the CMM and PM^2 from their own supporters in the software industry, or the PMI members; and in addition the criticism of the SPICE model pointed out from participant #4 – has resulted in limited use by the industry and therefore in moderate success. Furthermore, the boundaries of MMs and their definition are seen as critical.

So it is clear that a concept which is discussed in many industries does not escape criticism. However, much of the literature on MMs criticises their flexibility, in particular if organisations undertake unusual projects at the operational level (Kujala and Artto, 2000). Furthermore, Kujala and Artto argue that "the main weakness of many MMs is the lack of a focus on the strategic management of project-based organisations" (2000, p. 47). And, as pointed out earlier, the literature involves criticism addressed to the CMMI (Bach, 1994, Herbsleb *et al*., 1997, Hartman and Skulmoski, 1998). However, there are in addition studies which counter the criticisms, for instance through the work of Curtis (1994).

Attitudinal Area 4: Standard structure

The attitude that MMs would deliver an undesired ***'standard structure'*** for a LC implementation was articulated by participant #5 who said *"I don't like a standard structure to achieve a LC implementation"*. This view was countered by participant #2 and #6 regarding the implementation process of LC. Participant #2 stated that "*many companies start with LPS and companies in the UK or Brazil start with different things"* and participant #6 concurred, pointing out that they found the "*implementation of [LC] extremely surprising and not a standard"*. However, it is worth considering more closely what kind of standard an MM would establish. MMs provide a common and shared language and understanding (Klimko, 2001) i.e. in PM or LC. Although somewhat dependent on the specific MM, in general most MMs are non-prescriptive.

Attitudinal Area 5: Next level

Attitudes about a progression measured in maturity levels (***'next level'***) were made in the context of the LPS; with participant #3 illustrating the point by stating: "*I know companies will ask what the next level to go to is, but should there be a next level! Since Toyota e.g. moves towards the ideal state of zero inventories*." Hence practitioners are interested regarding information about the next steps to undertake within a LC implementation; however a moot point is whether there is a next step which is the same for all. This links to the earlier discussion of a target situation (Attitudinal Area: 1). Emphasising the power of MMs it was in addition stated (#6) that MMs would undoubtedly help people to identify the next step. However, the scepticism about the ability to clearly identify boundaries, discussed in the previous section, stresses the crucial task of defining maturity levels.

Attitudinal Area 6: Value

An attitude about the concept of maturity in a MM for LC was linked to ***'value'***, as participant #7 said that "*a MM will show the path of the LC evolution"*. Furthermore, participant #6 pointed out that MMs have some value whilst he suggested Crosby's QMMG (Crosby, 1979) as something that delivered positive and general boundaries within MMs.

5.2.8 Group interview: Summary

The purpose of the group interview was to utilise a pre-test of the research and its underlying ideas. As a result, the feasibility and importance of the research was emphasised by leading specialists and academics in the field of LC. Hence the understanding of the investigation and the topic was enhanced. Consequently, new ideas in terms of the planned methodology and the focus of further investigations such as a likely focus and application of any LC maturity development emerged. Moreover, a contribution towards the completion of the first and second objectives of this study was achieved.

Moreover, it was found that the perceptions regarding the term 'maturity' of the LC specialists and academics are diverse and could lead to potential misconceptions and concerns. Yet maturity was in addition generally perceived as providing the path for LC

evolution. It was further revealed that metrics such as tools are regarded as inappropriate for assessing maturity in LC. Certainly it was revealed that the voiced concerns about the concept of maturity being applicable are at odds with current literature.

Some potential pitfalls that need to be avoided were revealed, for instance the development of inappropriate dimensions which leads to the striving for greater maturity in LC to work against Lean's underpinning philosophy. Additionally, the results stress that a MM and the concept of maturity for LC must capture the behaviour, understanding and outcomes of a typical organisation which is in transition from traditional to LC in order to be suitable for more than one entity. The results in addition highlight that being mature is not an endpoint which will be achieved by everyone; rather it is a desired target that is forever moving.

5.3 Individual interviews: Findings

The individual interviews are conducted to enhance the depth and breadth of knowledge about the phenomenon of LC maturity, as it is logically presumed that LC practitioners experienced the phenomenon over time. Furthermore, the interviews contribute towards the achieving of the second and third objectives of this research. Such interviews are seen as particularly useful in the construction industry according to Shehu and Akintoye (2010). According to the sample presented in section 4.5.3.1, 11 LC practitioners from three continents and six different countries were selected and interviewed to identify: attributes of LC maturity and moreover the level of acceptance of maturity and MMs in respect to LC, as well as potential areas for appropriate dimensions of LC maturity. Moreover, the interviews enhance the understanding of the phenomenon.

Each interview lasted approximately forty-five minutes and was tape-recorded and transcribed afterwards. Following the key steps of the Framework Method© (see section 4.7.2.1) the collected data have been analysed by following the steps highlighted in blue within Figure 5-5, p. 161.

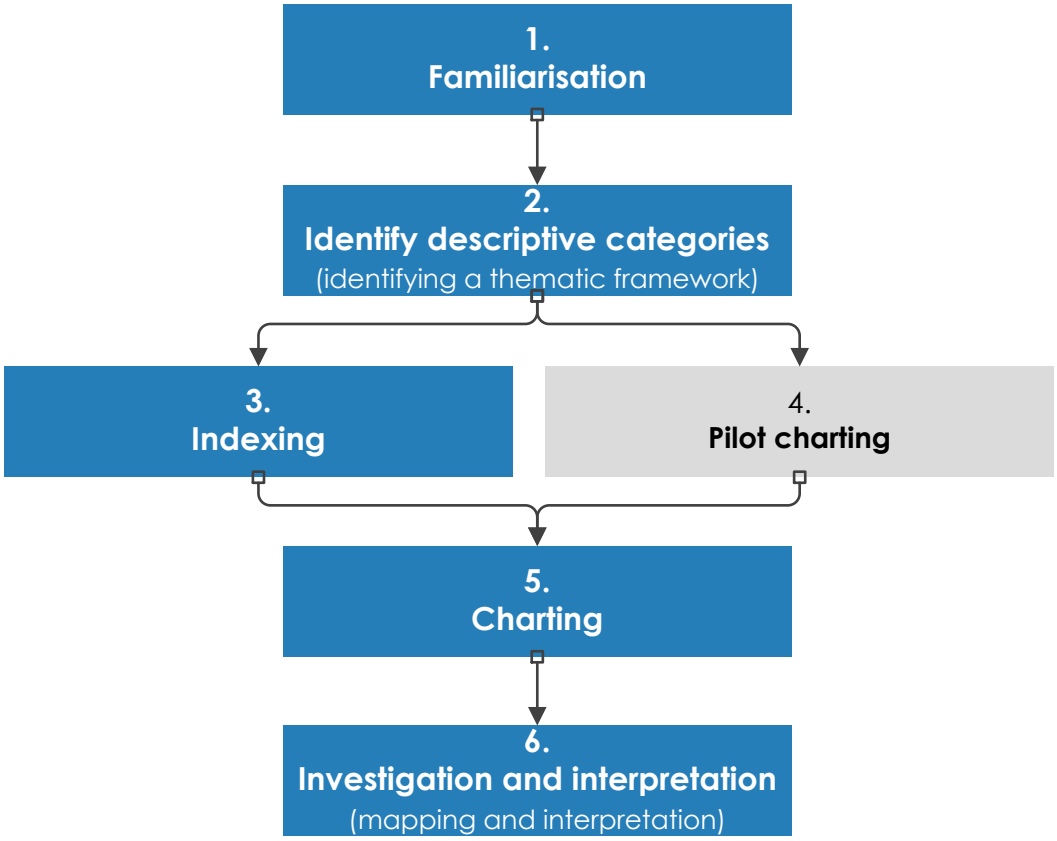


Figure 5-5: Key steps of the Framework Method©: Individual interviews

Before the result of each step is presented, the next section provides an overview of the participants' profiles.

5.3.1 Individual interviews: Participants' profiles

As the interviews involved 11 LC Practitioners (LPs) (see section 4.5.3.1 for more details of the sample), prior to the analysis they were classified as in Table 5-5 below.

Table 5-5: LP Classification: Individual interviews

Participant	Continent	Country	Practising LC	Gender	Current role	Total work experience
OLP#01	Europe	Germany	3-9 years	Female	Operational LP	10-19 years
CLP#02	Europe	United Kingdom	10-19 years	Male	Consultative LP	30-39 years
OLP#03	Europe	Spain	1-2 years	Male	Operational LP	20-29 years
OLP#04	South America	Chile	3-9 years	Female	Operational LP	1-9 years
OLP#05	North America	USA	10-19 years	Male	Operational LP	40-49 years
CLP#06	North America	USA	1-2 years	Female	Consultative LP	10-19 years
CLP#07	North America	USA	10-19 years	Male	Consultative LP	30-39 years
CLP#08	Europe	Germany	3-9 years	Male	Consultative LP	30-39 years
CLP#09	South America	Peru	10-19 years	Male	Consultative LP	10-19 years
OLP#10	North America	USA	3-9 years	Male	Operational LP	10-19 years
OLP#11	Europe	United Kingdom	3-9 years	Female	Operational LP	10-19 years

5.3.2 First step: Familiarisation

The familiarisation with the interview data involved several readings of the produced transcripts (an example can be found in APPENDIX D) and additional listening to the recorded conversations of all 11 interviews. As a result, a comprehensive familiarisation with the range and depth of the interview data was achieved.

5.3.3 Second step: Identify descriptive categories (thematic framework)

Being familiar with the data, the researcher identified a number of sub-themes and themes through note-taking in the first step. As a result, a list has been developed including the initial identified thematic framework with sub-themes and themes. This conceptual thematic framework is illustrated in Table 5-6 below.

Table 5-6: Conceptual thematic framework: Individual interviews

Conceptual thematic framework for the individual interview data
1 Maturity
1.1 Understanding of Maturity
1.2 Suitability of this term within LC
1.3 Understanding of LC maturity
1.4 Reason for not using this term within LC
1.5 Reason for using this term within LC
2 LC Maturity Framework
2.01 Potential application
2.02 Usefulness
2.03 Focus
2.04 Importance
2.05 Maturity assessment
2.06 Implementation
2.07 Value
2.08 Outcome
2.09 Output
2.10 Who are the users
3 Dimensions of LC Maturity
3.1 Indicators
3.2 Immaturity
4 Potential support for this research
4.1 Development of any LC Maturity Framework
4.2 Continuous improvement
4.3 Other issues

5.3.4 Third step: Indexing

Due to the amount of data collected, it was decided to use indexing, which is described by Ritchie *et al*. (2003b) as categorising and fitting (applying) the conceptual thematic framework to the data. The indexing was carried out electronically to use the advantages offered by the earlier identified CAQDAS - NVivo. The sequence of the indexing can be seen in form of screenshots in APPENDIX E. The process of indexing further led to a refinement of the sub-themes and themes and therefore to a finalised thematic framework, shown in Table 5-7 below.

Table 5-7: Finalised thematic framework: Individual interviews

Finalised thematic framework: Individual interviews
1 Maturity
1.1 Understanding of Maturity
1.2 Suitability of this term within LC
1.3 Understanding of LC maturity
1.4 Reason for not using this term within LC
1.5 Reason for using this term within LC
2 LC Maturity Framework
2.1 Potential application
2.2 Usefulness
2.3 Focus
2.4 Importance
2.5 Maturity assessment
2.6 Implementation
2.7 Value
2.8 Who are the users
3 Dimensions of LC Maturity
3.1 Customer focus
3.2 Thinking
3.3 Processes & tools
3.4 Expertise
3.5 Culture & behaviour
3.6 Continuous improvement
3.7 Business results
3.8 Other issues
4 Potential support for this research
4.1 Development of any LC Maturity Framework
4.2 Other issues

5.3.5 Fourth step: Pilot charting

This step was not relevant because indexing was carried out.

5.3.6 Fifth step: Charting

The charting process was also carried out with the CAQDAS - NVivo. Hence the indexed data was charted as a condensed summary for each theme and each LP for all related sub-

themes. The sequence of this process utilised within NVivo is further illustrated within APPENDIX E. As a result, four thematic framework matrixes for each theme were created (an example can be found in APPENDIX F).

5.3.7 Sixth step: Investigation and interpretation

Within the 11 interviews four major themes and 24 associated sub-themes were discussed (see Table 5-8, p. 166). This table provides an overview that represents the thematic framework with all themes and associated sub-themes, together with the number of the established passages from the interview transcripts. Furthermore, the table shows how many of the interviewees contributed within this theme or sub-theme.

Table 5-8: Overview of the established passages and contributors for the thematic framework

Theme and Sub-themes	No. of established passages	No. of contributors
1. Maturity	**77**	**11**
1.1 Understanding of Maturity	13	7
1.2 Suitability of this term within LC	23	11
1.3 Understanding of LC maturity	24	9
1.4 Reason for not using this term within LC	6	4
1.5 Reason for using this term within LC	11	4
2 LC Maturity Framework	**230**	**11**
2.1 Potential application	24	8
2.2 Usefulness	36	10
2.3 Focus	42	11
2.4 Importance	27	9
2.5 Maturity assessment	82	10
2.6 Implementation	4	2
2.7 Value	8	5
2.8 Who are the users	7	3
3 Dimensions of LC Maturity	**139**	**11**
3.1 Customer focus	13	4
3.2 Thinking	9	3
3.3 Processes & tools	19	6
3.4 Expertise	24	8
3.5 Culture & behaviour	49	10
3.6 Continuous improvement	4	2
3.7 Business results	8	3
3.8 Other issues	13	6
4 Potential support for this research	**49**	**8**
4.1 Development of any LC Maturity Framework	28	7
4.2 Other issues	21	5

A total of 495 related passages were established and referenced from the interview transcripts to the thematic framework. As illustrated in Table 5-8 the number of contributors is evenly distributed, with an exception for some specific sub-themes. Only the fourth theme ***potential support for this research*** was indexed with the responses provided from only eight LPs. However, the interviewees had different classifications regarding their current role, years of experience and the continent of practice. So clusters in terms of the number of related passages identified from each interviewee have been developed. These are illustrated in Table 5-9.

Table 5-9: Profile of the established passages within the thematic framework

	1 Maturity	2 LC Maturity Framework	3 Dimensions of LC Maturity	4 Potential support for this research	Total
Operational LP	50	163	97	42	352
Consultative LP	27	67	42	7	143
10-19 years' Experiences in LC	42	100	54	36	232
3-9 years' Experience in LC	27	111	73	11	222
1-2 years Experience in LC	8	19	12	2	41
Europe	33	85	55	10	183
North America	37	100	51	36	224
South America	7	45	33	3	88
Overall	77	230	139	49	495

It can be seen from the table above that the discussions with the OLP set produced 352 related passages, significantly more than double the amount of the established passages than the discussions with the CLPs. It is further apparent from this table that a few passages (41) were established from the LPs who was classified with 1-2 years' experience in LC. This may be caused by the fact that only two LPs (both with 2 years experience) fall into this classification and that in-depth experience in LC was of greatest importance for the sample. However, it is obvious from the table above that related passages surged with the years of experience. Predominantly about half of the total related passages were generated from the discussion with the LPs from the North American countries and the European countries. Again it must be considered here that only two LPs from the South American countries participated within these 11 interviews, whilst the other continents had five LPs from Europe and four from North America – more than twice the number of other participants.

Within the discussion of the second theme, ***LC Maturity Framework*** emerged as the largest contribution with 230 associated passages. This key theme was not only the most dominant theme in the summary in terms of related passages but in addition within all classification sets. With 139 established passages the discussion about the third key theme ***Dimensions of LC Maturity*** produced the second largest amount of related passages. This is followed by the established passages in the first theme ***Maturity*** (77), and from the discussion about the fourth theme ***Potential support for this research*** with 49 passages.

Since the most significant differences within the related passages have been identified within the classification set OLP and CLP, this set of classifications will be elaborated on in more detail within each of the four themes. Further, each case will refer to OLP#number for each operational LP case and CLP#number for each consultative LP case.

5.3.7.1 Theme: 1. Maturity

The discussion within the theme ***Maturity*** concentrated on the expressed meanings in terms of maturity in general as well as in terms of LC, and produced 77 related passages which involved the contribution of all 11 interviewees. This theme was further broken down into five sub-themes, as illustrated in the thematic model in Figure 5-6. The thematic profile in Table 5-10, p. 169 elaborates further the differences of the responses amongst the sub-themes and in terms of the classification set (OLP and CLP).

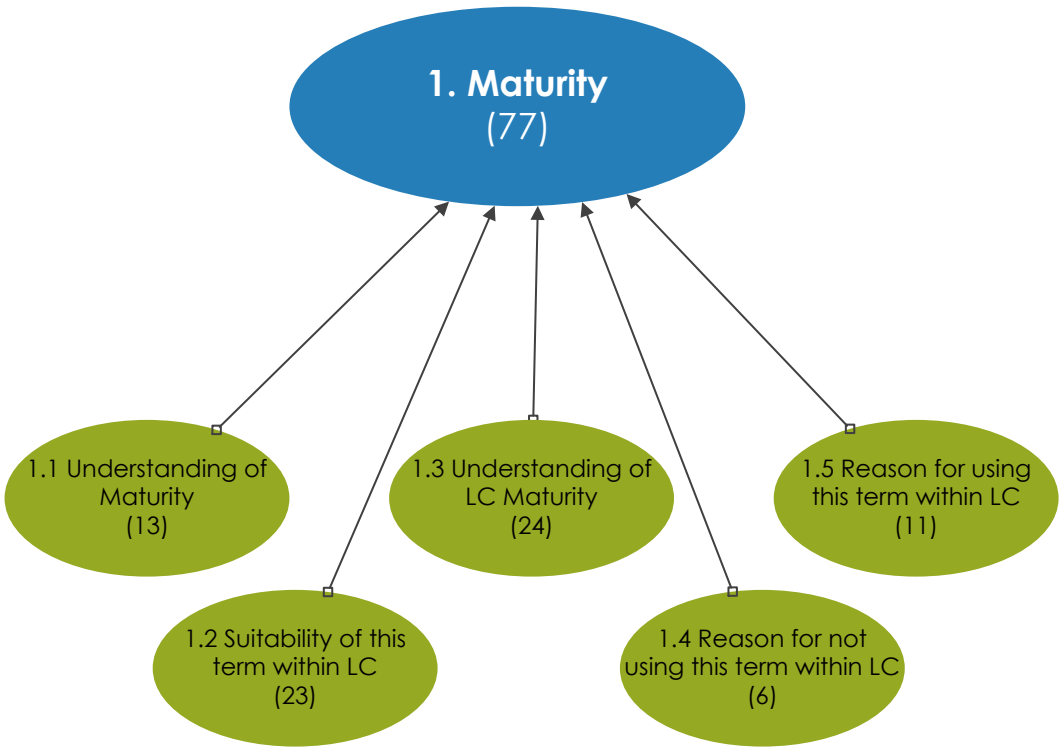


Figure 5-6: Thematic model 1. Maturity

Table 5-10: Thematic profile theme 1. Maturity

	Operational LP	Consultative LP	Total
1.1 Understanding of Maturity	7	6	13
1.2 Suitability of this term within LC	14	9	23
1.3 Understanding of LC Maturity	18	6	24
1.4 Reason for not using this term within LC	2	4	6
1.5 Reason for using this term within LC	9	2	11
Overall	50	27	77

1.1 Understanding of Maturity

It is apparent from the table above that the ***understanding of maturity*** was frequently mentioned by both the OLP set and the CLP set (13 passages). However, there was a significant difference about the understanding of maturity within the CLP set. This becomes clear when CLP#02 stated *"the idea with maturity is there is some end"* and contrastingly CLP#6 associated maturity with nonstop learning when it was stated that *"maturity could relate to … you're never really done with learning."* Moreover, it was evident that OLP#11 and participant #05 connected maturity with levels and models as well as the thinking.

1.2 Suitability of this term within LC

The ***suitability of this term within LC*** was a more frequently discussed sub-theme (23 passages) which was predominantly positively emphasised from the OLP set with 14 related passages. OLP#05 for instance stated *"I like maturity, because it is much more related to behaviour"* and OLP#04 unquestionably already connected maturity with LC when it was said it *"has to do how well the organisation is mastering LC"*. In addition, CLP#09 underlined this suitability and CLP#07 further stressed:

> *We have a maturity model for … the LPS… and at the same time we have to explain it on a regular basis because people in the industry, they don't have a sense of what a maturity model is*.

In addition, CLP#02 expressed his concerns in terms of the problematic, that *"we have no idea what a mature LC company will be like"*.

1.3 Understanding of LC Maturity

The ***understanding of LC maturity*** was again noted predominantly by the OLP set (18 passages). OLPs #01, #03, #10 and #11 pointed out that LC maturity is about where you are on your Lean journey or Lean implementation within your organisation. OLPs #11, #04 and #10 added to this the immigration of the Lean philosophy together with the Lean principles or concepts throughout the organisation. There was in addition a clear association of LC maturity with processes, culture, training and teaching people how to learn and improve, problem solving, Lean techniques and other issues stated by OLP#11. A more detailed understanding was given by OLP#05, who described LC maturity in several levels and through his experience of his own maturity tool for LC projects; these are: behaviour, adequate thinking (systemic and scientific thinking), the five elements of Lean thinking, constancy of purpose, processes and tools.

The understanding of LC maturity was in addition discussed by the CLP set (six passages) and a different perspective was voiced by CLP#07 when he pointed out he liked the way of thinking about LC maturity through the Shingo Prize criteria, which involved – particularly in the 2008 version – the following levels of Lean maturity: *"tool driven"*, *"system driven"* and *"principle driven"*. Another view of LC maturity was pointed out by CLP#02 when he stated *"I would see in a mature Lean organisation a systemic continuous improvement."*

1.4 Reason for not using this term within LC

A small number of passages (six) were established from some statements that involved ***reasons for not using this term within LC***. This was mainly enforced by the CLP set in which CLP#02 stated *"There is maybe a problem with maturity that it has an end and LC is a journey without end."* Further, CLP#06 pointed out that maturity involves degradations *"because you are always going to have to say people are infantile, which they wouldn't like to be called"*.

1.5 Reason for using this term within LC

A number of passages (11) related to ***reasons for using this term within LC*** and these passages were predominantly produced from the statements of the OLP set in which OLP#11 pointed out that it makes sense to use the term maturity in regard to a maturity framework for LC *"as you could say how mature you are on your Lean journey"*. This was in addition noted by CLP#02 who mentioned that *"maturity is maybe the best word"* but it would make sense to make sure that there is no better alternative in a thesaurus.

5.3.7.2 Theme: 2. LC maturity framework

The second theme discussed ***LC maturity framework*** and produced 230 related passages – the highest number of passages. This was mainly generated by the OLP set with 163 passages, with the CLP set having considerably less at 77 passages. This key theme was then broken down into eight sub-themes (see Figure 5-7 and Table 5-11, p. 172) from which ***maturity assessment*** is the one that – with 82 passages – was the most frequently mentioned sub-theme before the sub-theme ***focus*** (42 passages) and the ***usefulness*** (36 passages) of any LC maturity framework. The ***implementation*** of any LC maturity framework was, with four related passages, the least discussed sub-theme.

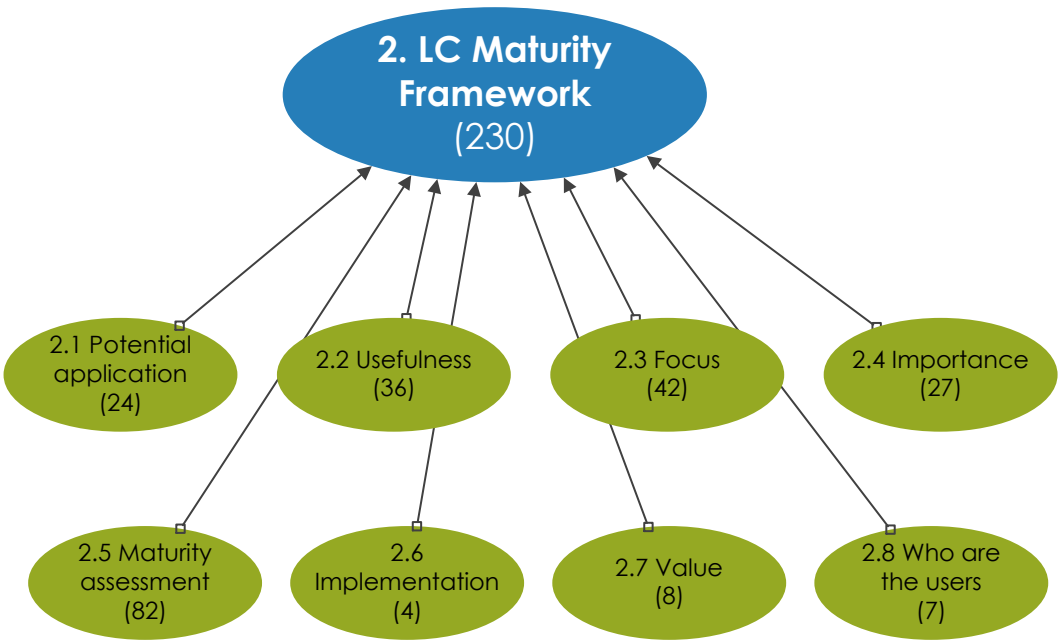


Figure 5-7: Thematic model 2. LC Maturity Framework

Table 5-11: Thematic profile theme 2. LC Maturity Framework

	Operational LP	Consultative LP	Total
2.1 Potential application	18	6	24
2.2 Usefulness	23	13	36
2.3 Focus	31	11	42
2.4 Importance	18	9	27
2.5 Maturity assessment	58	24	82
2.6 Implementation	4	0	4
2.7 Value	5	3	8
2.8 Who are the users	6	1	7
Overall	163	67	230

2.1 Potential application

The importance of a ***potential application*** of any LC maturity framework was largely mentioned by the OLP set (18 passages). Within this OLP#01 stated that a LC maturity framework *"could be something that is applied before LC implementation takes place as a preparation stage."*

Furthermore, this participant pointed out that it could be applied to identify weak areas that need particular attention in order to be able to improve. OLPs #01, #04, #10 and #11 saw the monitoring and measuring of where you are on your Lean journey – including the identification of areas for further improvement – as a potential application. In addition, OLP#04 pointed out that the monitoring could also be applied to an owner organisation and their portfolio of projects. This view was shared by CLP#02, who argued that owners should only measure themselves to see how good they are. Interestingly, OLP#05 stated that:

> *The maturity model can be applied to all kinds of companies … and a Lean assessment tool can be applied to all situations because it focuses on the philosophy and on the thinking.*

A similar but limited meaning was identified by one consultative interview when CLP#02 mentioned that a potential application would be for big projects that run for years but it is much more limited for everyday projects.

2.2 Usefulness

The ***usefulness*** of any LC maturity framework was noted by both the CLP set (13 passages) and the OLP set (23 passages). Both generally acknowledged that any LC maturity framework would be very useful. This was further justified by CLPs #02 and #08 through the benefits of an evaluation of their own development in terms of LC as it is for instance beneficial to get an idea of where you are and if you are getting better or not. This was in addition identified by OLPs #11, #04 and #10 and further detailed by OLP#10 who said *"If you don't have any measurement you can measure against then you running into the fog or into nowhere."*

Further, OLP#04 mentioned in the interview *"if you don't measure where are you at this point, it's very difficult and very hard for an organisation to improve"*. In addition, OLP#04 sees this as part of the CI cycle. A similar justification of the usefulness was provided by CLP#09 when he said that without such a framework *"maybe you can be thinking that you are applying things that you are not really"*.

2.3 Focus

The discussions in terms of a ***focus*** of any LC maturity framework produced the second largest amount of related passages (42). This was predominantly discussed by the OLP set, and so OLPs #11, #04, and #05 acknowledged that a focus on the temporary project organisation involving in addition the embedding of the owner perspective is desired but does not exclude the adaptation to all kind of organisations. Additionally, OLP#01 emphasised that:

> *In a project organisation there are the key players, and they come up with value and useful information ... if it would*

focus on only one, a very important part of the project would have been left out.

This was also identified by CLP#07 who argued that the focus certainly has to be on the whole project organisation. However, slightly contrasting, CLPs #02 and #06 mentioned that there should not be a focus as all architects, owners and contractors need to see how good/mature they are. Further, CLP#06 said that *"focusing limits people ... a framework for everyone has no limitation"*. However, a problematic issue was further pointed out by CLP#02 and OLP#03 who mentioned that a focus on project organisations is challenging because of the limited time of small and everyday projects.

2.4 Importance

A number of passages (27) related to issues that have particular ***importance*** within any LC maturity framework. This was noted by both the OLP set (18 passages) and the CLP set (six passages). Within the interview OLP#11 elaborated on the importance of the fact that Lean means different things to different organisations and the key point of *"having that flexibility that enables the organisation to define what Lean means to them"*; further, it was mentioned that the criteria to measure have to be chosen carefully and should be not too prescriptive. Another important issue mentioned within the interviews of CLP#02 and OLP#04 is that owners should not use such a framework to assess the contractors or ask them about their results as they would be pushed to look good and start to deceive themselves, which would not help anyone. CLP#09 emphasised the importance of having *"less things on which the model concentrates… just a few powerful things."*

Within the interview with CLP#07 it was elaborated that it is important to identify if an organisation is using tools in a Lean or non-Lean way because *"adapting another tool makes you not Lean at all"*. A further important issue of any LC maturity framework was pointed out within the discussion of OLP#05, that it has to be systemic and focus on the philosophy, thinking and the input which is *"customer value, processes, tools, systemic- and scientific-thinking and constancy of purpose."*

Moreover, it is argued by OLP#11 that the important issue in maturity is *"the fact that people can see change"*.

2.5 Maturity assessment

Maturity assessment was the most prominent sub-theme, with 82 related passages. Predominantly, this theme was discussed by the OLP set (58 passages) but also by the CLP set (24 passages). In all discussions a general agreement was established that LC maturity can be recognised. Further, with the one exception of CLP#02 who said that he is not sure if it can be measured, it was commonly agreed that LC maturity can actually be measured. This assessment of LC maturity was further elaborated within the interviews of both the OLP set and the CLP set. Within the latter, CLP#09 emphasised that measuring the maturity of a person involves subjective and objective things and *"there is no problem about using subjectiveness when you have the right people – they are looking at that"*

So a LC maturity assessment means to him *"being able to put into a system a subjective way of look at things"*. Other responses to this included CLP#06 who expected a matrix or a kind of a 360 degree review that allows a broader look at a LC maturity assessment because people have different perceptions and often think they are Lean until they see a mature way of LC. CLP#07 explained in the interview how they assess with their LPS maturity framework:

> *We looked at key behaviours, for us we said people in a project organisation should be able to observe the behaviours, and we described 30 or something behaviours regarding LPS … a tool that people doing the assessment of maturity are learning when they are doing it and they put themselves into action to do better…but can they get outstanding behaviour? I don't think this alone would describe what outstanding behaviour is, that's why I would look to something like the Shingo Prize criteria as a way*.

A different viewpoint to this was identified within the interview of CLP#08 when he stated *"you have to be very careful to ask the right questions that you are able to measure it [LC maturity]"*.

This was in addition restated from the side of the OLP set when OLP#01 identified that maturity questions must be answered *"in a group that each one hears what the other one has [to say], because at the end of the day we all have to work together"*. However, the assessment in general is seen as a challenge by OLP#11, but:

> *There are maybe certain tangible things that you expect to see in a more mature organisation and if you spoke to ten people and you got a consistent message from them that would identify really good communication, and vision and value is being communicated to people*.

Another important point within LC maturity was mentioned in the interview of OLP#10 when he stated that it is important to have the right measurements. Moreover, OLP#04 stated that *"it is easier to measure how you are applying tools rather than how Lean you are…it is important to have one team, one standard"* to assess LC maturity through interviewing people, reviewing documents or doing a test with simple questions of the Lean concept; this will lead to good results.

A different viewpoint of the maturity assessment was identified by OLP#05 by emphasising that assessing LC maturity:

> *Assesses the ability of the company to deal systemically with customers – are they customer driven – so it is not just the process it is the domain that we talk about and your process is one domain…when I evaluate the tool what I do is to look is the tool aligned with the process… if this tool is creating synergy in the process*.

OLP#05 further elaborated that he measures LC maturity as the scientific thinking and the systemic thinking because this is the fundament. Another claim by OLP#05 is that this assessment is done through a conversation because of his experience. However, the main

thing for the participant was to assess and see the maturity in the customer treatment, if the project organisations have the True North indicator identified and if they have ways to measure how much they deviate. An example pointed out within this interview is:

> *If the customer value is not identified the maturity level is zero…you see this in construction with the design; the start of the designing without having a clear programme and no systemic way*.

2.6 Implementation

A number of passages (four) related to the ***implementation*** of any LC maturity framework and these passages were established within the discussions of OLP#01 and OLP#04. In explaining the implementation OLP#04 admitted that a measurement of behaviour is desirable but must take place in the organisation. According to OLP#01 any LC maturity framework must be implemented:

> *As fast as possible early in the project before all designers and contractors are chosen because you need the information of how mature you are as fast as possible to react…so it has to be done very early on in the project*.

2.7 Value

The ***value*** (eight passages) in terms of a LC maturity framework which was in particular noted within the interviews was identified from both the OLP set with five passages and the CLP set with three passages. For OLP#01 the value of a LC maturity framework is:

> *To have something to understand the level of maturity that the people have first of all … a maturity model will give you good background information, how you can apply the techniques and practice; I mean if the maturity model tells you this organisation is a zero, you have to take the information to implement LC*.

More generally, OLP#04 stated that *"I can see value in all of them [owner, contractor, and project] but in the project it will be more easy to measure, or to see what is happening."* The participants on the consultative side identified an increase in value from a MM which can be put in an organisation through the application of LC. In explaining the value CLP#06 admitted:

> *You can look at how is the company doing with Lean, how are the different divisions doing, how can they rank their improvement, how far have they come the last couple of years, are they putting things in place to continuously improve.*

This was equally addressed by CLP#02 when he stated *"having some sort of way in which companies can evaluate their own progress, as a whole and in the project level".*

2.8 Who are the users

Some passages (seven) have emerged concerning ***who are the users*** of such a LC maturity framework. This was mainly addressed by the OLP set (six passages); for instance there was some acknowledgement established within the discussions with the OLP set when some of them indicated that a defined team should be the user and not one person. OLP#01 identified the project manager as a critical and not appropriate user when he stated *"I don't think that the PM is in a position to answer questions in terms of how mature is the project."* The participant also explained that the people who use this framework for a project organisation have to implement it to get the expected outcome. In addition, CLP#02 identified the owner or clients only as a user when they want to assess their own organisation.

5.3.7.3 Theme: 3. Dimensions of LC maturity

The third theme ***dimensions of LC maturity*** was the second most prominent theme identified within the 11 interviews. The discussions within this theme produced 139 related passages in terms of dimensions for LC maturity that the participants identified. This theme was further broken down into nine sub-themes which also represent broad categories into

which the related passages that included dimensions for LC maturity have been sorted. The sub-themes and the thematic profile are illustrated in Figure 5-8 and Table 5-12.

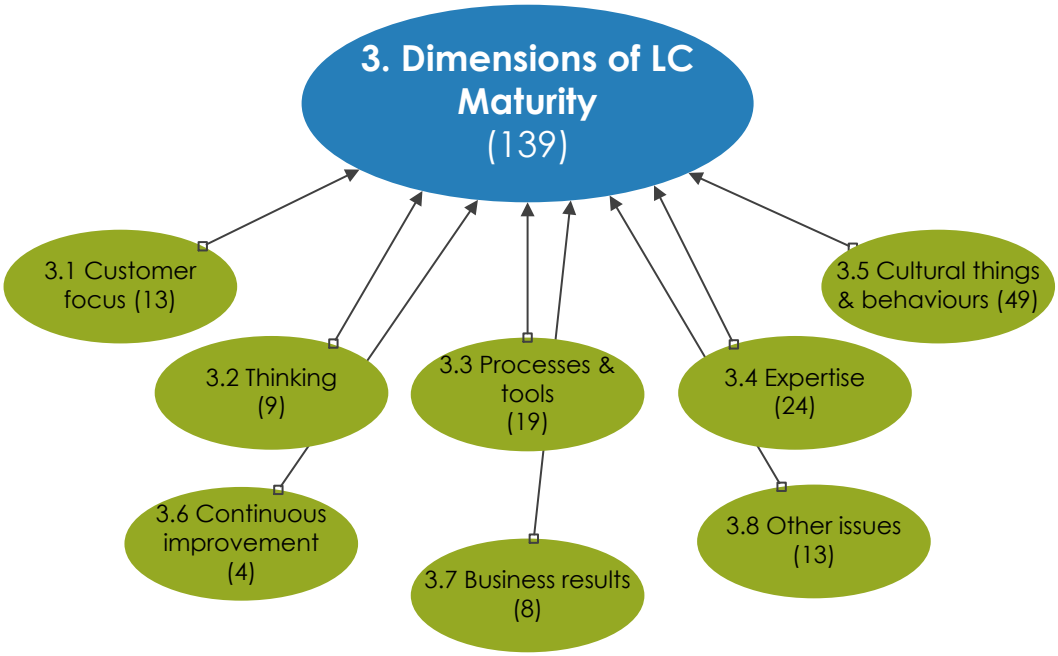


Figure 5-8: Thematic model 3. Dimensions of LC Maturity

Table 5-12: Thematic profile theme 3. LC Dimensions of LC Maturity

	Operational LP	Consultative LP	Total
3.1 Customer focus	10	3	13
3.2 Thinking	8	1	9
3.3 Processes & tools	14	5	19
3.4 Expertise	13	11	24
3.5 Culture & behaviour	33	16	49
3.6 Continuous improvement	2	2	4
3.7 Business results	7	1	8
3.8 Other issues	10	3	13
Overall	97	42	139

The related passages within this theme were mainly produced through the discussion of the OLP set (97 passages) but in addition from the CLP set (42 passages). However, in general all participants agreed on the existence of several dimensions of LC maturity that are inherent in both organisations and temporary organisations (projects) deploying LC. As a result, a total of 62 dimensions were recognised within the OLP passages. On the other side,

there were a total of 32 dimensions identified for LC maturity within the 42 CLP passages. Hence, including repetitions from several participants, a total of 94 LC maturity dimensions were mentioned within the interviews. Without ignoring the importance of these identified dimensions, these were grouped into sub-themes which can be seen as broad categories in which all dimensions for LC maturity can be captured.

3.1 Customer focus

The first category ***customer focus*** was predominantly established from the discussion with the OLP set (10 passages) but in addition the CLP set contributed to this (three passages). Within this category a significant dimension was mentioned by OLPs #04 and #05 and CLP#09 when they pointed out that the customer value must be monitored and hence the value and waste in the processes must be measured. OLP#05 highlighted that:

> *When I assess the maturity of a project or a company the first thing I ask is do you understand your customers' value? ... the second thing is do you know how to measure that? ... how much you are deviating from your customer value, we call that measurement of effectiveness ... don't even think about processes or streamline your process if you don't understand customer value ... and so how they measure value, because you have some qualitative value like collaboration and you have quantitative value like schedule or time.*

This was further emphasised by CLP#09 when he said that:

> *Another part of a maturity model should relate to the value and its mean [intention] to deliver and how much value they are being able to get, to offer to the client. I am actually not sure how to measure that but this is something I would like to measure and this is something I would like to see to find out: how mature a model is. So is or was value added?*

OLP#04 further highlighted that measuring the waste includes *"where is the waste, what kind of waste they have and what they are doing to improve"*. When putting together the

dimensions mentioned by CLP#08: *"the satisfaction of the customer"*, OLP#04: *"do they have client orientation"*, *"are they really thinking of what the client needs"*, "*how is the relationship with the client"* and *"are they doing the best work for the client or are they trying to do what is better for them",* and OLP#05: "*are they customer driven*", all these individual dimensions can be captured in one: the customer orientation.

3.2 Thinking

The importance of the ***thinking*** was again mainly discussed by the OLP set (eight passages) and only one CLP (one passage). As a result, three dimensions in regard to the thinking were identified. The first is process thinking, which was noted by OLP#01, the second is systemic thinking, which was emphasised by both OLP#05 and CLP#07. The latter utilised the Shingo Prize criteria (v. 2008) to express his opinion and thinking about systemic thinking as a dimension for LC maturity. OLP#05 explained that maturity is not just behaviour, *"but in addition the thinking because the thinking leads to behaviour"* and *"you have overlapping all the time the thinking with the other domains"*. OLP#05 further highlighted that:

> *It is the thinking because if you ask people, did you measure customer value? 'oh yeah I did' and then they show you the final user as the customer; I know they are thinking systemic … and see the customer in a systemic way, even when we talk about processes, do you see your processes in a systematic way - how do these processes communicate with each other.*

As a result, OLP#05 claimed that in addition the thinking between Lean Production and LC is the same and therefore he: *"looks to the systemic thinking…in three levels, (1) the holistic thinking, if they see the big picture; (2) the closer look thinking, the ability to identify problems, understand the current situation and practice continuous improvements through all the chain of customers; and (3) the system of customers, if they see a system of customers and internal-customer then we say an internal customer is everyone that makes you a request in a project - if he makes a request you can call him a customer".*

The third dimension of the thinking is scientific thinking, which was identified within the interview with CLP#07, who again utilised the Shingo Prize criteria (v. 2008) and their focus on the scientific thinking to emphasise the importance of this dimension. The extract in terms of scientific thinking within the interview with OLP#05 revealed that:

> *Scientific thinking is the ability to collect data to support the decision making or to support the creation of their processes and how they test their hypothesis and how they put countermeasures in place in order to make adjustments … I know for example how you measure collaboration. Normally you put a survey and then you score with points, so I ask them did you do that? 'No just talking about collaboration' - then your scientific thinking is very bad, you aren't collecting data properly.*

3.3 Processes & tools

A number of passages (19) related to dimensions in terms of ***processes & tools***. This was predominantly noted from the OLP set who provided various statements as for instance OLP#05 systemic processes, OLP#01 process-oriented work, OLP#11 different processes and standardised work, and OLP#04 with value stream maps for their processes – a significant emphasis that LC maturity can be indicated in processes. This was further highlighted when OLP#11 stated that a dimension for LC maturity is certainly in:

> *Companies' processes, in their operating processes. I think you would recognise aspects of Lean in both the processes themselves, what they are, and in addition the … level to which those processes are accepted within the business, so arguable a company manages standard ways of processes and working are an example, and standardised work to an extent. If those aren't accepted or compliant with all in the business and people see processes and think [they are] totally separate from real life, I think that's some measure of maturity in business and understanding of processes and the need of compliance and standard ways of working. So you can find maturity in what the processes are and how people*

> *accept them, and use them, and behave with them … maturity could be seen in all processes and it should reflect a Lean philosophy or a Lean approach or Lean thinking should be reflected, whether that is in your health and safety, your project management; that thinking and mentality can be embedded into all the processes and the way people approach those*.

The importance of processes as a dimension for LC maturity was in addition identified by CLP#09 who stated that maturity is about *"how much the process is aligned to really encourage Lean, how flexible this process is … if they know what to choose and to apply. So your process should be smart enough to have this decision what to apply and what not to apply but then … to be very rigorous about that process, so it's very tricky"*. This was in addition identified by OLP#05 when emphasising that processes are one domain in which you measure if the process is aligned with the identified customer value (value-driven processes) and if these processes have flow and produce what the customer wants, when he wants it, and the exact amount he wants of it (fourth element of Lean thinking – pull).

Consequently, in his response to processes OLP#05 emphasised similar to OLP#11 that both processes and tools must be aligned with Lean thinking, but he argued *"you gonna differentiate a process from a tool, primavera is a tool, software is a tool, and a process is a sequence of actions"*. According to CLP#07 if tools are actually used in a Lean way, this should be a dimension of LC maturity. A slightly different viewpoint was added to this by CLP#06 who stated *"I think the variety of tools is a way you could identify how people are doing things"*. Additionally, OLP#04 argued that less variation of the PPC within the LPS was a dimension for the maturity. OLP#05 further emphasised that he avoids assessing the tool itself *"but if this tool is creating synergy in the process and in values that's assessment that I do"*. Hence tools not in themselves but in terms of how they are used and aligned with Lean thinking and customer value or creating synergy in the process are a noteworthy dimension of LC maturity.

3.4 Expertise

The importance of having an ***expertise*** in LC was frequently mentioned by both the OLP set (13 passages) and the CLP set (11 passages). Most commonly it was elaborated that the knowledge about Lean is a dimension of LC maturity, as for instance by CLPs #08 and #09, and OLPs #04 and #05. For example, OLP#04 explained that you want that all know the Lean concepts, as for instance:

> *My company was really lacking knowing the Lean concepts, like for everyone, like for workers to know or recognise waste ... my company in Chile was starting with Lean ... pretty much LPS ... that was their first step; they were not that mature in the sense of really knowing and applying Lean concepts on a daily basis*.

According to OLP#05 is the knowledge of the five elements of Lean thinking: (1) identify customer value, (2) value, (3) flow, (4) pull and without the (5) perfection, because it is more systemic to see CI as a domain. Further, this participant pointed out that people use an A3 report and do not understand the background of it; hence people often have just a piece of paper which is meaningless. OLP#05 considers the A3 report while asking: what is your value stream map? What is your process map? Where are your observations? Because *"there is a lot of preparation before you create an A3 report and people just don't understand that"*. As such, the participants believed that knowledge is an important dimension within LC maturity.

CLP#02 highlighted that learning is the absolute critical dimension in terms of LC maturity, stating that:

> *Is the organisation learning, are the individuals in the organisation learning and is this being done with people working together and ... [are] people still learning when they are not together ... but in addition what a learning organisation does with its learning it's got.*

The importance of learning was in addition emphasised by CLP#07, OLP#04 and OLP#10 who emphasised that the whole training - its quality and how people understand the training and how successfully they apply what they have learned including the feedback to the training department and also the effectiveness to support the change - is important. This was also identified and discussed by OLP#11 who stated that:

> *In an organisation that is more mature I think the people's learning and training would be based around the company's system, so you're not sending people off to training courses but you're actually training people in your company's ways of working, and a mature organisation would in addition be teaching people how to learn and how to improve ... teaching people problem solving and Lean techniques, if you like, Lean philosophy being embedded into that ... they see their management and the leaders delivering the training and develop that training delivery so they are coaching and mentoring their people rather than sending people on courses ... but it is maybe different types of learning so a workshop or an intervention or something practical in real life.*

For OLP#05 it is further important that people in Lean organisations should not learn and practise how to solve problems but how to avoid problems, because it is not all right to make mistakes except if the mistake is in a domain that you have not perceived before, which will lead to real learning. OLP#05 further points out that if the mistake comes up in a domain the people could have controlled this is also not all right, they failed and the customer has paid for that already. So what do people in the UK and the USA do? They write a change order.

As a third dimension within this category several participants noted dimensions related to the actual Lean journey. This was for instance mentioned by CLP#07 as he states that a team that is managed in a Lean way would be measuring where they are with a maturity framework on a routine basis. This was in addition identified by OLP#11 through pointing out that *"the way that you market yourself in your business"* is a dimension.

3.5 Culture & behaviour

Culture & behaviour was the most prominent category, with 48 related passages largely established by the OLP set (33) and a number of passages (16) produced by the CLP set. Within this communication was a frequently mentioned dimension during several interviews with the OLP. For instance OLP#01 explained that LC maturity can be indicated through:

> *Improved information flow, less need for constant meetings ... visualisation of the progress because if you go to a site or a project place and you see the progress is visualised that is an indication that people are thinking along the line of let's improve communication ... let's come together and try and understand the project organisation better*.

This was in addition identified by OLP#03 who stated *"something really important is communication; I would say communication is the ever-important aspect in this regard: to be able to communicate what LC will represent in the future for their role ... for their sub-organisation, and the project"*. Additionally, OLP#04 pointed out that it is particularly important when using LPS that the right people are in the meetings because of making commitments and also showing the importance of this meeting, for instance through the attendance of the project manager, and as well how well prepared the people who come to the meetings are.

For OLP#01 improved trust was a dimension for LC maturity, while OLP#03 acknowledged that *"to be able to implement LC you need trust; trust is absolutely essential between the people ... in a project"*.

From several OLPs and CLPs collaboration was also suggested as a dimension; for instance CLP#09 explained that *"if they don't collaborate that much so all the Lean tools won't be able to give you as much as they could"*. This was also noted by OLP#01 who said *"in general better collaboration [means] people working better together"*. The extract of the interview with OLP#10 emphasised this position as he believed that *"one of the important values or True North indicators is collaboration"*.

Moreover, OLP#10, CLP#07 and 09 identified leadership as a dimension. OLP#10 emphasised this through his statement:

> *Leadership is one of the most important ones, the leaders have to understand it and to believe it and then the best is to teach everybody. It's important to get it quickly deployed throughout the company; the leaders have to believe in it and this is the key element.*

Some of the participants in addition suggested certain behaviours as dimensions for LC maturity. For instance, CLP#07 reported that he focused on key behaviours such as: *"did management spend time daily engaging the staff at the place for work, [are] our partners performing reliably in terms of time and quality ... do managers conduct their day in a systematic way?"* Additionally, CLP#06 suggested that the number of people engaging with Lean would be a dimension and OLP#04 noted that the overall commitment to Lean within the organisation is important. OLP#11 believed that in a more mature LC organisation you would see different cultural things and different things in the organisation. So OLP#11 mentioned examples that would indicate LC maturity as *"people are behaving throughout the organisation in the same way"* and *"in terms of the supply chain, the way the company behaves with its contractor and the suppliers"*. One behaviour that was observed and mentioned by OLP#01 is that in a more mature LC organisation people are opening up a bit more which further results in improving trust. The consistency within the purpose and the approach across the organisation was also identified by OLPs #11 and #05 and CLP#07. OLP#05 elaborated on that when he said:

> *When I assess maturity the first thing to assess is how the constancy of purpose happens with the understanding of customer value ... you have constancy of purpose, so you know the direction you have to fall."*

Furthermore, this constancy of purpose was mentioned as the particular need of a vision, as for instance by CLP#08 and OLP#04, whilst the latter explained that the vision or mission of the organisation shows if they have that actual purpose to go Lean.

3.6 Continuous improvement

A number of passages (four) related to ***continuous improvement***. OLP#05 explained for instance that he is focusing on *"how people practise continuous improvement, are they practising continuous improvement in a systemic way? ... how do they identify a problem?"*. This was in addition noted by OLP#11 and CLP#02, with the latter stating: *"I would see in a mature Lean organisation, a systematic continuous improvement"*.

3.7 Business results

The importance of the ***business results*** produced eight related passages mainly through the contribution of the OLP. Within these OLP#01 elaborated that obviously achieving targets and milestones as well as reducing the costs and increasing the profit should be a dimension of an increased maturity in LC. The achievements were further pointed out by CLP#07 when he mentioned that the Shingo Prize criteria focused on the business results by cost reduction, quality, delivery, financial impact and competitive impact. CLP#07 further elaborated that:

> *Today there is not enough attention in the LC community on business results; are we on time, are we on budget is the extent of it.*

OLP#11 in addition suggested that within the business results there are dimensions for LC maturity, as for instance:

> *Within the commercial, with the way it behaves commercially, so is it driven on price or driven on overall cost? So do we worry just about the price of a package or do we think about the whole picture, the quality, the health and safety all those aspects, so definitely the commercial approach ... and in terms of finance the way a company goes about their accounting, that would be a real measurement of a Lean organisation, how you go about financial accounting for the overhead of'Lean accounting practices.*

3.8 Other issues

The final sub-theme ***other issues*** produced 13 related passages on the dimensions of LC maturity. This was again mainly established by the OLP, as for instance by OLP#01 and OLP#10 who both stated that in terms of LC maturity dimensions there are many different areas where this can be identified. OLP#10 further suggested that "*the important ones to measure are leadership ... collaboration ... coordination ... the whole training would be another one"*. For CLP#07 an important dimension of LC maturity was the levels of transformation or maturity within the Shingo Prize criteria; hence he suggests to look at maturity from three different viewpoints; these are tool driven, system driven and principle driven. As a result of the discussion about the dimensions of LC maturity, CLP#09 emphasised that less dimensions are actually better – "*just a few powerful things*". However, in slight contrast OLP#11 explained that:

> *I think when starting to implement Lean in a project, sometimes you look around what is everybody else doing, what are the measures of success; that can sometimes be misleading. I think it is more important for the organisation to think about what it means to them and set this initial start point and from then on define the levels of maturity for themselves.*

5.3.7.4 Theme: 4. Potential support for this research

The final theme discussed within the interviews was the ***potential support for this research.*** This theme was broken down into two sub-themes, development of any LC maturity framework and other issues – see Figure 5-9 and Table 5-13 below.

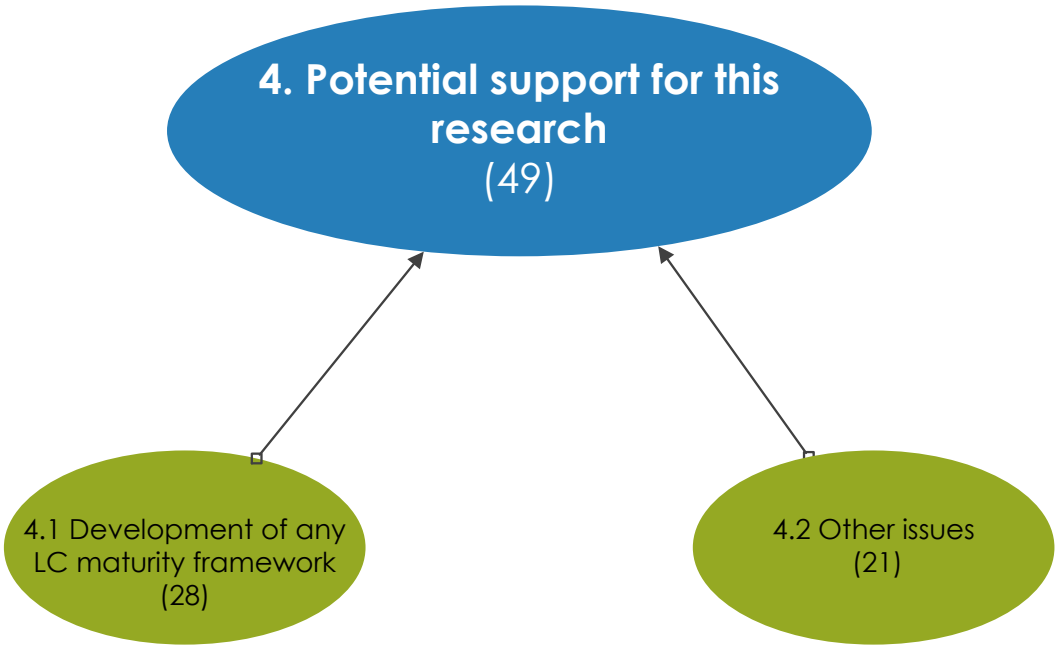


Figure 5-9: Thematic model 4. Potential support for this research

Table 5-13: Thematic profile theme 4. Potential support for this research

	Operational LP	Consultative LP	Total
4.1 Development of any LC maturity framework	22	6	28
4.2 Other issues	20	1	21
Overall	47	7	49

4.1 Development of any LC maturity framework

All the suggestions that the participants mentioned within the interview in terms of the ***development of any LC maturity framework*** produced 28 related passages. This was manly discussed by the OLP set, as for example OLP#01 said:

> *A maturity model for LC and a project organisation will be a difficult task to develop something that you can get good value from, but I think it is possible … Just final words, don't forget about the practical implementation.*

A similar viewpoint was identified by OLP#11, who stated that *"If it is aimed at more than one group"* it may be slightly different *"so if it is for the client it might be different from the people who implement Lean in the business or for the management team to assess themselves"*. Additionally, OLP#05 suggested that designing a maturity level for LC must focus on Lean rather than on construction, because:

> *It is the evaluation of the five elements of the Lean thinking; this is one level, the second level is processes, the third level tools, the fourth level the thinking and the fifth level is the continuous improvement part*.

Other participants such as CLP#07, OLP#04 and #10 pointed out that they would think it is useful to put a LC maturity framework together and gather practical experience by applying it in big companies. Interestingly, CLP#07 criticised the usefulness of the CMM as a basis and suggested instead the Shingo Prize Model as a basis by which to understand the maturity in terms of Lean in an organisation, because *"it involves a good description of the thinking behind the model"*.

4.2 Other issues

The second and final sub-theme involves any ***other issues*** that could be of importance for this research. The contribution towards this sub-theme was produced largely by the OLP set (20 passages) but in addition through CLP#07 (one passage) through pointing out that:

> *Companies today adopt Lean approaches for one or two reasons: one is they're competitively disadvantaged because the others do it and the other is they are told to do so by the client*.

Another issue that was discussed was the relationship between CI systems and a maturity framework. OLP#03 identified similarities between these approaches and pointed out that *"companies miss a systemic way to implement a CI system"*. As mentioned earlier in theme three, practising CI in a systemic way was identified by OLP#05 as a dimension for LC maturity. However, OLP#05 clarifies that CI is not Lean because:

> *Lean is delivering customer value, CI is how to fix or how you make corrections, how you improve the way you are delivering this value … and CI is driven, driven by the ability to understand customer value … so we wanna focus on the input and the input is customer value, processes, tools, systemic and scientific thinking, constancy of purpose. If you don't have that your CI is just wrong.*

This participant further pointed out that the industry lies when they think construction projects are uncertain, because they fail to think systemically and thus make these projects uncertain. Therefore OLP#05 stated that *"uncertainty comes from a variable or from a value that I couldn't have, that I couldn't identify … so your process hasn't enough flexibility to adjust itself to some abilities that happen in the job, all you can have is a plan B".* Therefore, projects are not uncertain, projects are complex and that differs from uncertainty and chaos, and following the arguments of OLP#05 *"if you are not able to understand the system you are in chaos, that's it".*

A last passage identified within the discussion with OLP#05 explained that:

> *I don't know why they are trying to identify what is Lean; let me define LC: the Lean definition provides customer value through streamlining processes, practising continuous improvement, that's it. It's a philosophy; people try to define LC, that's not the point; and I think the common definition of Lean for all these companies is common sense.*

5.3.8 Individual interview: Summary

As disclosed at the beginning of the chapter, the purpose of the individual interviews used within this research was twofold: on the one hand these interviews were used to enhance the depth and breadth of knowledge about the understanding of LC and Maturity in LC whilst identifying the level of acceptance of maturity and MMs in respect of LC, and appropriate dimensions for LC maturity. On the other hand, the conducted interviews contributed towards the identification and building of attributes towards LC maturity. Accordingly, the

contributions of each participant (see Table 5-8, p. 166) provided all 11 LP vital insights into LC and the understanding of LC maturity. The analysis of the individual interviews revealed four major themes in terms of LC maturity; these are:

- Maturity and its revealed facets in terms of LC and the construction industry;
- the importance and application of any LC maturity framework with its maturity assessment;
- dimensions where LC maturity can be measured or recognised; and
- support for this research in terms of the development of any LC maturity framework.

In terms of the first theme 'maturity of LC', there was wide consensus that it indicates where an organisation is on their Lean journey and enables an assessment of how well the Lean philosophy, principles and methods have been assimilated throughout the organisation. The theme described attributes which encompass an organisation's processes, culture, way of thinking, training of people and behaviour of individual employees. In terms of the second theme it was widely perceived that maturity and MMs play a vital role in some organisations that are seeking greater maturity in LC. Furthermore was found that a LC maturity framework helps in particular to identify areas for further improvement in terms of a Lean transformation programme. Within the third theme - the dimensions through which LC can be measured or recognised - a total of 96 separate dimensions and information for an assessment were identified. Within these elements those relating to a) understanding customer value b) measuring of waste c) the thinking of the people d) their expertise e) culture and f) behaviour were prominent. Finally the fourth theme draws some attention to potential applications and the different focus of a potential LC maturity framework for owners, projects or organisations.

The essence of these findings is further reflected by a tag cloud generated through a semi-automated query of the interview transcripts utilised by NVivo. This tag cloud consists of the 50 most frequently used words within the interview discussions and is illustrated in

Figure 5-10. The essential keywords that most frequently occurred within the 11 interviews were: 'think' (195 count), 'Lean' (184 count), 'maturity' (161 count), people' (113 count), 'organisation' (89 count), 'project' (89 count) and 'construction' (81 count). Further keywords were: 'maturity', 'measure' or 'model' as well as the focus of 'people', 'project', 'owner' or 'organisation', 'tool', 'value', 'processes', 'understand' and 'customer', which furher highlights the themes revealed in the analysis. Moreover, this alignment of the word frequency count and the findings contributes to the transparency of this analysis.

Figure 5-10: Word frequency tag cloud (top 50)

5.4 Chapter summary

This chapter has presented the findings of the supplementary data collection. These findings have been derived from a systematic and rigorous data analysis and synthesis. Consequently, the evidence for those findings and the execution of the data analysis have been transparent presented. In addition, links and examples of the verbatim data and the synthesis of the data/meaning have been illustrated.

Undoubtedly, the first supplementary component (the group interview) underpinned the feasibility and importance of this research by leading specialists and academics in the field of LC. Consequently, the results delivered rich information that contributed to the achievement of the first and second objectives of this study.

Subsequently, the individual interview data provided vital insights into the depth and breadth of the understanding of LC maturity. This in addition delivered a major contribution of achieving the second objective of this research. As a result, the level of acceptance of MMs in respect of LC, characteristics, potential areas for application and appropriate dimensions were identified.

CHAPTER SIX

FINDINGS – PRIMARY DATA COLLECTION

6 Findings - primary data collection

6.1 Introduction

This chapter presents the transparent execution and evidence of the analysis for the primary data collection in this research. This primary component is predominantly conducted to achieve the second and third objectives of this research. In addition, this chapter contributes towards the fourth objective. Consequently, examples of the data for the primary component of this study are illustrated. Accordingly, the synthesis of this data set, its meaning and the findings are demonstrated in the following sections.

6.2 Focus groups: Findings

The purpose of the FGs within this study was to develop an in-depth understanding of the phenomenon 'LC maturity' and to identify what maturity in LC looks like, how it is characterised, how it can be improved and what kind of outcomes and outputs are associated with being mature in LC. Two FGs with either five or six LC practitioners were conducted. Each FG lasted approximately two and a half hours. At the beginning of each discussion the participants were informed about the ethics and motive of this research as well as the voluntary nature of their participation. The FG participants have gained extraordinary experience in LC over several years and the FGs were conducted to access their experience and sense of LC maturity that they had developed through being involved in the process of maturing and transforming from a non-Lean to a LC paradigm in temporary project-based organisations as well as single entities, such as owners/clients or contractors.

The data gathered through both FGs was analysed through the developed framework explained in section 4.7.2.2. The steps of this phenomenological analysis framework are illustrated in Figure 6-1.

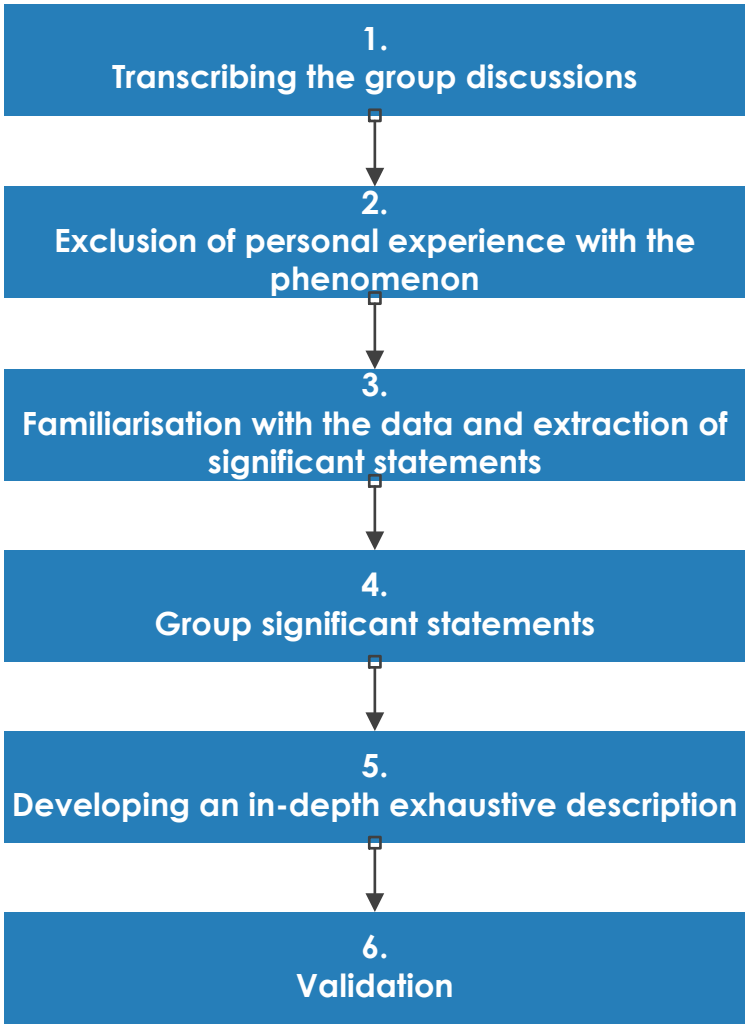


Figure 6-1: Steps in the researcher's analytical framework

Each step and its results are presented in the following sections, after an overview of the participants' profiles.

6.2.1 Focus groups: Participants' profiles

The FGs required participants with quality experience in LC to make sure that they experienced the phenomenon of LC maturity. This was achieved through a systematic sample strategy which was described in section 4.6.3.6. With their in-depth experience in Lean and LC, the participants selected for this study fulfilled the requirements. At the beginning of each FG the participants were given the opportunity to introduce themselves and their experiences in LC. Additionally, each participant filled in a profile sheet to complete their profile. The summary of this information is shown in Table 6-1.

Table 6-1: Summary of the participants' profile

Partici-pant	Location	Experience in LC (years)	Total work experience (years)	Current role/ position	Role
PL#1	Midlands	7 (+ 15 in Production)	22	MD	CON
PL#2	North West	2	34	SM	CON
PL#3	Midlands	11	37	MD	OP
PL#4	Midlands	8	25	MD	OP
PL#5	North West	5 (+ 15 in Production)	26	OD	CON
PN#6	Midlands	8 (+ 8 in Production)	30	MD	OP
PN#7	Midlands	36 (incl. early adaption of Lean in construction)	40	AD	CON
PN#8	Midlands	4	12	MD	OP
PN#9	Midlands	5	26	R/PM	OP
PN#10	North West	3	33	LTM	OP
PN#11	Midlands	4	7	MD	CON
Sum:		86	292		

MD=Managing Director; SM=Senior Manager; OD=Operations Manager; AD=Associate Director; R/PM=Researcher/Project Manager; LTM=Lean Technical Manager;
CON=Consultant; OP= Operational
PL=Participant of the focus group in Liverpool; PN=Participant of the focus group in Nottingham

As is obvious from the table above the participants were mainly managing directors in their respective organisations. Some of the participants had more specific roles in their organisations, e.g. Operations Manager or Lean Technical Manager. One has experience in LC from the industry and is currently undertaking research in LC for the industry. The majority of the participants are responsible within their respective organisation for clients of their consultancy organisation, to lead Lean transformations for all sorts of companies and major national and international projects such as: new build, refurbishment and infrastructure work, hydro-electric plants, nuclear power plants, and pharmaceutical production facilities. Additionally, some of the participants led Lean programmes for the supply chain in the construction and aerospace industry. The vast experiences of the majority of the participants (over 80 years in total) clearly demonstrate their in-depth experience in LC, which was a key requirement for this research.

6.2.2 First step: Transcribing the group discussions

The applied transcribing procedure for the two FGs (illustrated in detail in section 4.6.3.7) resulted in two verbatim transcripts with a total number of 50,000 words. Through analysing the contribution to each FG, the ratio of the word count between the participants and the moderator within the verbatim transcripts was measured and is illustrated in Figure 6-2. The ratios for both FGs highlight that, with around 90%, the participants in each FG contributed predominantly to the discussion and not the moderator (an example of a transcript can be found in APPENDIX H).

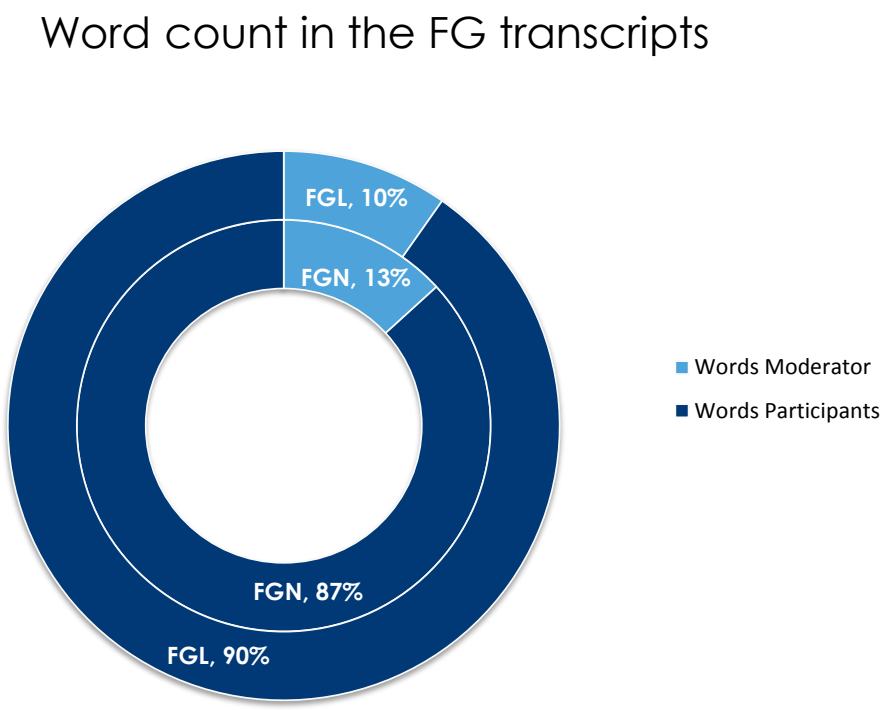


Figure 6-2: Ratio word count between participants and moderator

6.2.3 Second step: Exclusion of personal experience with the phenomenon

The process of exclusion or setting aside of the beliefs, perceptions, preconceptions and experiences of the researcher is a concept of Husserl which is labelled epoché or bracketing; this is an attempt to be more open or faithful to the phenomenon under investigation (Moustakas, 1994). As Tufford and Newman (2012) remind us, epoché or bracketing

support a deep level of engagement of the researcher with the data and facilitate innovation and renewed insights in the phenomenon under investigation; they emphasise this with an example from physical science when Galileo excluded the widespread opinion and beliefs that the earth is not moving to then discover that the earth is moving around the sun. Similar to this nowadays is the concept of thinking-outside-the-box. As a result of this the researcher is more likely to focus exclusively on the experience, the positive and negative views and the depth of the data provided through the participants within the discussions of the FGs.

Hence the first step within this analysing framework consists of the description of the experiences, beliefs and perceptions of the researcher.

Although having no significant practical experience in LC, the researcher does have some notable experiences in PM and the construction industry. These experiences are:

- Five years of site experience as a trained carpenter working on several small-scale construction projects as foreman and site manager, including off-site construction;
- six months' project experience as assistant of the project manager of a major international high-rise building project in Africa; and
- two years of daily work experience as project manager on the client site for projects such as: office buildings and museums. This includes experiences as scheduler for construction and finishing works of a large multi-million € project.

The perceptions and beliefs of the researcher in terms of LC are as follows. The researcher's perception is that the construction industry is not able with its current principles, methods and practiced PM to consistently deliver projects that are successful in terms of client satisfaction, scope, cost, time and quality. Moreover, it is the perception of the researcher that the current PM and construction management practices are only able to deliver occasional successful projects. However, the researcher believes that LC can transform the

industry and its traditional paradigm of delivering projects to a new and different way of project delivery and PM which is more collaborative, effective and more likely to consistently deliver successful projects across the world.

Having described the relevant experience, perceptions and beliefs of the researcher following the concept of epoché or bracketing this will facilitate innovation and renewed insights into the phenomenon under investigation (LC maturity) in this research.

6.2.4 Third step: Familiarisation with the data and extraction of significant statements

Familiarisation with the textual data started within the 'correction and alignment' of the transcripts through a partial retyping from the audio tapes and a consistency check of the identified and assigned participants through comparing the video-recordings of the FGs with the transcripts. Several readings through transcripts, the observer notes, and the flipchart notes were used to achieve an adequate sense and feeling for the data.

In order to identify the significant statements both transcripts (data) were imported into NVivo whose indexing/coding function was utilised to extract the significant phrases and sentences from the data (see APPENDIX J for some screenshots of this analysis sequence). Having identified all significant statements from the data these were exported from NVivo into an Excel spread-sheet. Within the spread-sheet a non-repetitive list of 241 significant statements was generated (see APPENDIX I). A selection of these identified significant statements is illustrated in Table 6-2 below.

Table 6-2: Selected examples of significant statements

Significant statements
41 I think there's one thing that we've not talked about yet that is for me a sign of maturity. And that's when the motivation to be religiously on a Lean journey is intrinsic. We've talked about client pull and so on, that's extrinsic as far as I'm concerned. As soon as you take the pull away, people stop doing it. It's got to be embedded in the organisation. As a construction company, as a design company, as a client you don't need anyone to tell you to do it. [Agreed by PL#3, PL#4 and PL#5.] What you need to recognise is it's worth doing because of what it's going to do for your business. The bottom line is to do with how we relate as people.
45 Buildings are too complex these days to do it through command and control, you've got to use other means, hence the design intent plus alignment.
93 Well for a start you're not getting the contract out every five minutes to go through … you know, there's a maturity in understanding, in managing change and … that's seamless almost. So yeah and non-confrontational … and we're a long way off that I know but that's the way it should feel and that's the way it would feel in other industries when it's working well.
94 Maturity is actually a one-size-fits-all. If you develop it correctly, it will apply whether it's a five-man outfit or a 50,000-man outfit. It's irrelevant of the size of the entity. It is … Lean will apply regardless of size.
99 So it becomes all-pervading, so people I think are applying it … it's a bit like safety you know, you can apply safety when you get to work but you can in addition apply it in the wider context, it's a complete behaviour change. [All agreed.]
108 And change is … in a mature organisation, change is a way of life and everyone can deal with it. So because you've got continuous improvement, I mean at the end of every day, every meeting, every gathering if you like, everyone should be - when it really is working - saying what could we do better? What did we do right in the last hour, what did we do right in the last day? What do we need to do better? And that should just be … and then there should be a reaction to that, not just yeah, okay, I'm going to put that on my pad and then forget about it, it's yeah, I'm going to do something with that. So we say everyone can deal with it and everyone's empowered then to go and make it happen, not expect someone else to take it away and fix it for them. … So change is fix in the processes of the organisation.
145 Demonstrate to us that you've utilised lessons learnt through every stage of the lifespan of this project to say I've identified that as a possible issue and I've gone and looked at the lessons learnt and what we've done to mitigate that in the past is this. If we haven't got it on the system already, I'm going to make sure it's on the system for the rest of my colleagues to utilise going forward. And that to me is a real sign of maturity. … If we're doing that, then I would say to somebody yes, you are a more mature organisation than others.
157 And we are developing unique tools to address specific problems rather than having tools searching for problems … To solve specific … to address specific problems. So we're doing what Ono and Shingo and everyone else did in the early days, they didn't have tools that they could pull off the shelf and a lot of problems to solve; they had problems and they developed tools. We should be doing the same.
171 Less adversarial behaviour. And then as a consequence, a true constructive atmosphere was created to find alternative ways of constructing or designing. We worked with the architect to simplify his design, whilst keeping the value for the client.
183 When we understood that, we understood the real value. So there's an understanding of the critical customer goals … so it's the goals but then what is it, what does the customer really want? It's a bit like … and this is where this company are quite good at getting their management requirements done and the true understanding of what is the real requirement from the construction system and the built environment. Understanding what the ultimate aim is, so you're not just building a building, what you're going to use the building for, how does the client see it being used and understanding that across the team inherently means that you fix the things that really matter to them.
190 Honestly I can't see any difference. I've worked in aerospace, telecoms, rail and construction and there's no difference. …But I think you'd have more uncertainty in civils. But I don't think that means it doesn't work. I think it works to a different level. And you won't get to 100%, you won't get to 99%, you could get to 80%, which is good.
233 I think it's about leadership championing the change or the increase in maturity that the leadership needs to internalise it. It's not just a mouthpiece, it's actually really understanding it. So they can say with a passion they've got that fanaticism.

6.2.5 Fourth step: Group significant statements

In this step the significant statements were grouped in themes with a three-level hierarchy, as illustrated within Figures 6-3 and 6-4. The sequence of this process is further demonstrated in APPENDIX J.

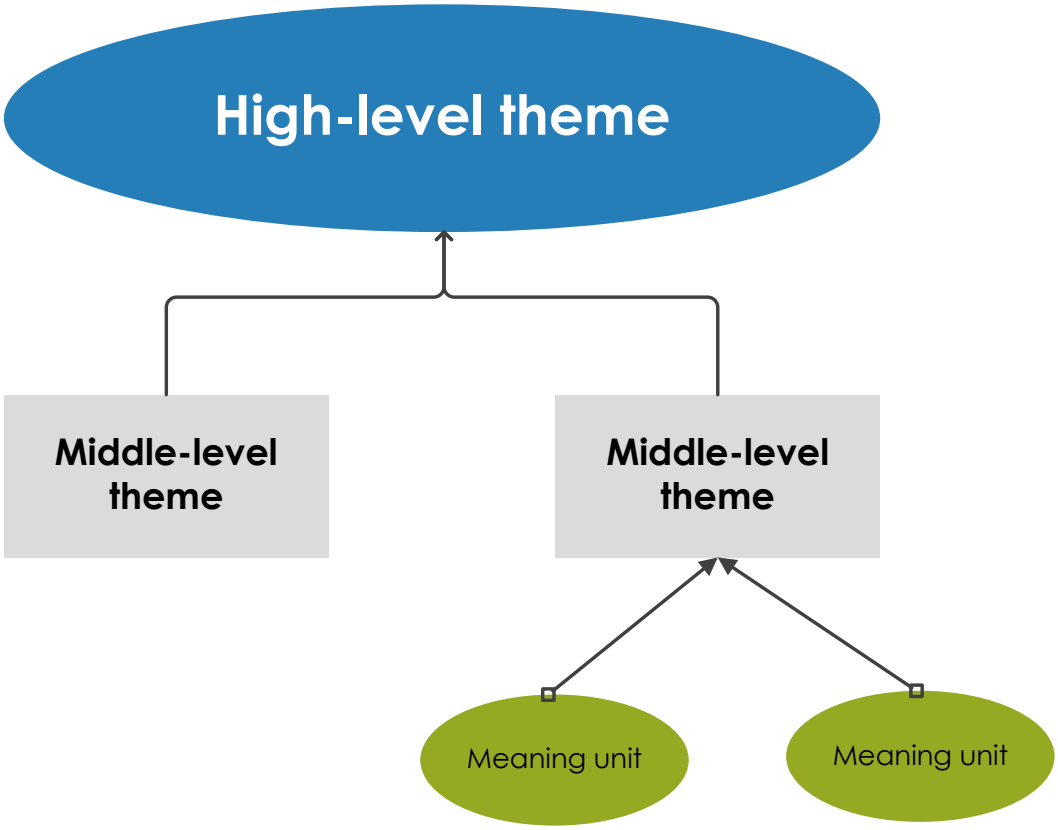


Figure 6-3: Theme hierarchy

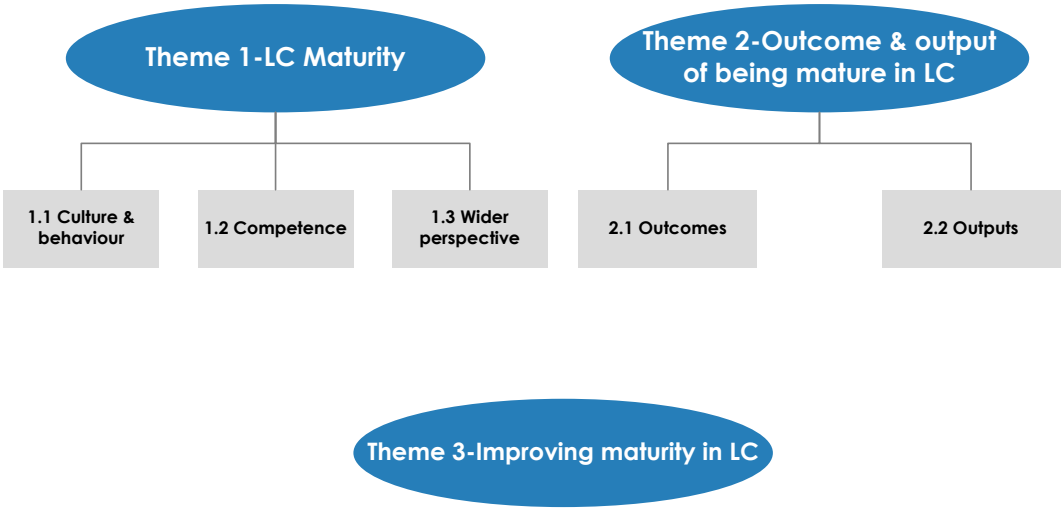


Figure 6-4: High-level and middle-level themes

These themes were further subdivided into 25 meaning units, as illustrated in Figure 6-5.

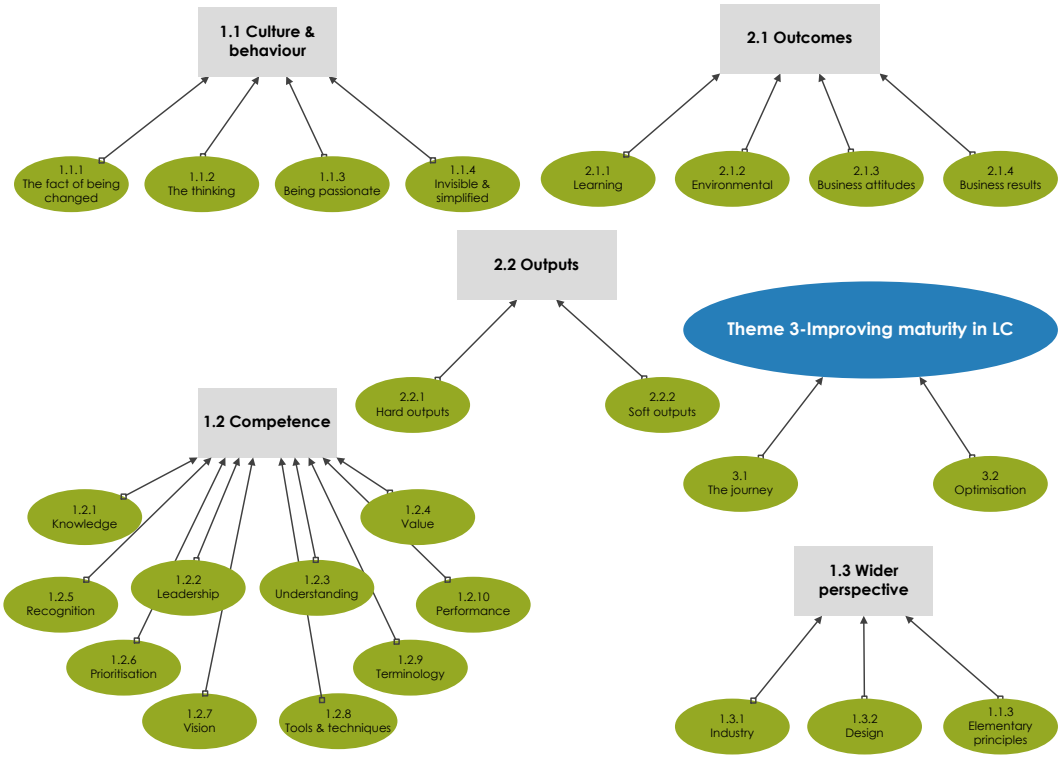


Figure 6-5: Low-level themes

Verification of the themes

Since the important opinions occurred as a consensus amongst the groups within both FGs those were recorded on flipcharts. These flipchart notes have been double verified by the participants: firstly through reflecting on those notes and gathering of confirmation of the

accuracy at the end of each FG; and secondly by a follow-up process that involved summarising and sending the summary to all participants for them to clarify the veracity of these key points. All participants confirmed that they were an accurate reflection of the discussions in the FGs. Hence those notes must be considered as a verified and ordinary reflection of the meaning expressed within the discussions. Considering this, a comparison of the developed themes and the verified notes has been used to prove the veracity of the developed themes and meaning units. An example of such a comparison is illustrated in Figure 6-6 below. This shows that the meaning in the keywords in the notes is in agreement with the developed themes and their meaning units. Therefore the built meaning units in form of the grouped themes are considered to be verified.

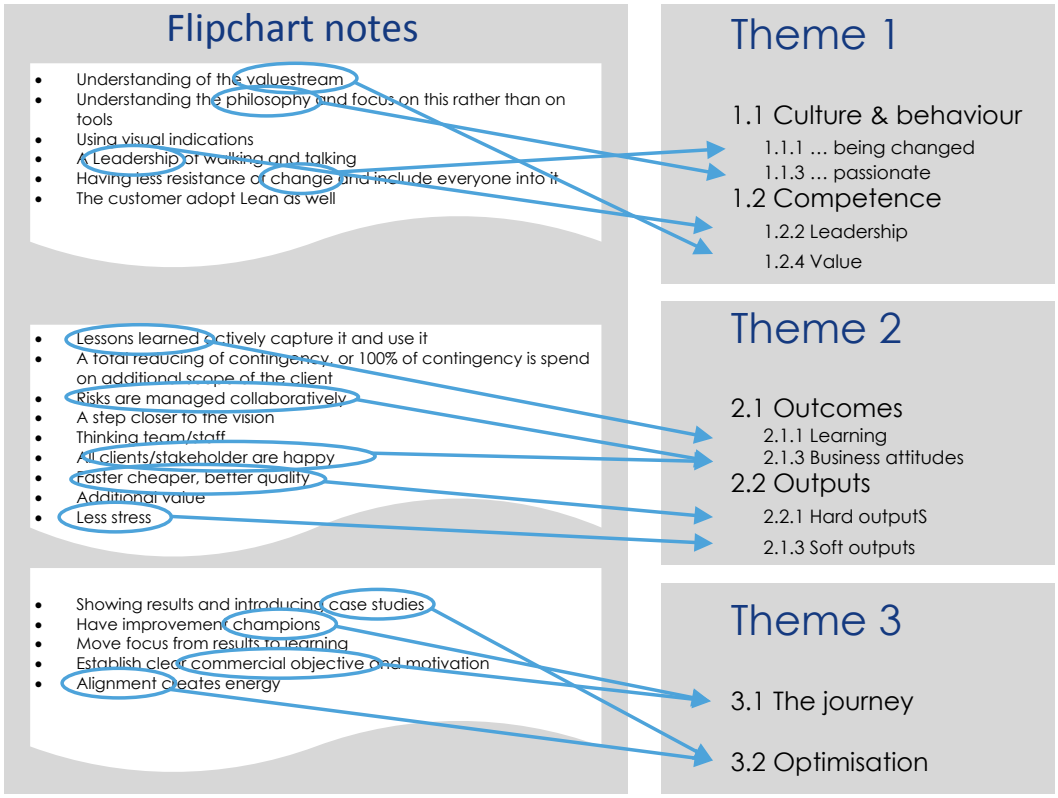


Figure 6-6: Verification of the developed themes

6.2.6 Fifth step: Developing an in-depth exhaustive description

The three high-level themes including all their containing meaning units contributed to an exhaustive description of LC maturity.

6.2.6.1 Theme: 1. LC maturity – 1.1 Culture & behaviour

Focusing on culture and behaviour was a key element for the participants in the discussions of the first theme in both groups. This middle-level theme was further broken down into four meaning units, as illustrated in Figure 6-7 below.

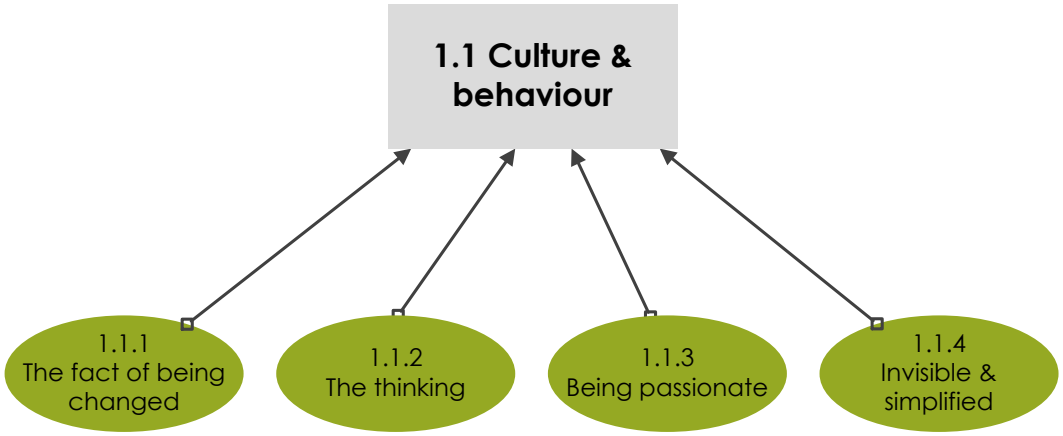


Figure 6-7: Theme 1.1 Culture & behaviour

1.1.1 The fact of being changed

One of the most encompassed images of maturity within the group discussions was change. This became clear through general arguments such as paying lip service to change management, which misses a fundamental part of maturity. This description in particular received strong agreement from the other group members. Accordingly they argued that you must find something like a change management policy from senior management level as a sign of maturity in LC. Additionally, it must be obvious that the organisation is changing and not only a few individuals who pull and influence their colleagues. Hence the change must be incorporated into the organisation and in all sorts of things they do. One major change is that mature organisations see problems not as failure but rather they see occurring failure and issues as a signal to solve and prevent problems in the future. Therefore, they look out and begin seeking for bad information as early as possible. Further, it was described that mature organisations accept changes from customers and have the confidence and system in place to deal with those changes. Accordingly, they would see changes in

technology as an opportunity to do things differently and these changes the social relations around that new technology. For example it was stated that:

> Lean allows you to say 'oh that's a new technology, how do I do things different to make best use of that technology?' rather than 'how do I fit that technology into my traditional approach?'

Certainly the change itself was part of maturity but besides that it was explained that an agile behaviour exists in more mature LC organisations towards adapting to the change. This was further described as the ability of being agile in adapting to changes irrespective of whether these are caused by the customer or by environmental requirements. In addition, this flexibility towards change in more mature organisations was described as *"they don't mind new techniques, new ways"*, and *"change is a way of life and everyone can deal with it"*. Another example of change was mentioned: a senior leader has to be prepared for someone to challenge her/his objectives, and should listen to them because s/he might want to adopt these new objectives.

A further part of change is the resistance to it. This point received the attention of the observer in the FG, hence it was noted by the observer as an interesting topic of the discussion. A low resistance to change leads to sustainable change and is considered as mature, whereas the opposite leads to unsustainable change and shows immaturity. It was argued that the vision of where the organisation wants to be in terms of LC should always be stronger than any resistance to change. Experiences that reduce the resistance of change were described as the inclusion of people through an effective communication of not only the corporate goals but including the value for the individuals – *"what's in it for me"*. So individuals agree to a change because they understand their value in the change as well.

Another description of change in mature organisations focused on how to overcome groups and people who are totally against any change and everything involved with Lean. The experiences of the participants showed that mature organisations either have the *"ability to be able to detect it and cope with it"* or those people/groups simply *"disappear"*. One

participant described his experience within a team which actually sorted this issue out themselves *"because it's got that momentum behind it and they realise that they're not succeeding because of that group"*. Furthermore, it was explained that *"maturity comes when instead of just living with that, you get rid of it … I've seen that people actually leave themselves … because the culture isn't that"*. Moreover, it was pointed out that *"truly mature"* is when this sorting out (getting rid of the people who are against the change) happens automatically. This behaviour was additionally noted by the observer as an interesting part in the discussion.

1.1.2 The thinking

In this meaning unit, the participants focused on the different thinking associated with LC maturity. One way of thinking described was *"total system thinking"* and the ability of creating the space (time) that allows thinking differently about the things we are doing in general. This enables behaviour challenging the way things have been done in the past - *"the status quo"*. For example, it was stated that total system thinking as behaviour means:

> *Let's build this ten-storey office block; is there any way we can improve … [what] we've already known? Is there any way we can improve on what we did before? Can we make it easier to look after it and maintain it? Can we make its lifespan better?*

This will further create a thinking team/staff that goes from doing things as they did them in the past to *"really think about what you're doing and how you are doing it"* this time. Hence they become more aware about *"safety"*, *"using their brains"*, and being *"part of the decision-making process"*. This reflected likewise a stated *"pre-set position for Lean that everything can be improved…So once you've got here, you're already thinking about going there, wherever that is"*. The participants describe these thinking teams and staff further through behaviour of looking out and delivering improvement through challenging processes and seeing the value chain in the organisation from the top to the bottom regardless of the

subject, department or processes. Both the thinking teams and the total system thinking were noted by the observer to be a particularly interesting experience that has been discussed.

Scientific thinking was described as leaders collecting information through standard interactions to feed it back into the corporate management and the strategic decision processes. However, a LC maturity in thinking is distinct through the alignment of everybody's activity in a direction of improving the corporate goals. This means the thinking applied is not only in the operation (construction) but also in the top level to make it more systemic and establish the links between the corporate goals and the operational performance. This thinking further contains every aspect of the business *"whether that's R&D activities ... training activities, marketing strategies or the engineering"*. However, one participant differed from the majority of the group and pointed out that every organisation needs the people *"who are thinking differently ... who are not aligned, who are thinking the awkward thoughts and challenging leadership so that we continue to develop"*. So there is a need for alignment and small misalignment, which the participant calls the *"grit in the oyster in order to produce the pearls"*.

Another participant pointed out that system thinking actually leads to realising that the design phase can benefit from the *"inherent knowledge of the workers"*.

Moreover, it was pointed out that in thinking of maturity in LC it is very difficult to say what is actually mature, and suggested that *"some things are more mature than others"*. Another way of thinking about Lean maturity was pointed out as well. This sees an ultimate top point of maturity where some expected a genuinely achieved culture that "*aligned the goals of all of the employees and motivated them with a passion to be constantly improving that performance ... against those goals*".

1.1.3 Being passionate

Individuals and teams that are more mature in LC are passionate about Lean and the Lean Journey. An example found to be important by the observer explained that, *"the motivation to be religiously on a Lean journey is intrinsic ... so as a construction company, as a design*

company, as a client you don't need anyone to tell you to do it". So they are passionate about it and know that it is worth doing it and Lean belongs to the business by its very nature.

If the people or the organisations do not own Lean as a permanent and inseparable strategy of deployment they show a lack of maturity. The participants consistently described a strong connection to Lean and its philosophy, as illustrated in the following statement:

> *The thing with a mature Lean team is that they are fanatical about perfection. And I mean fanatical in an extreme way. They're living it and it's all about lead times, it's about removing waste, planning and they're totally living it. And they apply it in the workplace but they're probably applying it in their normal lives outside as well. So they just become all-encompassed.*

Being passionate about Lean becomes spread throughout all parts of the organisation: *"it's a complete behaviour change ... so they can say with a passion they've got fanaticism".* One participant described this as really critical and stated that:

> *I know it's not easy and it's not good English and all the rest of it but 'getting it' for me at a senior level and in 'getting it' down through the organisation ... because you've got to understand it ... you've got to more than just understand it, you've got to get that embedded in your DNA and then start to get fanatical about it.*

In addition, it was generally agreed and stated that *"you can talk all the right terminology and use all the correct tools and techniques within the process"* but they need to really understand that Lean is a way of thinking and a philosophy for the whole business. This is further evident in the following statement *"a philosophy for the whole business not just for the construction phase ... and you can't just pick it up and use it".* Therefore the individuals and teams have to own Lean and they need to 'get it'. Accordingly, it was explained that there would have to be a feeling of honesty, completeness and transparency amongst the people.

1.1.4 Invisible & simplified

In this meaning unit the participants focused on the invisible input of Lean and its simplicity. Lean as invisible input was in addition perceived by the observer of the discussion as a particularly interesting topic. These invisible inputs were explained for instance in the following example:

> *So it's like an invisible input … a bit like a magic trick, somebody convincing somebody this is the way forward and saying that's the way, it's the answer, let's move forward … listening to the client, working collaboratively between the designers, the structural engineers, the architects and the M&E [Mechanical & Electrical] brought a very good solution; it worked very, very well.*

Furthermore, it was described that LC is often invisible in particular in the overall high-level area because it is *"buried down below there"*. In addition, there was an agreement between the discussion and the observer notes that it is indeed important to look at what the individuals are actually delivering to the customer to avoid a *"false picture*".

Moreover, simplicity was mentioned as a key part of Lean maturity. Hence it was argued that everything gets simpler when we are maturing in Lean; however, the start can be *"quite complicated*" but then things become simplified. For example, the way we look at construction projects from "*building one-offs*" becomes simplified to *"we do very similar processes in different locations with different constraints"*. The simplicity is also evident in a *"true constructive atmosphere"* where simplified solutions and ways for the design and construction processes are created whilst the value for the client is maintained.

6.2.6.2 Theme: 1. LC maturity – 1.2 Competence

The second middle-level theme discussed in the theme ***LC Maturity*** focused on the possession of required skills, qualifications, or capacity. This is captured under the label

competence. The middle-level theme was broken down into ten meaning units, as illustrated in Figure 6-8.

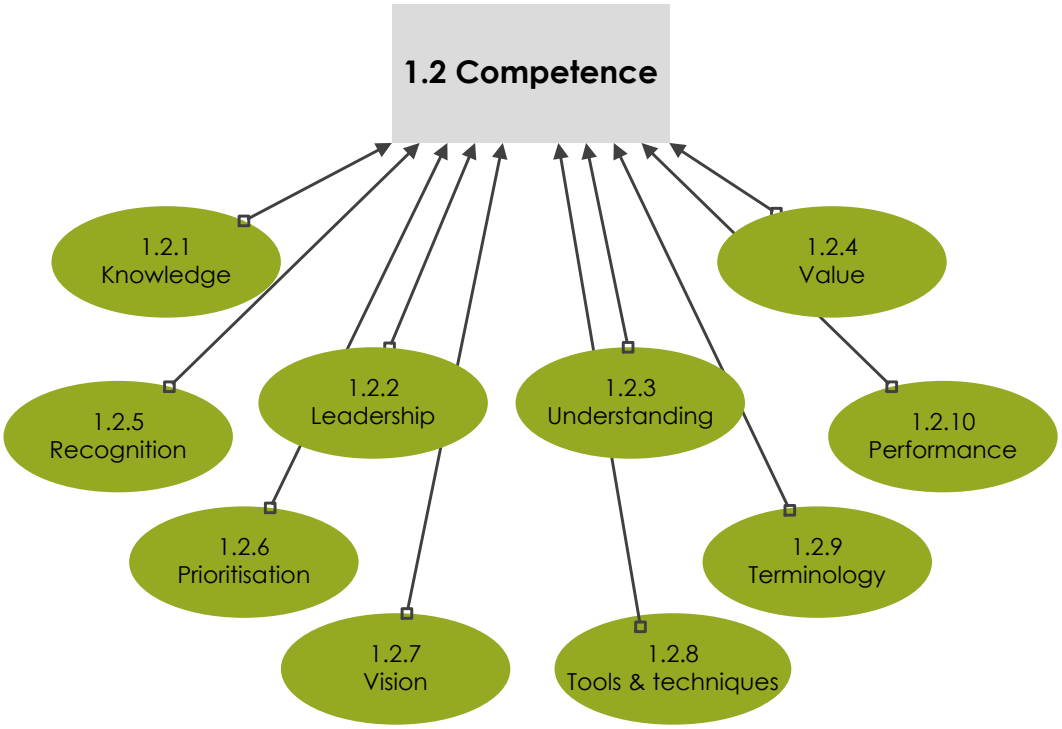


Figure 6-8: Theme 1.2 Competence

1.2.1 Knowledge

The knowledge about LC was pointed out as a required competence for maturity. It was explained that the knowledge about the whole picture of LC is important because:

> *Nine times out of ten when people say 'Yes, I know all about Lean', they know all about 5S and the seven wastes … but what they think is Lean is a tiny piece of the equation.*

Further, it was described that often people do not know that Lean is much more than some tools and techniques (which is arguably the way Lean is often spread in the industry). With a strong agreement in the discussion, the experience was described that often people are familiar with the term Lean but *"they don't understand that the culture and behaviour is as important, if not more important, than the tools and techniques"*. Accordingly, they would often not know how Lean is able *"to drive a business strategy"*.

The irregular existence of LC knowledge was described as *"pockets of excellence"* with a *"big disjoint"* between those. *"So it is quite easy to have small pockets of excellence"* and one example that was experienced *"on a regular basis"* was that *"people struggle with defining what the difference between cost and value is"*. In addition, it was argued that due to these pockets of excellence you cannot see a fast increase of support *"but when you mature it becomes, the whole ... the mass of the whole organisation"*. So we are getting some maturity when the whole organisation or teams and the supply chain work and have the required knowledge in Lean. Mature organisations have the knowledge and the capability to choose the right tools and techniques that work for the current circumstances and they know *"how to build a team, how to facilitate the process"*. Further, it was pointed out that a Lean practitioner or an expert is perceived to have this knowledge because he has delivered value and implemented Lean in different circumstances when he calls himself an expert.

Some knowledge for LC maturity is in addition required from the client. Clients often focus on the wrong things in the process because *"they've tried to step out of their comfort zone into ours and work and guess what the outcome is"*. Our competence of knowledge is to actually *"move into their world and understand what the business outcome is"*, what they really want to achieve with the project; we understand the customer value. So it is about going to *"the client and discuss their requirements and make him think more laterally"*. We need to clearly know *"what does it actually mean? What are we expected to achieve in this"*. The experiences describe a fundamental focus at the front end of the project that enables one to identify customer value.

1.2.2 Leadership

The participants identified leadership in their experience as significant for LC maturity. This was also noted by the observer and further confirmed by the participants through predominantly choosing leadership as the topic with the greatest importance for LC maturity at the end of both FG discussions. An example for the intense focus on leadership is the following statement:

> *You can get every initiative in the world but if you don't look at your leadership, look at bringing people forward and understanding what leadership is ... it's something critical reflection ... reflective judgements and all these*.

Hence leadership was experienced as a required qualification to bring people forward and to *"develop things within your people and that's top-down, bottom-up"*. Furthermore, it was argued that the leadership needs to really understand and focus on the nature of Lean. For instance, it was expected from leaders within a more mature environment that they adapt "*the pre-set position for Lean that everything can be improved"* for their own objectives. It was pointed out that it is critical in terms of leadership in more mature organisations for leaders to provide the alignments between the team and the design intent. Another experience of mature leadership was discussed in the form of simplifying things, as for instance work in progress, and reducing the uncertainty whilst the people are getting developed.

In correlation with the meaning unit 'being passionate' (1.1.3), the possession of fundamentally *"getting it"* was described as really important for the leadership because they will not be able to influence or develop people properly if they actually do not really understand Lean or are passionate about it. For example, they should say *"with a passion they've got that fanaticism"* about Lean. One participant explained this in the statement *"leadership, they've got to walk and talk"*. Moreover, it was described that the leadership needs in addition to *"understand the potential and that they're doing it for them"*.

Further, it was generally acknowledged that the leadership needs this understanding from bottom-up and top-down. In particular was explained that *"leadership from the top needs to engage ... understand ... have the visions"* to develop those leaders that actually drive Lean and the maturity forward. A different experience of one participant about leadership and LC maturity was explained in the following statement *"another thing that Lean does, it points out really bad leaders and bad senior management."*

Finally, it was discussed that in a mature LC organisation leaders do standard work similar to the operatives. This standard leadership work includes *"standard ways of interacting with projects, project teams and so on"* and within this interaction will take place the scientific thinking to gather the data that is necessary to make the right decisions at the strategic level.

1.2.3 Understanding

In this unit the participants focused on the understanding within LC maturity. The true understanding of the real value of the customer and its critical goals was for instance described in the following example.

> *The true understanding of what is the real requirement from the construction system and the built environment. Understanding what the ultimate aim is, so you're not just building a building, what you're going to use the building for, how does the client see it being used, and understanding that across the team inherently means that you fix the things that really matter to them.*

As a required understanding within LC maturity it was further claimed that the people have to understand that they cannot just apply tools and techniques without building the *"culture and behaviour alongside ... it's not worth doing"*. This becomes particularly clear when people have that misconception *"if I'm doing LPS, I'm doing Lean construction"*. It was argued that there must be an understanding that they are just 'doing' a strong tool in the construction phase and that LC *"is a philosophy for the whole business"*. Furthermore, it was explained that more mature organisations understand that the culture and behaviour is created *"amongst the group, amongst the team, amongst your peers"* to be able to actually build on that culture and behaviour in future.

A strong agreement was expressed when a participant explained that maturity comes down to the corporate understanding of Lean and what Lean is able to do for their business (business improvement). A personal experience of that was expressed when a participant pointed out that having the understanding of what Lean is able to do means nobody needs to tell you *"to*

do it, because I know if I do this I can blitz the competition". Furthermore, it was argued that more maturity means a better understanding *"where to apply these techniques to drive business performance improvement"*. Therefore, organisations with more maturity really understand when and where to select the right tool and technique. Another way of understanding was described within the work level where they understand to measure the outputs to make the improvement visible.

In addition, the following statement was generally acknowledged: *"as we mature, we get to a situation where we're going even above understanding that everything is a process and everything has deliverables and customers and performance figures to … the organisation exists for a purpose"*. Such a purpose would be for instance the efficient spending of government money for infrastructure in a certain timeframe. An example of going beyond the understanding was in addition given by moving from an existing differentiation between a day job which *"we're employed to do"* and *"Lean initiatives"*, to everything is a process and Lean is part of it.

Lastly, the more general understanding that construction contains variations which are *"unpredictable in certain areas"* was pointed out. That this is significant was further noted by the observer.

1.2.4 Value

In this theme maturity in LC was associated with a focus on value. The participants described more mature organisations as outstanding in identifying the real value they deliver to the customer. It was explained that more mature organisations are *"doing active things to prioritise and tackle"* the waste within the value stream. Further, those organisations ultimately have teams that focus on that value stream *"right from the top of the organisation down"*. Another participant pointed out that alongside the maturity grows an aggression, of identifying the waste; even in the previous identified value:

> *In a very mature organisation you'd be aggressively going at that value … and saying is it really … is it all real value?*

But in the early days it's all about waste for me. So looking at the ultimate value when you are more mature?

So, whilst they are maturing in LC those teams and organisations challenge their own understanding of value to actually identify the ultimate value.

Furthermore, it was explained that the value will be constantly changing not only from project to project but within one project. Hence mature organisations really revise and actively challenge the identified value.

Moreover, maturity in LC was associated with: *"measure[ing] how effective we are in delivering the value"* as well as gathering of information and details to actually improve this value delivering. One participant further explained that more mature organisations are *"value driven"* rather than profit driven. This was an important topic for the participant in terms of LC maturity, as the acknowledgement of the observer notes revealed.

1.2.5 Recognition

In this unit, participants focused on the recognition of things that are difficult to recognise without maturity in LC. One thing that more mature organisations recognise was experienced with some frustration by a participant. Because people often think that all the problems are in the construction phase and therefore they only try to fix this phase, it was pointed out that it takes them a long while to realise that most of those problems are actually *"symptoms of root causes that we've created throughout the length of this process"*. Hence the participant stated that they have *"got to wake up and not just stick to the tools and techniques"* they know and understand. Further, more mature organisations realise that they are just scratching the surface of LC through that and not using the whole potential that Lean offers for the business. In addition, they would recognise *"I need to speak to the client, I need to be working with the design team at that front end before we even get involved and engaged in the construction phase"*. A further experience described that those who are more mature use their data (from the scientific thinking) to start realising that:

> *The particular symptom you saw on site was caused because of this, this and this. Therefore in accordance, we need to address that in the system. So clients that I've been working with now ... process mapping the activities back in the office or ... process mapping the relationship between the client, the design team, the construction team.*

So, with more maturity in LC people recognise that most of the problems occurring in the construction phase are symptoms and just the tip of the iceberg. This was particularly evident in the statement *"design information is becoming even more key because our processes are getting more slicker in the construction phase [and] that's part of the general maturity… and to do Lean just in construction is not the way to do it because it's all the influences beforehand"*.

Furthermore, one group showed a strong agreement that mature organisations recognise that they have to bring everybody into the team; they *"take an umbrella and bring all that external supply chain into that thinking"*. Therefore, if a team is not recognising this and *"sit across the table between client and contractor: you're one side and we're this side"* that is not really a sign for maturity in LC.

One participant described that Lean maturity also involves recognising that each failure can contain information for improvement and is accordingly positive. The observer noted further an interesting experience described by a participant as recognising that the "cost model" in construction which is *"focusing on cost and only cost and I will generate my revenue out of dealing with my costs"* is the complete opposite of Lean. Further, it was explained that the extent to which *"they are using the cost model"* is associated with maturity in LC.

Lastly, it was described that *"when we're mature, we're going to recognise that with every pair of hands comes a free brain and we're going to use that brain"*. Therefore, we are recognising the potential and knowledge in the people, teams and organisations; and by doing so and using *"the brains of the guys on the tools"* we will receive *"much earlier warning when things are going wrong"*. So the people recognise early that the way we are

doing it *"doesn't enable us to achieve what we want to achieve"*, which is deliver customer value.

1.2.6 Prioritisation

Participants in addition discussed the ability and learning to prioritise as part of maturity. One part of this maturity was explained due to the issue that *"most organisations considered there's probably a million different things that need to be improved"*. Therefore, it is part of the maturity in LC to actually *"hav[e] a system that tells you what most needs to be improved"*. Hence it was further stated that those organisations:

> *Can make the value judgement as to which one matters most, which one most needs improvement, can interrogate the data behind it to determine and prioritise the pieces of our performance that's weakest.*

Furthermore, those organisations determine *"which of the tools and techniques are suitable to help us ... rather than 'let's do an improvement project on this'"*. Another viewpoint from a top-down approach or *"policy deployment"* was described with the statement *"knowing where your most value or criticality is and applying the tools in those places first"*. Just as important as the explanation of prioritising is the ability *"to analyse that they could become and see what that gap is"* to create an improvement plan accordingly.

One participant pointed out that in *"early stages of maturity"* prioritising is possible with a kind of a checklist. However, whilst an organisation is getting more mature they *"start to realise there's a lot more depth to it and then it's quite difficult to articulate"* because the thinking is changing and maturing as well and they have to respond to that.

1.2.7 Vision

In this unit, people focused on the vision for Lean. This topic received specific interest in the discussion because the observer noted this topic as being of particular importance. The vision was described as the first crucial thing that is absolutely necessary *"even at the very beginning"*. Hence it was pointed out that mature organisations need a vision which is

written down maybe in the form of a *"Lean strategic document which is signed off by the senior management, the board"*. This *"published vision and intent"* illustrates in addition *"some knowledge within senior management"*. Furthermore, it was stated that:

> *They don't care about the vision of having more profit, they care about ... delivering end value to their clients*.

The vision gives you an idea of *"what your outcome is going to reward you with"* and responding to this vision are steps that bring you closer to it.

Another participant explained that a team will be kept motivated if they have achievable targets that bring them closer to an extreme vision. So the vision brings the people together as a common goal.

Further, it was pointed out in the discussion that mature organisations have this vision and in addition the people who not only perfectly understand what they are doing in their job but also understand entirely what their contribution to the overall value at the end is. So a participant argued that *"when you're really mature the person who's doing the job"* knows exactly what the contribution of their job to the vision is. Furthermore, those people will be the indication for the vision as well, because the people who do the work personify themselves with the vision of the company and this can be seen in the way they are doing their job. Further, this participant pointed out that more mature organisations rely less on numeric data and computers for their vision indication because, through those people and the way they work, they have lots of visual processes *"like a kanban"* that indicate the vision *"instilled across our operation, in the offices and on-site somehow"* in real time, similar to the production line in manufacturing.

1.2.8 Tools & techniques

Participants did not associate certain tools and techniques with maturity. One participant explained that it is more about the people and how they are choosing the tools and techniques to support them and to address a problem. His experience revealed that a department has selected visual management to support them to manage a huge amount of

tasks. Furthermore they choose visual management *"not from telling them ... but it just materialised out of ... a problem"*. Another participant described that *"visual indications are a key part ... for people to see how what they're doing fits in with everything else around"*. Visualisation received general agreement as being general and useful; which was also noticed by the observer. Further, it was explained that visual information helps the people to *"digest and react ... because it's very easy, very visual and people can tell information really quickly"*.

In addition, it was described that more mature organisations have people who:

> *Understand values and choose tools according to necessities ... to deliver this value. So they are able to do this, they're not just following or picking up ... or anything, but they're choosing according to the needs of the current process or the current organisation or project.*

So maturity associated with tools and techniques comes down to being able to select the right tool and techniques for the current processes and problems to achieve customer value.

1.2.9 Terminology

In this meaning unit the participants focused on the terms used within LC. One participant described his experience from a project that achieved a great success with LC. To share this success within the department they avoided calling it Lean; rather they presented it at the boardroom level as *"different ways, different processes"* and illustrated the value and the target they achieved. Hence there was an argument that described that *"the real success is when we're not calling it Lean ... we're just doing it whatever, whatever"* it is called.

Another participant pointed out that the terms belonging to LC are in fact used by experts and the community of experts and that it needs *"a huge effort in making"* it accessible for everyone. Furthermore, it was explained that organisations can have their own "*detailed field-level language*" when they decide to not use the Lean terminology, but for the Lean maturity, Lean must lead the processes. Hence this level of language will serve as an

"anchoring system to anchor the process … if Lean's not leading the process, then anchor it to perfect delivery [field-level language]".

However, a general agreement in one group was expressed when a participant explained that:

> *The most important thing is … that everybody in one organisation talks the same language. So whatever language it is*.

Therefore, more mature organisations have one common language with common terms for LC.

1.2.10 Performance

Some of the participants explained a strong relationship between LC maturity and performance improvement. For instance, one participant pointed out that with more maturity a great goal would be to improve towards a key performance of having zero *"technical queries which [are] generally 300/400 on major £250 million projects"*. Furthermore, it was explained that *"being able to understand and manage the optimisation … such that they give as easy as possible path to delivery of the corporate goals … [is] part of the maturity of Lean"*. Hence a high level of performance improvement and *"competitiveness and reducing the cost of the delivery"* for the corporate goals was described as one performance of a more mature organisation in LC. This performance improvement contains everything below the corporate goals *"whether it be the sales, marketing activity, and engineering activity … irrespective of where it is"*.

Another part of performance in more mature organisations was described in the form of employees who are motivated *"with a passion to be constantly improving that performance, the performance against those goals"*. Hence a competitive performance against the corporate goals was pointed out as part of maturity in LC.

6.2.6.3 Theme: 1. LC maturity – 1.3 wider perspective

Within the third middle-level theme the wider perspective about maturity in LC was discussed. This involved two different meaning units (see Figure 6-9), first the industry and second some elementary principles about maturity that have been revealed in the discussions.

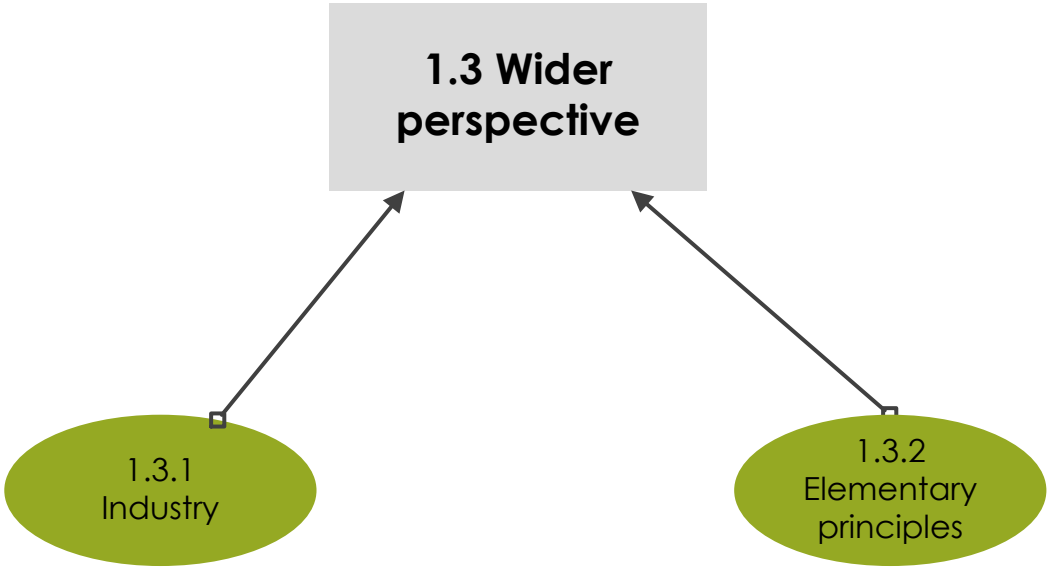


Figure 6-9: Theme 1.3 Wider perspective

1.3.1 Industry

In this meaning unit maturity in LC was associated with the construction industry. The participants did not perceive the degree of maturity of the whole construction industry in the UK to be high. Reasons for that were pointed out as for instance *"the short-term mentality"*, the regional and *"silo thinking"*, and a limited use of what Lean does offer the industry. Hence a participant stated *"it's like a dog beginning to beg and sit up and take notice"*.

Furthermore, it was described that the actual thinking *"all the industries are different"* in the construction industry is wrong. Hence the experience of a participant in optimising the building of pharmaceutical facilities from start to finish in 13 weeks instead of two years emphasised this. It was explained that this huge improvement was only possible through certain *"open-mindedness"* and looking into other industries. Hence this participant looked

at *"how caravans were made"* because *"they're just small facilities"*. Moreover, this participant pointed out that:

> *It doesn't matter what we're creating at the end of the day, every process has input, something that changes the nature, shape and form of those inputs to give desired outputs. And as long as you think about that alongside any industry sector or any process, that's what it is. If someone tells me every project's a one-off, well we do very similar processes, just in a different location with different constraints.*

In addition, in the first FG it was pointed out with some agreement that:

> *Construction isn't much different you know, in terms of the concepts, in terms of the maturity, it's certainly not far behind the ... aerospace.*

And within the other FG it was in addition pointed out that participants with more experience in Lean than in the construction industry do not see a big difference amongst the industries in terms of Lean. The participant stated in this regard:

> *Honestly, I can't see any difference. I've worked in aerospace, telecoms, rail and construction and there's no difference.*

However, it was accepted that the construction industry does have more uncertainty but this would not mean Lean does not work. Therefore the industry's maturity in LC is low and it comes down to a degree of open-mindedness that enables one to accept and learn from other industries that have similar processes.

1.3.2 Elementary issues

Although the participants discussed elementary issues with regard to LC maturity, one general and crucial issue about maturity was pointed out by the statement:

> *There are two fundamentals: one is you can have ... a Lean maturity self-assessment tool, which is HALMAT....or you*

> *can have a practitioner-led maturity assessment, which is a skilled Lean person going and doing it*.

The HALMAT was described as a maturity grid that supports the supply chain to get to some maturity, truly engaging *"leadership"*, *"getting training", "do your systems talk to each other?"* and *"do you understand what value is? ... etc."*. However, *"the practitioner-led assessment methodology"* is different to that as it does for instance check if the set goals for the Lean journey are widely published in the company, or if they are actually doing what they said they will do in their Lean Journey.

Furthermore, one participant pointed out that maturity is in addition something about having *"simple KPIs that trigger a reaction ... so choose an appropriate toolset based on the trigger and the context"*. For instance, it was explained that simple KPIs could indicate that the value we are trying to deliver is changing. Moreover, a dissenter described that KPIs actually have been misused as a *"smokescreen"* because they were too complex. Hence the participant would only use a few simple KPIs for LC.

Another elemental issue that received general acknowledgement was the fitting of maturity in different sizes like project organisations and small entities to huge organisations. Hence it was stated that:

> *Maturity is actually a one-size-fits-all. If you develop it correctly, it will apply whether it's a five-man outfit or a 50,000-man outfit. It's irrelevant of the size of the entity. It is ... Lean will apply regardless of size. ... It's just harder in a bigger organisation ... But the maturity model that is developed has to be a one-size-fits-all ... if you develop the correct one*.

Finally, it was explained that maturity models do not teach the people but they have among other things the *"capacity to measure are you performing to a Lean standard"*, which can lead them in their journey. This particular leading character is lacking in most of the organisations.

6.2.6.4 Theme: 2. Outputs & Outcome – 2.1 Outcomes from being mature in LC

For the second theme in the FG the researcher gave the participants a mind-set with an example of how to distinguish between an outcome and an output. So outputs have been distinguished as short-term and outcomes as long-term success criteria. Whilst keeping this mind-set the participants focused on outputs and outcomes of a LC project from their experience.

The participants were in general agreement with the following statement:

> *I think a non-Lean project which is organised on the traditional paradigm of command and control, adversarial, bilateral contracts and critical path method, top-down push programming, will find it very difficult to deliver most of these. ... Whereas relationally contracted multi-party agreements are based around collaboration and short-term planning systems will have a very good chance of delivering these [outcomes].*

Four meaning units have been created, as illustrated in Figure 6-10.

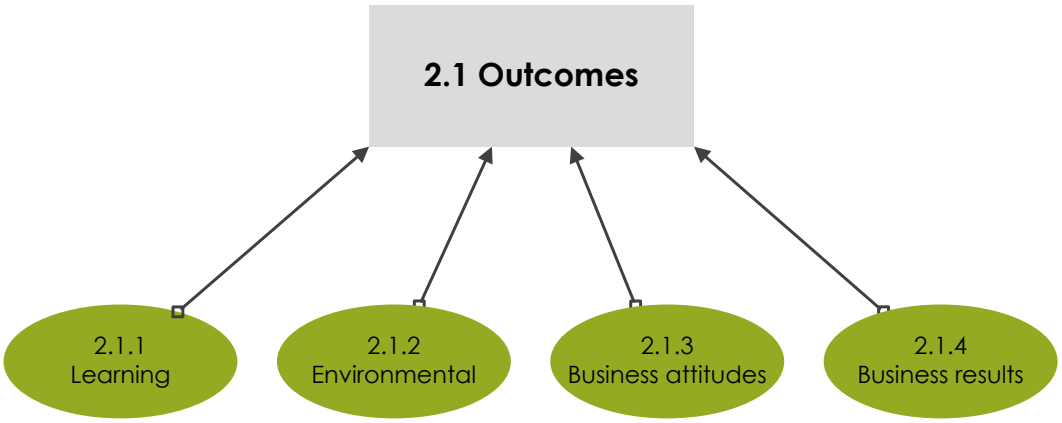


Figure 6-10: Theme 2.1 Outcomes

2.1.1 Learning

In this meaning unit participants focused on the learning that remains as outcome. An important one that a participant pointed out immediately was *"lessons learned and actually effectively using the lessons learnt"*. So the participant explained that *"there's lots of lessons we can learn"*. Because every project – even the ones people think are on-offs – have *"very similar processes in different locations with different constraints"*. Furthermore, lessons learned in a Lean project go beyond a typical financial project review as it focuses on the lessons that should be repeated and the one that should be done differently next time. Another participant stated that this has to include the following consideration *"is there something that we could have done differently with this one?"*. It was evident that mature organisations would use this process of feeding back the information (learning) for their CI, which is certainly different to only collecting lessons and *"not using them well enough"*.

However, lessons learnt was a critical topic as the following statement explains that:

> *Lots of traditional organised companies do lessons learnt and they end up in a filing cabinet ... and probably a lot of senior managers will delude themselves that the lessons they collected are used*.

Hence it was pointed out that the question is do they really use and learn from the collected lessons. For example, it was explained that a team who learned something *"in their way of working and their own experience"* then formally feed this back into the organisation, to change and improve processes towards better *"efficiency and reliability"*. Subsequently, this can be *"captured within the process instructions, the training materials ... [to] do this in more places ... [so that] it's transferred to the rest of the organisation as a way to do business"*. One participant sub-summarised this "*as a real sign of maturity*" with the statement:

> *Demonstrate to us that you've utilised lessons learnt through every stage of the lifespan of this project to say I've identified that as a possible issue and I've gone and looked*

> *at the lessons learnt and what we've done to mitigate that in the past ... If we haven't got it on the system already, I'm going to make sure it's on the system for the rest of my colleagues to utilise going forward*.

And one way that was described to achieve this feedback was visual management and A3s.

Within the discussion it was explained that the A3s are great because *"A3s are there to answer questions from people across the business and across related business ... they have a physical form, they can be in a file, they can be on site"*. Therefore, A3s are able to motivate and communicate the learning amongst the people *"as well as capturing all the knowledge that you've gained through the process"*.

Lastly, a participant stated that an outcome of the learning is that *"we are developing unique tools to address specific problems ... so we're doing what Ohno and Shingo and everyone else did in the early days"*.

2.1.2 Environmental

Some participants experienced a strong change of the traditional environment. For instance, a participant stated that a mature LC project is *"creating ... the environment for innovation, for soft management"*. Another outcome was pointed out as an environment which is much more "*proactive rather than reactive*". Furthermore, it was generally acknowledged that more mature organisations experienced less stress, and less argumentative and more cooperative behaviour. This creates "*as a consequence, a true constructive atmosphere ... to find alternative ways of constructing or designing*". The experience and result of such an environment is obvious in the following statement:

> *In fact I brought 12 of my people from the architects to the client to sail around Corsica [for] two weeks. Everyone was looking at it as 'Are you crazy?', I said 'No, we will have to learn how to behave together and on the same boat you can't escape, basically'. So we have boats where we learn how to behave together and then the project [went] extremely well and we saved 40% ... of the lead time.*

Another example pointed out was that creating such an environment results in greater health and safety. A participant stated that:

> *Well-planned projects that are not continuously changing their programmes where people go and do things out of sequence and out of knowledge of themselves ... that they are safer and have less accidents ... and it is going back to less stress. If people here are less stressed, they can concentrate on the job ... its reliability ... because when you're stressed you can have accidents or you tend to not really see the dangers that are in front of you.*

As a result, it was agreed in the discussion that more maturity in LC means in addition more confidence and predictability in construction projects.

2.1.3 Business attitudes

In this meaning unit participants focused on the orientation of the business. One attitude was stated as *"100% contingency is spent on additional scope rather than unknown unknowns"*. The participant explained that the contingency in construction cannot be eliminated *"because we don't know until we know"*; for instance we cannot know the ground conditions to 100% or in refurbishment projects *"what's behind the panels that we haven't yet removed"*.

Another outcome of being mature in LC for the business attitudes is no litigations, or reducing the amount of litigations. Accordingly, it was described that *"challenging the amount of customer changes with better collaborative planning"* will be an outcome.

Moreover, seeking to using new technology in the best possible way was pointed out as an outcome that the business is following. In addition, it was explained that collaboratively managing risks *"and planning is done at the lowest possible level, rather than planning is done at a high level and risk is pushed as low as possible"* are both outcomes of being mature in LC and shaping the orientation of the business.

In addition, extreme targets were presented as an outcome of being mature in Lean. However, this was also criticised because smaller and more achievable targets are more likely to motivate people. An excellent example that illustrates the attitude of a business setting extreme targets was given by a participant:

> *I'll give you an example, okay: on the railway, the last job I had, we had to cut the time to do a job from 54 hours to eight hours and everyone said it was impossible. And they've just done it. And you've got to be ... you've got to really set outlandish challenges and then look at how you're going to get there. But if you go for small challenges, you'd never move and you undersell the power of Lean.*

2.1.4 Business results

Although the outcomes of being mature are associated with business results, participants described *"happy clients and stakeholders"*, *"ultimately at the end repeat business"*, *"enhanced reputation"* and *"stimulating extra work as well"* as business results associated with a mature LC project.

6.2.6.5 Theme: 2. Outputs & Outcome – 2.2 Outputs from being mature in LC

As one participant pointed out that:

> *We're getting so many more outcomes than outputs. ... because if you do Lean, it becomes embedded and it is ... more outcomes than outputs because they're sustainable, because Lean gives you that constant improvement. So I don't think it's a surprise that we're getting more outcomes than outputs.*

The identified outputs in the discussions have been divided into hard and soft outputs (see Figure 6-11).

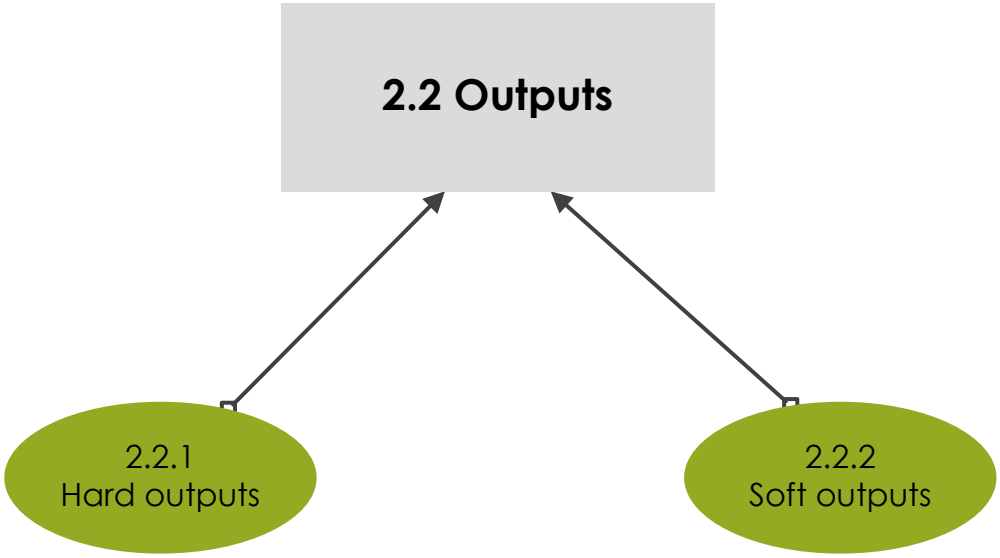


Figure 6-11: Theme 2.2 Outputs

2.2.1 Hard outputs

In this meaning unit outputs from being mature in LC centred on specific facts. Generally acknowledged hard outputs are the performance in terms of the *"quality"*, *"cost"*, time and *"health and safety and environmental impact"*. Further, it was stated that the hard outputs are *"achieving 100% right [quality] first time, delivering the programme as programmed [time], not as per rewritten and reprogrammed"* and delivering the project *"cheaper, safer"* and with *"better quality"* as originally planned. Hence the hard outputs are specific performance criteria for the project and the objective in being more mature is to challenge those original set criteria. This is particularly evident in the statement of one participant: *"my objective is always that I want to improve on that"*.

2.2.2 Soft outputs

Some of the outputs explained by the participants have been rather intangible and therefore associated with soft outputs. For instance, one participant witnessed in a more mature LC project that:

> *Everyone from the labour to the project manager was experiencing less stress … And for me it's an output almost immediate … because of less stress.*

This statement was generally agreed in the group and further stated by another participant as: *"absolutely, less stress … less availability …. Less formal, contractual discussions"*.

Furthermore, it was pointed out that the LC method *"Target Value Design"* is a soft output because applying this technique illustrates a certain maturity in Lean and it has to be done before the project takes place. Hence *"Target Value Design … can identify value and apply that value to your contract … to achieve the desired outcome, the desired value and desired cost. So it's an output"*.

Therefore, soft outputs of being mature in Lean come down to less stress and less need of formal communication whilst they are able to deliver the desired value.

6.2.6.6 Theme: 3. Improving maturity in LC

In this last theme the participants discussed their experience in improving the maturity in LC (see Figure 6-12).

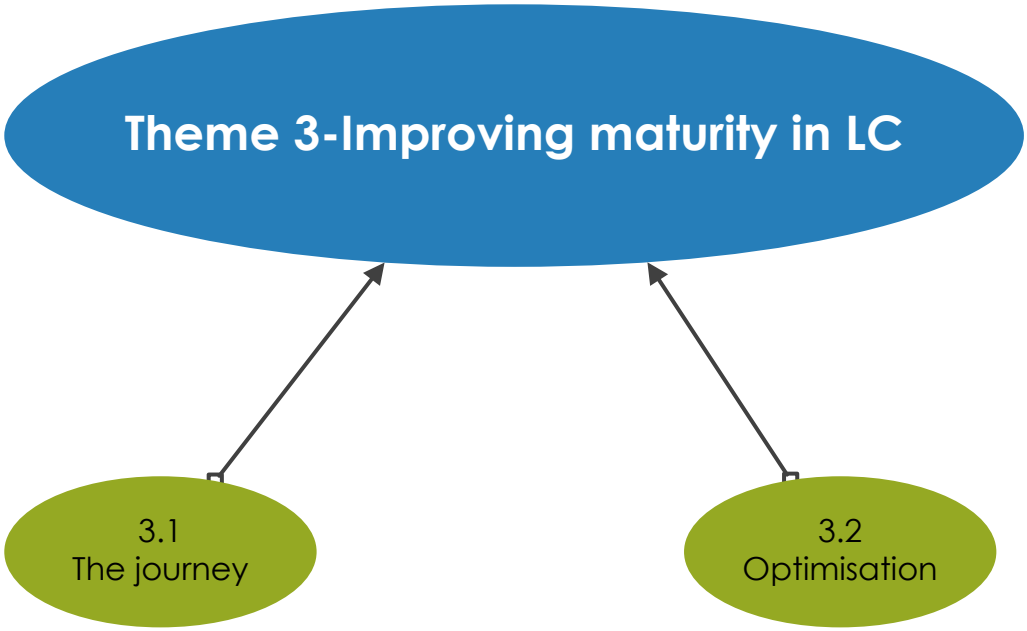


Figure 6-12: Theme 3 Improving maturity in LC

3.1 The journey

Participants associated the process of maturing and improving of maturity with a journey. This was also evident within some statements in earlier themes. One participant emphasised the significance of this in the following statement:

> *People have got to realise it's a journey. You know, it sounds very clichéd but it is a journey that you're starting and we can use all the terminology of single steps and all that but to me it is a journey and it's understanding there's different points of that journey that we will achieve*.

Consequently, it was pointed out that methodologies, tools and techniques can support a moving along the journey but there is in addition the need for an *"internal capability ... to take you further along"*.

Another participant explained that it is important to start this *"journey in the correct manner"*. One way of doing this was described as a clear definition of customer value for each project and the building of a real team for this journey which shares the same ethic and value that they are trying to deliver. Further, it was argued in the discussion that starting a journey towards more maturity in LC requires actually *"some maturity"* in existence. This existing maturity could be for instance the acceptance of the Lean methodology/philosophy as second nature for the organisation. Hence it was stated that there must be something already embodied *"so they've got some concept of this [Lean] but they may need to be educated further"*. It was pointed out that *"educating"* and *"influencing"* from project to project contribute towards putting them into a higher level of maturity in LC. This was in addition explained in form of growth mushrooming so that it grows and grows until it is *"all embedded in the company"*. However, this also involves a detailed look into the organisation as it depends where the existing maturity is: it *"might be at the bottom, it might be somewhere near the top"*.

Although was argued that the establishment and allowing everybody to effectively share knowledge about their *"teething problems"* and what *"worked out well"* contribute to

improving the maturity, it is in particular more useful *"to hear that from the horse's mouth rather than a consultant … or senior management team, tell … about that".*

A last statement from a participant implies further that somebody should not wait to start their Lean journey *"I think Deming's answer was a really good one. And it doesn't matter when you start, so long as you begin today."*

3.2 Optimisation

In this meaning unit participants discussed their experience in increasing Lean maturity. Some participants distinguished in optimising LC maturity between a temporary (project) organisation and an entity. Hence it was stated that:

> *At a project level, I think it's really important to start with short-term planning because that's going to tease out reasons for not doing what the programme says should be done. And as you start to understand that, then you can start putting systems in place which enable you to do what you want to do.*

In addition, it was argued that optimising maturity at a project level can be done through the establishment of a context for the improvement efforts. This can be supported with the alignment of the *"management objectives and motivation to the successful achievement of that project"* objectives.

One way to improve the Lean maturity in a company that was pointed out as an *"incredibly powerful way"* is the *"study action team"*. This team contains managers and senior managers from all levels of the company "*talking, reading together and then discussing in a systematic way what their learning is from the book*". Those managers read and discuss books like: The Toyota Way, Toyota Kata, etc. This process then will create a shared thinking about the implications of Lean as well as an alignment amongst the managers regarding the way they want to proceed. This alignment was noted to be important by the observer and described as being effective in creating energy for the optimisation. Another

participant stated that *"it needs to be intrinsic ... it's got to be what happens within your organisation"*.

Case studies were described as being really effective for both types of organisations. Hence the *"use of examples that people can relate to ... let people visually see that they're not taking a risk; it's not necessarily something new that's not been done successfully before"*. Furthermore, it was pointed out that that it is in general important *"to move from a focus on the individual and a project to a focus on the system";* sequentially a *"move from a focus on results to a focus on learning"* will follow. Moreover, more mature organisations in particular are good at learning and thinking systemically about every single thing they do.

One participant argued that it would be difficult to achieve this learning and thinking systemically at the same time, as is further suggested by Terry and Smith (2011). As another way forward to optimise LC maturity, a participant described a *"Lean champion ... or improvement champion"* as having a better chance of successfully driving the change. However, there was a general agreement that improving LC maturity needs to convince the top management (following Edward Deming's suggestions back in the 1950s) as well as the middle managers who have to change their behaviour and the people at the bottom of the organisation. This is particularly evident in the following statement:

> *If people at the grassroots level are thinking about ... 'hold on why are we doing this there? Why is that causing us a problem there?' ... and in addition the senior management team have the overall strategy being built in the process, at same point it's got to be successful. That's the best way for me I honestly believe.*

Furthermore, it was pointed out that the organisation needs to keep those champions pure, pure Lean champions; although organisations also need to understand that optimising LC maturity is *"not going to be a quick win"*.

Finally, it was generally acknowledged amongst the participants and noted to be important by the observer that culture and behaviour is important: they need to work on the culture and

behaviour. Hence it was stated that *"you need the right culture to make it happen ... it's not about tools and techniques, it's about culture and behaviours of people"*. Therefore, optimising Lean maturity has to follow this statement:

> *Do it to them and it doesn't work. Do it with them and it works ... there's construction managers or project managers, etc., with 20/30 years' experience, they've got some good things they're doing already.*

Accordingly, there was a consensus in the group that the biggest driver of optimisation is the culture and behaviour because LC maturity has to be improved with the people and with the understanding of the top management and the commercial goals of the organisation.

6.2.6.7 Major correlations

The analysis identified a network of relationships between the meaning units and the themes in this primary study. However, since the relevant correlations will be discussed in the next chapter, this section will present only a small overview of the major correlations. Therefore, Figure 6-13 illustrates four themes and 12 meaning units with the highest occurrences of relations amongst them.

For instance, the meaning unit 'Optimisation' (3.2) correlates significantly with 'Leadership' (1.2.2) and 'The fact of being Changed' (1.1.1); this is particularly evident in the statement *"the people that will implement [LC] are the leaders"*. Additionally, correlations between 'Optimisation' and several meaning units (1.1.2, 1.1.3; 1.2.3 and 1.2.4) were identified. The unit 'Being Passionate' (1.1.3) argues for instance that leaders need to being passionate about Lean. Another significant relationship is between 'Leadership' and 'The Thinking' (1.1.2); this was outlined when the participants explained that leaders collect data with scientific thinking to feed this information back to the organisation.

Looking at the themes from the perspective of correlations amongst them, the themes: 'Culture & behaviour', 'Competence', 'Outcomes' and 'Improving maturity in LC' contain the major relations in this data set.

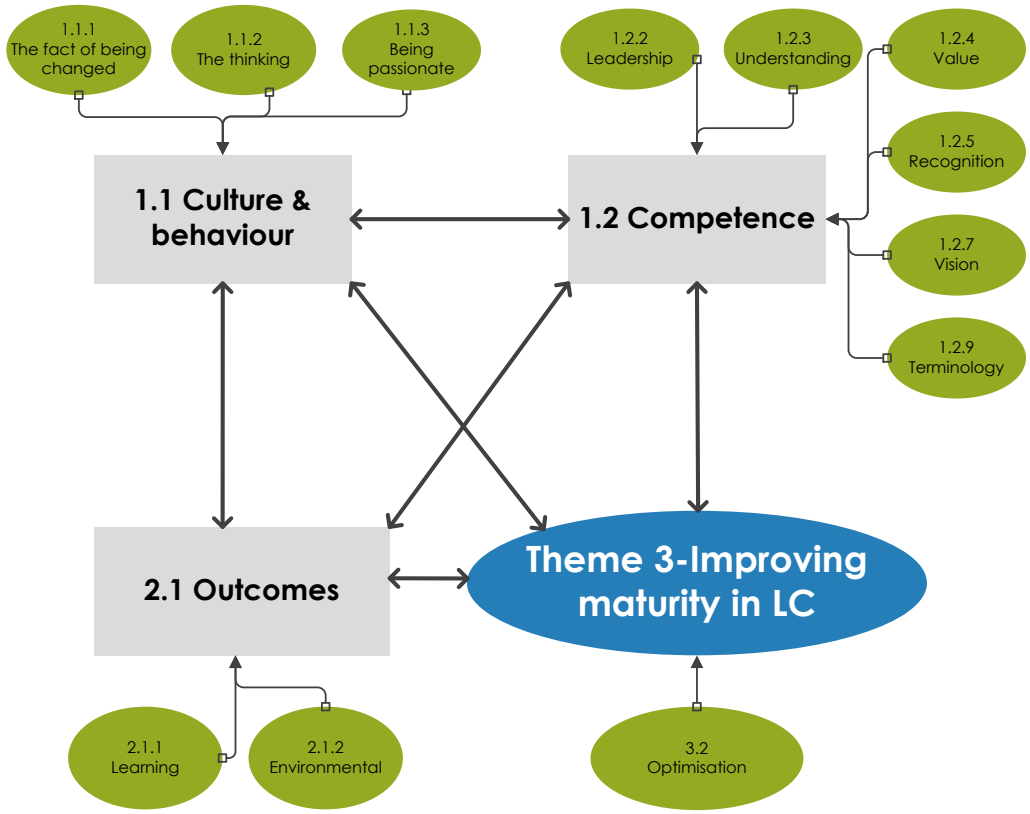


Figure 6-13: Major correlations between the themes and meaning units

6.2.6.8 The essence of LC maturity

The exhaustive description of the themes and meaning units is now condensed into the following short paragraphs which include the essence of LC maturity.

LC maturity comes down to the culture & behaviour and as well to key competencies such as a leadership which fully own and drive LC as a whole. Furthermore, the knowledge and corporate understanding of what Lean is able to deliver and that everything is a process with deliverables as well as every entity exists for a purpose is another crucial competence of LC maturity. Understanding what the ultimate value for the customer is and knowing that culture & behaviour is more important than the tools and techniques together with a published vision is in addition part of LC maturity. Hence maturity is not about the tools and techniques; rather a part is about choosing the right tool to address specific problems, and support the processes that deliver the ultimate value.

Maturity in LC is in particular a culture that does not mind changes and automatically deals with those people who will not accept Lean at all. A further important part is the systemic and scientific thinking for the strategic decisions. Finally, maturity involves making things simpler and having an unrestrained intrinsic motivation to make Lean embedded in the DNA and totally live this philosophy.

6.2.7 Sixth step: Validation

This step was carried out as part of the validation strategy described in the previous methodology chapter and is presented in the next chapter.

6.3 Chapter summary

This chapter has presented the findings of the primary data set in this research. These findings are the result of a systematic and rigorous data analysis and data synthesis. Evidence and the execution of the data analysis for all presented findings have been transparently presented. This was further enhanced with examples of the verbatim data and the synthesis of the data, its meaning and the link to the verbatim transcripts and notes.

The analysis of this primary data led to the development of three overarching themes, which were labelled as follows:

- LC maturity, its culture & behaviour and relevant competencies;
- outputs and outcomes of being mature in LC; and
- improving maturity in LC.

Within these themes the FG discussions revealed insights into the experience of LC practitioners, the meaning they attached to LC maturity and their degree of consensus about LC maturity. This enabled the researcher to reach an understanding adequate to those of the participants in terms of LC maturity. Therefore, an in-depth understanding of what maturity in LC looks like, how it is characterised, what are its attributes, how maturity can be achieved, and what outcomes and outputs are associated with being mature in LC was

developed. The findings suggest that LC maturity is characterised by a certain culture and behaviours – for instance an attribute of that describes that such a culture is open for change. Furthermore, there are crucial competencies present in a more mature organisation – for instance leadership that fully owns and drives a LC philosophy across the whole organisation. LC maturity is about understanding what *value* ultimately means for the system of 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 the ultimate customer *value*. In addition, LC maturity incorporates a systemic and scientific-type of thinking for strategic decisions. It involves active learning, making things simpler and having a high level of motivation that embeds Lean thinking in the DNA of the organisation – and hence lives the philosophy in all its activities. Consequently, these findings of the primary study have contributed towards the achievement of the second and third objectives of this study.

CHAPTER SEVEN

DISCUSSION AND FRAMEWORK DEVELOPMENT

7 Discussion and framework development

7.1 Introduction

The aim of this chapter is to discuss and to combine the outcome of the undertaken research endeavour to develop a framework that enables organisations to measure their current LC maturity. This framework incorporates the achieved first and second objectives of this research and contributes through defining 11 Key Attributes that simplify LC maturity to the achieving of the third objective of this research. Further, this chapter addresses the fourth and fifth objectives of this study through the development of a validated framework to assess organisations' LC maturity. Throughout this chapter a discussion takes place around the elements of the framework with links back to the literature and the findings from both the supplementary and primary data analysis. The second section of this chapter summarises the need and the objectives to develop such a framework that assesses the maturity of LC, and guides organisations towards more maturity. The third section presents the developed structure of the framework and elaborates on these elements. In section four the backbone Key Attributes of the framework is defined by referencing back to the findings and the literature. The fifth section presents the deployed validation process and its outcome for this framework. In the last two sections of this chapter the revised and validated framework for LC maturity together with its practical implications and limitations are presented.

7.2 The rationale for developing this framework

One of the most significant current discussions in the construction industry is the required improvement of the productivity of this industry. In Chapter one it was illustrated that the construction industry has not made any significant improvement in productivity since the 1960s. The past decade has seen the rapid development of LC in this industry and LC was further referred to as the most prominent strategy for improvement (Sage *et al*., 2012). However, central to the entire philosophy of Lean is that it requires the transformation of

organisations, their culture, processes, and people towards LC maturity. Therefore there is a need for the management of this transformation, knowing where you are on your Lean journey, and the sustained embedment of the Lean philosophy and principles. However, little to no attention has been paid to what maturity in LC means, and there has been little discussion about using MMs to manage and support this transformation, as identified in Chapter two. Thus, it is important to support the organisations in their transformation and to understand what maturity means in terms of LC, and to assist transforming organisations in diagnosing 'where they are' on their Lean transformation, which can then support organisations towards greater maturity. As pointed out in Chapter two, the literature supports the need to develop a framework for the assessment of LC maturity.

So far MMs has been applied in many industries and disciplines. However, the concept of maturity has only been applied to a few disciplines within the construction industry such as PM, change management, and process management. However, there are further applications of maturity in relation to the use of Building Information Modelling (BIM) as for instance by McCuen *et al*. (2012), and Khosrowshahi and Arayici (2012). Furthermore, with the development of the LESAT, the MIT showed that MMs can be used to assess the Leanness (Lean maturity) within the aerospace industry. The most significant MM, the CMMI, have been reviewed and a comparison amongst nine selected models was carried out within Chapter two. This comparison resulted in factors which differentiate a MM from other assessment approaches. Hence these factors need to be considered when developing a framework for assessing LC maturity. On the basis of these factors and the aim of developing a framework to support organisations in their transformation towards LC, key objectives have been phrased. These are:

- to facilitate an holistic view of the current state of maturity which uncovers strengths and weaknesses and raises awareness of the areas of concern;
- to establish a shared and common language for LC, alongside the establishing of a systemic and objective basis for assessing the maturity in a simple but comprehensive way; and

- to guide organisations towards more maturity and support them in prioritising their improvement efforts.

The framework for LC maturity being developed in this chapter will address the above key objectives through linking the empirical evidence and the literature. The development of the framework structure is elaborated in the next section.

7.3 Structure of the framework

The basic structure illustrated in Figure 7-1, p. 245 has been adapted from the CMM for people (Curtis *et al*., 2009). Hence the major underpinning of this framework is derived from the CMM development. This is particularly evident as this framework aims to indicate the LC capability within an organisation, while it does measure the current state of maturity. In addition, this framework is non-prescriptive and addresses the institutionalisation and implementation of LC. In other words, this framework supports organisations and their transformation towards greater maturity in LC. The framework components (see Figure 7-1, p. 245) are: five ***maturity levels***; they contain 11 ***Key Attributes***, which are organised within a ***Top Layer*** with factors. The ***Key Attributes*** are further described by a number of ***Behaviour Goals & Practices (BG&P)*** of which each one is expressed in one or more ***Ideal Statements***.

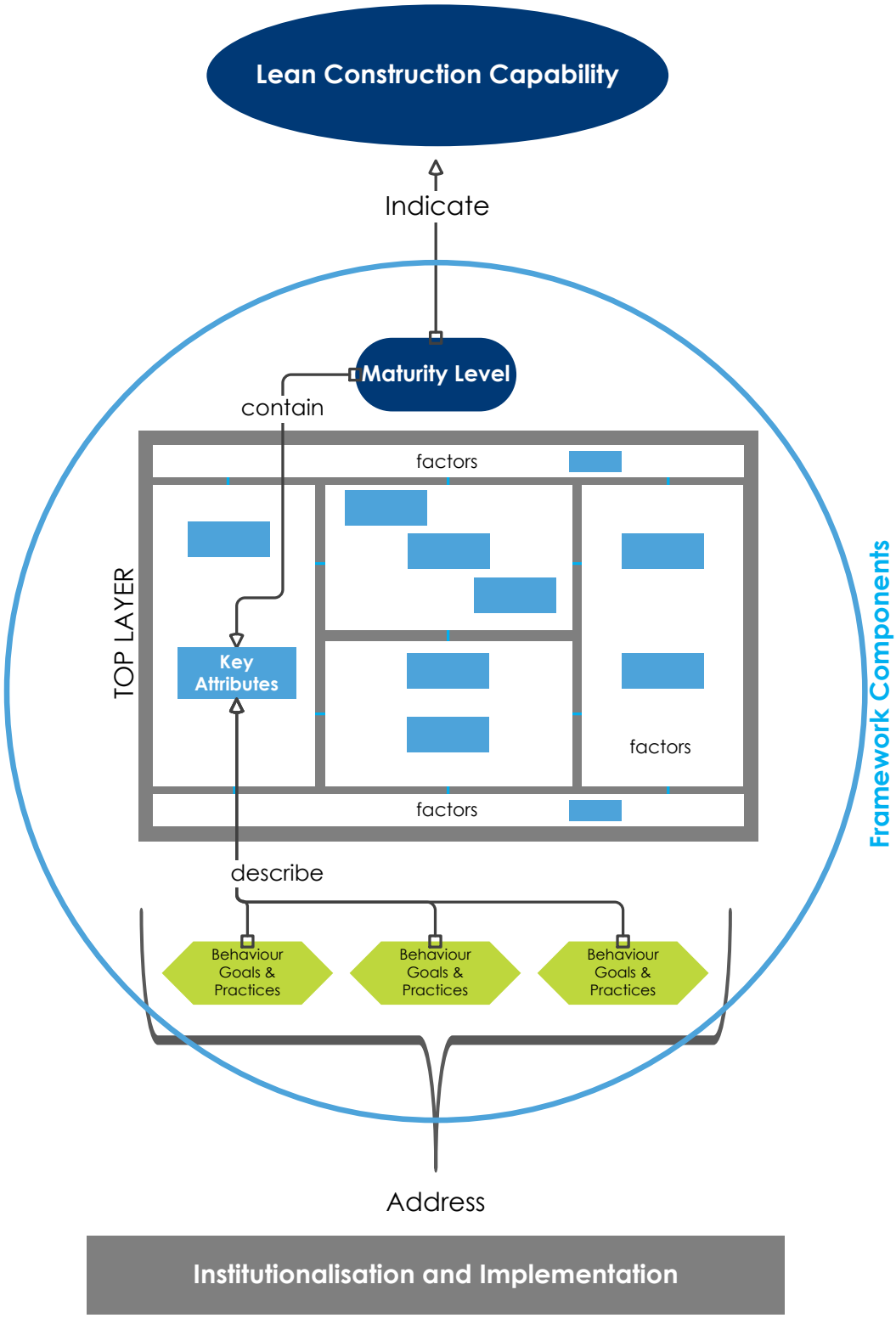


Figure 7-1: Structure of the developed framework (LCMM)

Those components can be further portrayed through five hierarchies, as illustrated in Figure 7-2. Each component/hierarchy of the framework is elaborated in more detail in the following sections.

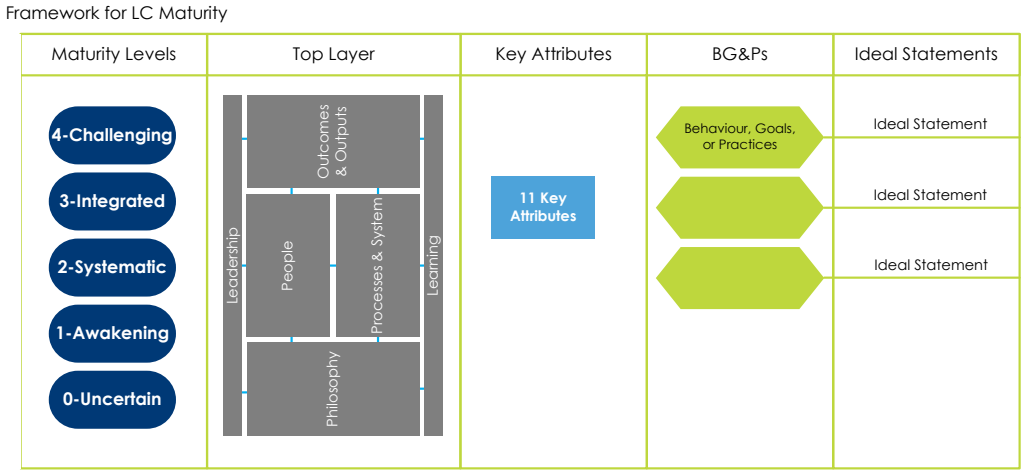


Figure 7-2: Hierarchical architecture of the framework

7.3.1 Maturity levels

The first hierarchy features five maturity levels, each containing the same 11 Key Attributes. Five maturity levels are most common and this is one of the factors identified within the literature review. In detail, the first two levels, 'Uncertain' and 'Awakening', were adopted from the QMMG from Crosby (1979). The levels 'Systematic' and 'Integrated' were adapted from a CMM framework developed for change management in construction (Sun *et al*., 2009). The name of the fifth level 'Challenging' acknowledges the findings of the group interview (a MM for LC should not have an endpoint). Hence 'Challenging' implies that the highest level of maturity in terms of LC is to challenge what this framework set out to be: the ideal of a more mature organisation. This last maturity level is therefore interchangeable with a 'True North' vision to which an organisation will strive towards in their Lean journey. Hence developing towards the highest level of maturity in this framework and beyond provides organisations with a clear 'True North' direction (Rother, 2010). Moreover, each maturity level builds the foundation for the following level; this is similar to the evolutionary

steps as defined in the CMM (Paulk *et al*., 1993a). The adapted maturity levels of this framework are illustrated in Figure 7-3 below.

Figure 7-3: Maturity levels of the framework

The numbers of the maturity levels are not aligned to the CMM because level 0 (Uncertain) implies that an organisation delivers no evidence of any maturity in LC initially, and is therefore zero rather than one, as within the CMM. This is consistent with the importance of defining the current reality as precisely as possible (Fritz, 1999); the researcher believes that confronting people with the current reality of the maturity level (zero) contributes towards a fuller understanding of this reality.

Furthermore, each maturity level contains the same set of Key Attributes including their BG&Ps with their Ideal Statements. However, a Key Attribute can only be at one level of maturity at a time, following the concept of evolutionary steps introduced by Crosby (1979).

7.3.2 Top Layer and Key Attributes

The Top Layer of the framework comprises six factors, as shown in Figure 7-4.

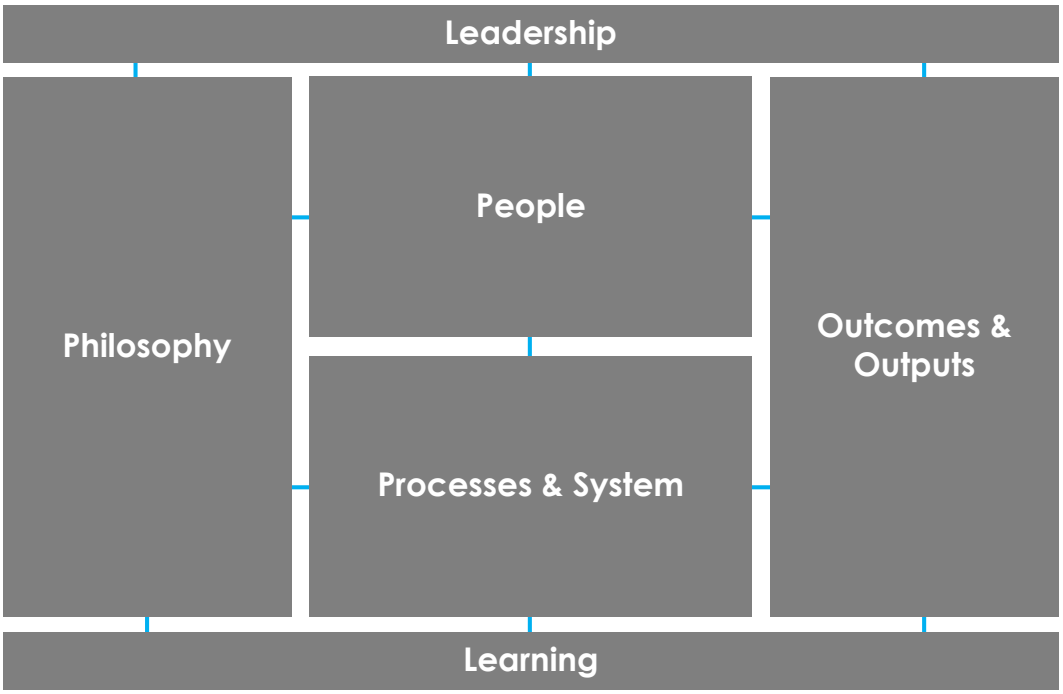


Figure 7-4: Top Layer of the framework for LC Maturity, inspired by EFQM (2012)

The factors in the Top Layer are best defined by Suhr (1999), who defines them in the context of choosing by advantages as "a container for criteria, attributes, advantages, and other types of data" (p. 126). This resulted in factors as a container for the Key Attributes and the BG&Ps, as illustrated in Figure 7-5.

Figure 7-5: Factors defined as a container

Because the framework is used to diagnose and steer an organisation towards their maturity in LC, adopting a definition for factors from a decision-making system seems absolutely appropriate. The six factors in the Top Layer are furthermore named as high-order abstractions (ibid.).

7.3.3 Key Attributes

The Key Attributes of LC maturity has been derived from the synthesis of the findings of the analysis of both the supplementary and primary data of this study. Hence the findings have been combined and condensed to define 11 Key Attributes that simplified LC through a lens of a more mature organisation. In addition, this required simplification addresses the fifth objective of this study. Most MMs simplify the management discipline through best practices, as for instance the OPM3 (Project Management Institute, 2003). However, since the findings of the data analysis of this study see LC not as a set of best practices, or a number of key processes, the researcher decided it is best to capture the characteristics, attributes, experiences, goals, outcomes and outputs, behaviours, and practices of an organisation more mature in LC as Key Attributes. Hence those Key Attributes have to be seen as equal to the key process areas defined within the CMM family. Because of this similarity the Key Attributes of this framework – similarly to the CMM family – adapt a 'purpose statement' as an informative component that describes the purpose of the Key Attribute. For example, the purpose statement of the Key Attribute 'Customer Focus' is ***'to establish and maintain an understanding and focus on both internal and external customer value'.*** The 11 Key Attributes defined are organised through the Top Layer and its factors in Figure 7-6.

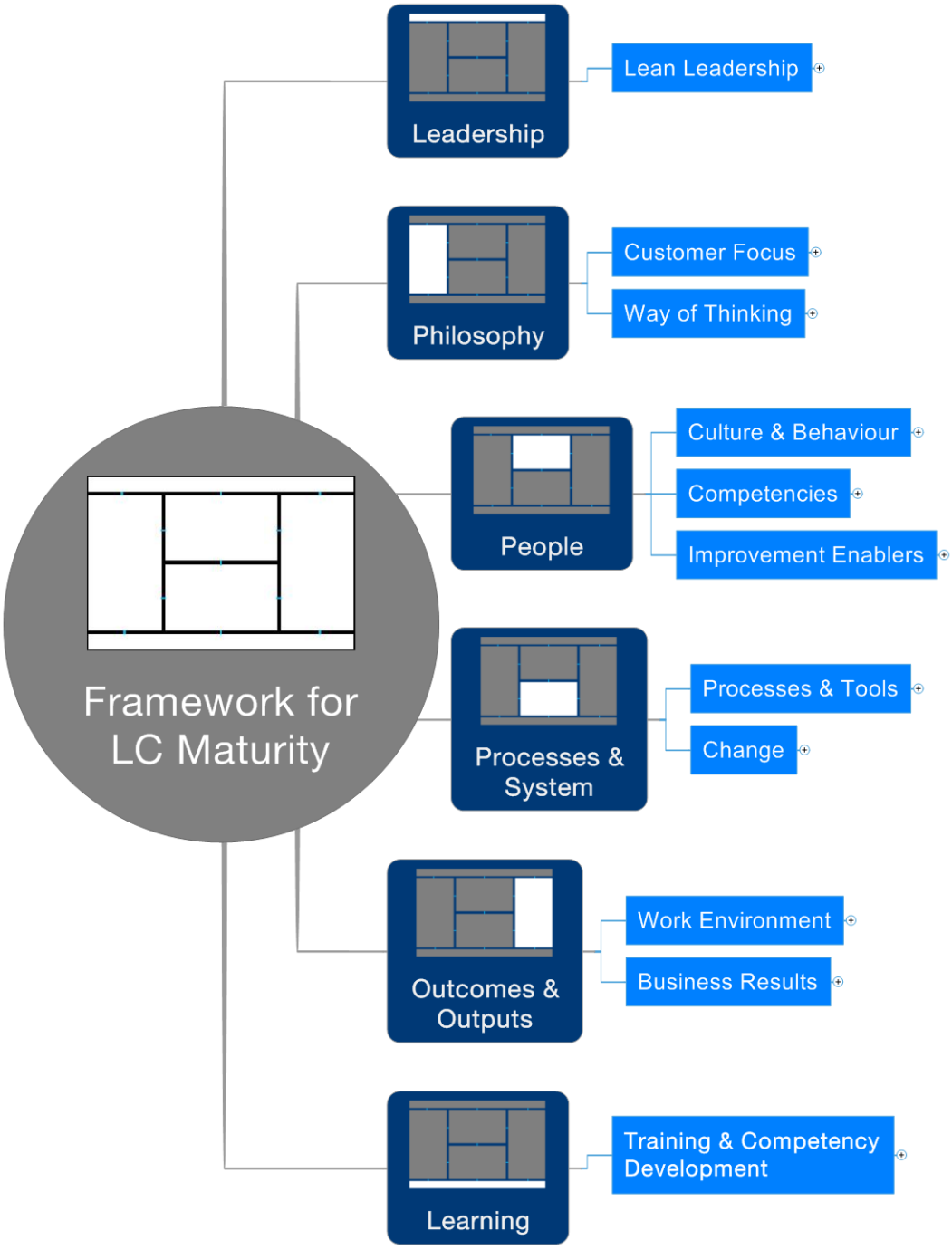


Figure 7-6: Key Attributes organised by the factors

7.3.4 BG&Ps and the Ideal Statements

The BG&Ps within this framework are a combination adapted from the CMMI and the Shingo Prize Self-Assessment Tool SCOPE (CMMI Product Team, 2010, The Shingo Prize,

2013b). The component 'goals and practices' has been adapted from the CMMI but without the differentiation of specific (unique for the process area) and generic (applies to multiple process areas) goals & practices. However, the concept described within the CMM family for the goals as characteristics that must be present to satisfy the process area (Key Attribute within the LCMM) and for the practices as a "description of activities that are considered important in achieving the adapted goals" (ibid., p. 499).

The behaviour part has been adapted from the SCOPE assessment of the Leanness within the Shingo prize. This self-assessment tool focuses on the behaviours of leaders, managers and other individuals within the organisation in terms of Lean. The fact is that the findings of both FG and interviews have revealed that culture and behaviour must be considered to be important within LC maturity; this forms the rationale to combine behaviours with goals and practices. As a result, the combination of the BG&Ps within this framework can be defined as either:

- a behaviour associated with LC maturity;
- a goal in the form of characteristics of a more mature organisation; and
- a practice of activities which are considered to be important for LC maturity.

Each BG&P in the framework comprises a name and one or more Ideal Statements. The names are considered as an informative component and the Ideal Statements are the required component, which must be present in an organisation to satisfy the related (Key Attribute) Key Process Area (CMMI Product Team, 2010).

7.3.5 Maturity Assessment

Following the objectives for the development of this framework, it was necessary to apply a simple but comprehensive method for the maturity assessment.

The applied maturity assessment is similar to the framework based on the CMMI and its Standard CMMI Appraisal Method (SCAMPI). From this maturity assessment method it was adopted that the assessment comprises the gathering of objective evidence in the form of

documents, site visits, and interviews. These will be carried out by at least one person experienced in LC who is trained in using this framework. The interviews to gather the objective evidence should take place with a variety of people of all hierarchies in the organisation and in some sample projects. In addition, it is mandatory that assessors observe the actions and behaviours of the organisation taken on a daily basis. This could be best achieved in the form of site visits and the observation of project meetings.

Furthermore, the assessment method of this framework consists of the element evaluation of an 'ideal behaviour' adapted from the Shingo Prize Self-Assessment Tool SCOPE (The Shingo Prize, 2013b). Accordingly, the maturity assessment involves the evaluation of the fulfilment of the Ideal Statements through the organisation. Hence each of the Ideal Statements in the framework for LC maturity is evaluated with the gathered evidence, observed behaviours, and actions an organisation takes. This evaluation is then divided through the five maturity levels presented in section 7-3.1. As a result, each Ideal Statement is mapped to a maturity level and its definition. For example, if an Ideal Statement is hardly evidenced in the gathered information, and actions an organisation takes, it is evaluated with the maturity level (0) Uncertain. An overview of the definition of each maturity level is shown in Table 7-1.

Table 7-1: 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

In order to achieve a maturity level for each Key Attribute, this crucial rule was implied, ***'The lowest [shared] maturity level defines the maturity level of the unit'***. Hence the maturity level of each Key Attribute is defined by the lowest shared maturity level of all BG&Ps within this Key Attribute. This applies also if a BG&P contains more than one Ideal Statement. Since the maturity levels build on each other through the evolutionary steps, a

higher evaluated level also includes the satisfied lower level, e. g. a BG&P evaluated with maturity level 3 also satisfies levels 0, 1 and 2.

When all BG&Ps have been mapped to a maturity level, the maturity level for each Key Attribute can be assigned by following the above-stated rule. These assigned maturity levels are then illustrated in a spider diagram. A random example of such a maturity summary is shown in Figure 7-7.

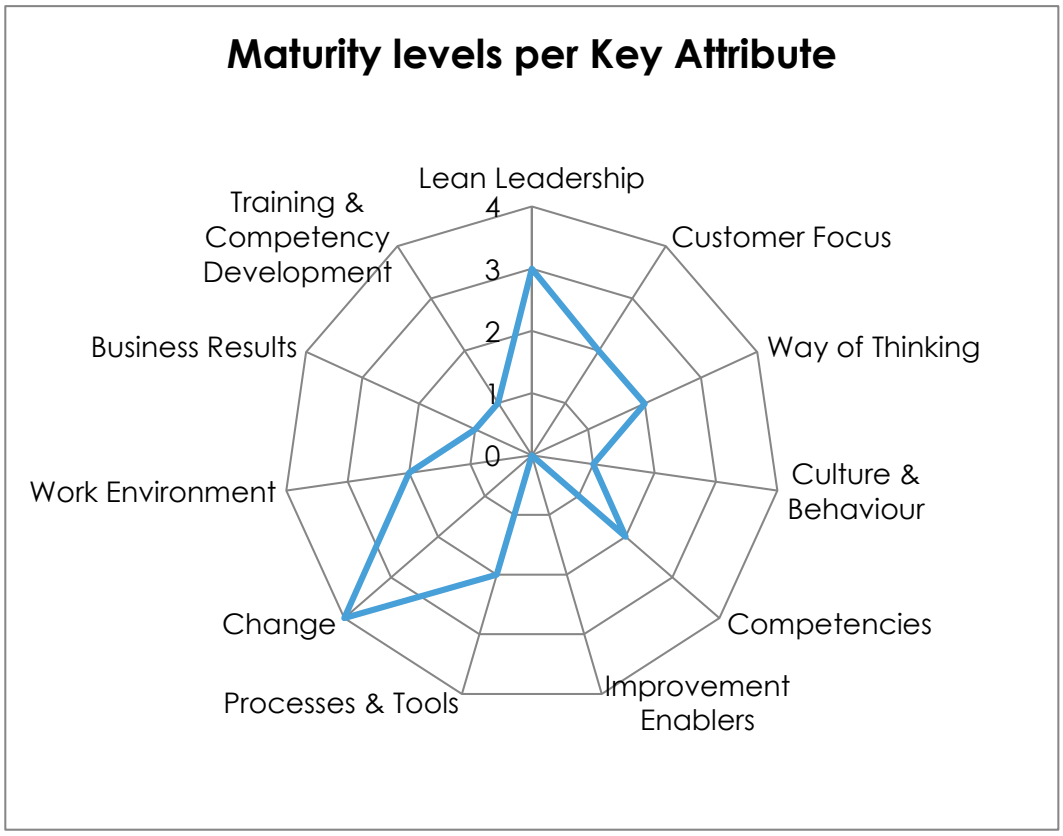


Figure 7-7: Example of a maturity assessment summary

7.4 Definition of the Key Attributes, BG&Ps, and Ideal Statements

In order to allow a simple but meaningful presentation and discussion of the framework components, the consequent order of the Key Attributes mapped to the six factors was used to structure this section. Hence each attribute is discussed within the organised factor to which it belongs. Derived from this discussion, which links the findings back to the literature, the purpose of each Key Attribute is defined as a purpose statement and the BG&Ps and its Ideal Statements have been developed.

7.4.1 Factor - Leadership

Figure 7-8: Factor - Leadership with Key Attributes

7.4.1.1 Key Attribute - Lean Leadership

The Key Attribute 'Lean Leadership' is the crucial element for LC maturity. This was identified from both findings of the interview and was in particular voted for by most participants in the FGs. This was further neatly summarised in one interview as *"leadership is one of the most important ones [attributes]. The leaders have to understand [LC] and to believe [in it]. It's important to get it fast deployed throughout the company"*. As an example the possession of fundamentally *"get it"* was described as really important for the leadership to be able to influence and develop people properly. Further, the leaders have to have the *"passion [and] they've got that fanaticism"* about Lean. In addition, it was stated that leaders in more mature organisations *"understand the potential [of LC] and that they're doing it for them"*. Equally, it was stated in the FGs that you have to *"look at your leadership"* and the leaders really need to understand and focus on the nature of Lean.

Moreover, it was emphasised that leaders in more mature organisations adopt *"the pre-set position for Lean that everything can be improved"* for their own objectives. Hence leaders internalise this pre-set position and apply it on a daily basis. Furthermore, the FGs revealed that the leaders of more mature organisations see themselves as a key element for the deployment of LC maturity and new behaviour within the organisation. Therefore, it was stated that *"they've got to walk and talk"* in order to teach and deploy LC maturity quickly throughout the organisation. This is further recognised as teaching by being the example

within the literature in the context of leadership and its role in organisational change (Graetz, 2000). Since leadership was experienced as a required qualification to bring people forward and to *"develop things within your people and that's top-down, bottom-up"* the leaders on the top of the organisation *"need to engage ... understand ... have the vision"* to develop the leaders that actually drive Lean and the maturity forward. Surprisingly, it was additionally illustrated that Lean "*points out really bad leaders and bad senior management*" if they are not able to fully understand Lean and develop the people accordingly.

Generally, it was acknowledged in both findings that leaders of more mature organisations have a standard and systemic way, similar to the operation, to do their work. For instance, it was stated that they conduct their day in a systemic manner and engage with *"the staff at the place for work"* on a daily basis. In addition, it was described that standard work for leadership includes *"standard ways of interacting with projects, project teams"* and within these interactions scientific thinking is embedded. Hence the standard work of leaders within mature organisations includes the gathering of data to make the right decisions at the strategic level.

Derived from this discussion, a purpose statement of 'Lean Leadership' has been defined, which is: ***'to establish and maintain leaders who actively encourage and drive individuals and teams towards more maturity in LC'***. Furthermore, four BG&Ps have been developed, including their Ideal Statements, which are illustrated in Table 7-2.

Table 7-2: BG&Ps and their Ideal Statement of the Key Attribute - Lean Leadership

Behaviours, Goals & Practices	Ideal Statements
1. Passion	Their leaders fundamentally own it and have a passion about Lean so that they are doing it for themselves.
2. Pre-set Position	Their leaders have an internalised pre-set position that everything can be improved and they apply it to their own objectives.
3. Walk the Talk	Their leaders drive, deploy and spread the new behaviour by being the example.
4. Standard Work	All leaders conduct their day in a standard and systemic way.

7.4.2 Factor – Philosophy

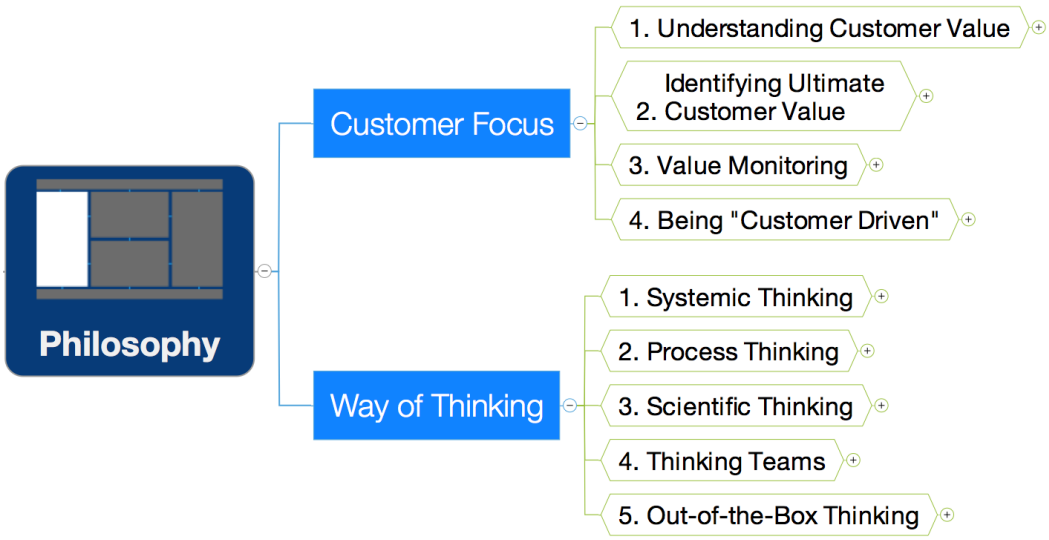


Figure 7-9: Factor - Philosophy with Key Attributes

7.4.2.1 Key Attribute - Customer Focus

The importance of the first Key Attribute in this factor was stated in the interviews with a particular focus on the understanding of customer value. In addition, it was explained in the FGs that being mature means being *"outstanding in identifying customer value"*. Both refer back to the first principle and critical starting point of Lean thinking 'specify value' (Womack and Jones, 2003), and the arguments that value is divided into internal value amongst the delivery team and external value as the customer value (Emmitt *et al*., 2005). In addition, it was demonstrated by Salvatierrra-Garrido and Pasquire (2011) that customer value involves the requirement of at least three client groups, "owner, user and society". Finally, the key to understanding customer value is to respect the value perception of the customer (Erikshammar *et al*., 2010). Moreover, the FGs identified that mature organisations *"really revise and actively challenge the identified value"* towards the "*ultimate value"*. Equally, Emmitt *et al*. (2005) and Salvatierrra-Garrido and Pasquire (2011) argue that customer value will change over time and is therefore subjective. This mutation of value over time has been further recognised and documented by authors within value management such as Green and Moss (1998) and Thomson *et al*. (2003).

Hence it is important to continually revise value once it has been identified. Further, it was pointed out in the interviews and the FGs that the effectiveness of the value delivered to the customer needs to be "*monitored"*. This was neatly summarised by an interviewee as: *"the first thing I ask is do you understand your customer's value? The second thing is: do you know [by] how much you are deviating from your customer's value?"*. Monitoring customer value was further linked with the identification and "*measuring of waste"*. The FGs demonstrated that more mature organisations *"do active things to prioritise and tackle"* the waste within the value stream. So, by understanding and monitoring customer value, the organisation or project establishes a focus of *"really thinking what the client needs"*. This was further proposed in both findings as being *"customer driven/value driven"*.

Derived from this discussion, a purpose statement of 'Customer Focus' has been defined which is: ***'to establish and maintain an understanding and focus on both internal and external customer value.'*** Furthermore, four BG&Ps have been developed, including their Ideal Statements, which are illustrated in Table 7-3.

Table 7-3: BG&Ps and their Ideal Statement of the Key Attribute – Customer Focus

Behaviours, Goals & Practices	Ideal Statements
1. Understanding Customer Value	A: They understand that customer value involves the requirements of the chain of internal and external customers up to the end user. B: They are focused on the value perception of the chain of customers to be clear about what is the required value that needs to be delivered in the best possible way.
2. Identifying Ultimate Customer Value	A: They are outstanding in identifying real value for their customers. B: They actively revise the identified value stream to react to any changes of the customer value and to tackle any waste in this sequence of processes to create the ultimate value.
3. Value Monitoring	They know their deviation from the customer value by monitoring the effectiveness of delivering this value.
4. Being Customer Driven	Leaders and managers focus on doing the best work for the customer and accept that being customer driven is no contradiction to the business drivers such as satisfaction of the shareholders.

7.4.2.2 Key Attribute - Way of Thinking

The 'Way of Thinking' as an attribute for LC maturity was predominantly identified in the interviews. Its importance was reflected in the statement: *"maturity is not just behaviour, but also the thinking because the thinking leads to behaviour"*. Three different types of thinking were identified from the interviews and FGs: 1) systemic thinking, 2) process thinking, and 3) scientific thinking. Systemic thinking was explained in the interviews as seeing the customer and the processes in a systemic way as a system, e.g. *"a system of customer"*. Following Atwater and Pittman (2006), systemic thinking contains three dimensions: synthesis, behaviour over time and feedback loops. Equally, the Shingo Prize criteria illustrates these three parts of systemic thinking as: holistic thinking, dynamic thinking and closed-loop thinking (The Shingo Prize, 2010). They further argue that thinking systemically means seeing the system as a whole, recognising that the synergy between all parts of the system is far greater than the sum of the parts and understanding how the information flows amongst the parts. Production systems such as Lean production and their approaches can significantly benefit from systemic thinking (Hines *et al*., 2006). According to Bartlett (2001) the concept of systemic thinking is in particular underpinned by Goldratt's theory of constraints and systems thinking.

Correspondingly, systems thinking is further very similar to process thinking, but the second emphasises processes, their relationships, objects and structure (Emblemsvåg and Bras, 2000). In addition, the findings of the FGs revealed a correlation of (total) system(s) thinking and LC maturity. Considering this, it makes sense to incorporate these findings under process thinking. Hence the findings suggested that the thinking has to challenge the process (way) things have been done in the past, *"the status quo"*. Further, it was explained that such thinking about the processes and the systems leads to realisation that the design phase can benefit from the *"inherent knowledge in the workers"*. Not surprisingly, this is similar to the systemic thinking argument in the literature that the important element of systems thinking is to understand the system and see the whole picture (Seddon and Caulkin,

2007). The most successful application of systems thinking is Toyota with the Toyota Production System (TPS) which underpins Lean management with systems thinking (ibid.).

Scientific thinking was described in both findings as *"collecting information through standard interactions to feed it back into the corporate management and the strategic decision processes"* and *"how they [people] test hypotheses and how they [people] put countermeasures in place in order to make adjustments"*. According to Richmond (1993), scientific thinking means the application of a rigorous agreement of thinking about variables, dynamics and the way hypotheses are tested. In addition, scientific thinking is a part of the Shingo Prize Model (The Shingo Prize, 2010). According to The Shingo Prize (2010) there are several models which reflecting scientific thinking, as for instance: A3 thinking, the creation of an A3 report that supports clear thinking and learning (Liker and Convis, 2012), or the Plan, Do, Check, and Act Deming cycle (Darrington and Howell, 2011).

The FG discussions further identified that the above way of systemic thinking and process thinking will develop a thinking team or thinking staff that goes from doing things as they did before to *"really think about what you're doing and how you are doing it next time"* so that they become more aware about *"safety", "using their brains"*, and being *"part of the decision-making process"*. Moreover, it was stated that with more maturity the thinking of those people will align with everybody's activity in the direction of improving the corporate goals. Further, it was pointed out that thinking teams can be identified through behaviour of delivering improvement, challenging processes and seeing the value chain in the organisation from the top to the bottom regardless of the subject, department or processes.

Finally, it was pointed out that it is beneficial to have some people who are not aligned, some people who think "*the awkward thoughts and challenging leadership"*, and people who are "*the grit in the oyster to produce the pearls*". So in a mature organisation there must be some lateral thinkers who often go off the beaten tracks to find new solutions and challenge the leadership to stimulate improvement.

Derived from this discussion, a purpose statement of 'Way of Thinking' has been defined, which is: ***'to establish and maintain a holistic approach of thinking that supports LC maturity.'*** Furthermore, five BG&Ps including their Ideal Statements have been developed which are illustrated in Table 7-4.

Table 7-4: BG&Ps and their Ideal Statement of the Key Attribute – Way of Thinking

Behaviours, Goals & Practices	Ideal Statements
1. Systemic Thinking	They think systemically to see the big picture, the whole, the information flow within the system and establish links between every value stream and aspect of the business to create synergies. For example: they practise continuous improvement to see processes and customers in a systemic way.
2. Process Thinking	The people accept that value is created through processes and understand those processes and their relationships.
3. Scientific Thinking	They are rigorous in collecting information about variables to support the decision-making process and testing hypotheses in a scientific way.
4. Thinking Teams	Everybody's activity is aligned in a direction of delivering improvement and challenging processes, from the top to the bottom regardless of the subject, department or processes.
5. Out-Of-The-Box Thinking	There are some lateral thinkers who often go off the beaten tracks to find new solutions and challenge the leadership to deliver improvement.

7.4.3 Factor - People

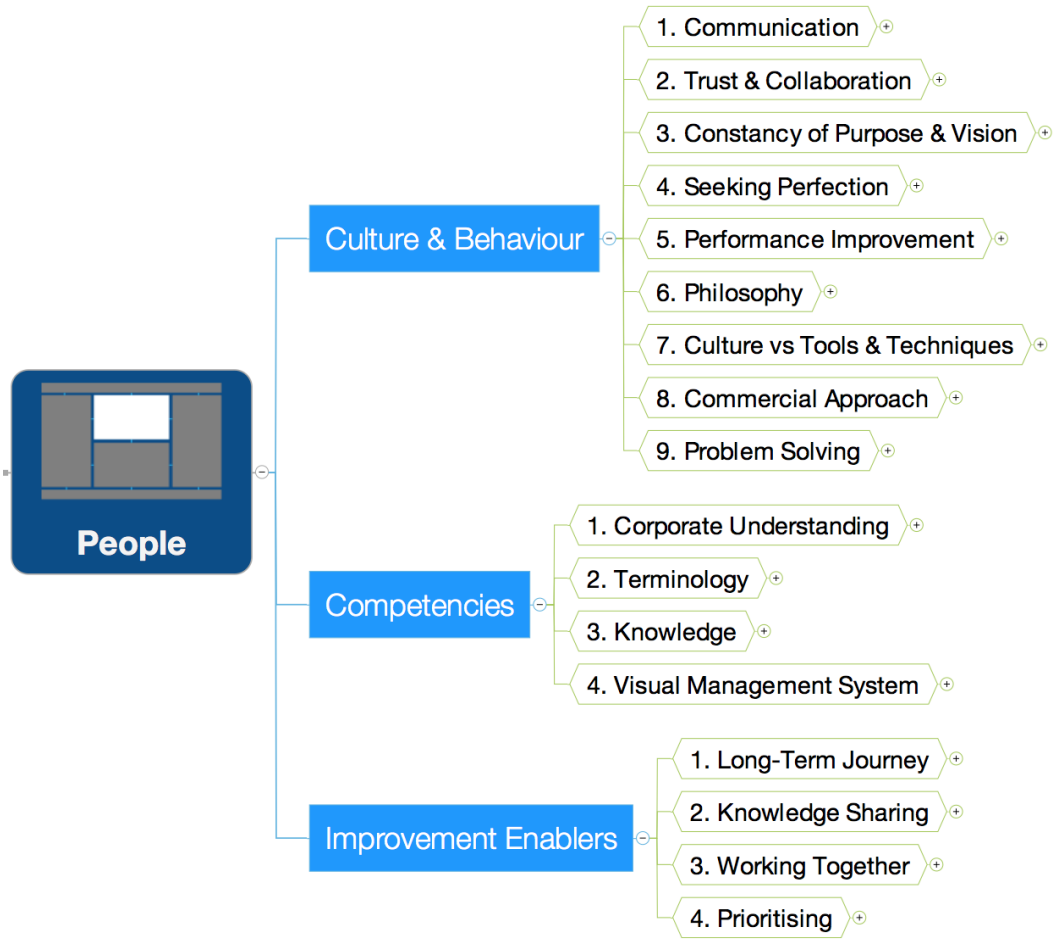


Figure 7-10: Factor - People with Key Attributes

7.4.3.1 Key Attribute - Culture & Behaviour

The Key Attribute 'Culture & Behaviour' comprises nine BG&Ps. These were predominantly formed by the interview findings such as: communication, trust & collaboration, constancy of purpose & vision and seeking perfection. For instance, it was stated: *"I would say communication is the most important aspect in this regard [LC Maturity]"*. Further, it was stated that communication is improved through a better flow of information and *"less need for constant meetings"*. In addition, it was explained that mature organisations are characterised by a *"really good communication, and vision and value are being communicated to people"*. Moreover, it was pointed out that trust amongst the people in the project and organisation is absolutely essential and will be recognised as the "*people*

opening up" and working better together and collaborating more with an increased maturity in LC. Further, it was argued that collaboration is *"one of the important values"* and *"if they don't collaborate that much all the Lean [tools] won't be able to give you as much as they could"*. Accordingly, it was claimed in the FGs that collaboration is a fundamental part to be able to deliver associated outcomes of LC. Furthermore, it was argued that people actually realise and spread in the organisation that "*working collaboratively between the designers, the structural engineers, the architects and the M&E brought a very good solution; it worked very, very well*". Additionally, it was stated that collaboratively managing risks and planning is shaping the orientation of being mature in LC. Similar to those findings in terms of communication and collaboration, the development of improved communication and collaboration under LC is identified in other studies such as Ballard and Howell (2005) and Eadie *et al*. (2011). That collaboration and trust are important for LC is further shown by Saaty (1990), who argues that these would enable bottom-up management. Comparatively, the importance of communication is also pointed out from research focusing on measuring the extent to which the 14 management principles from Liker (2004) are applied in LC off-site manufacturing (Koskela *et al*., 2006).

The constancy of purpose, Deming's first point out of 14 (Darrington and Howell, 2011), was mainly identified in the interviews as part of LC maturity and further described as the consistency within the direction and the identification of the purpose to be on a Lean journey. Hence it was stated if *"you have consistency of purpose"* you know the direction in which you are going to fall. In both interview and FGs findings it was argued that the vision of the organisation to be on a Lean journey is an important part of LC maturity. In addition, it was described in the interviews that the vision identifies their purpose and commitment of becoming Lean. In addition, the FGs revealed that the vision is the first crucial thing *"even at the very beginning"* that illustrates, when published as a *"Lean strategic document ... signed off by the senior management"*, some knowledge about Lean at the board level. The requirement of a long-term vision was for instance demonstrated in the literature as a focus of direction for implementing LC (Nesensohn *et al*., 2013). Further, the constancy of

purpose and having that vision as a strategic direction is also rooted within the Shingo Prize criteria (The Shingo Prize, 2010).

Seeking perfection was identified through statements in terms of being – in a positive way – fanatical about perfection and practising of CI. Evidence was demonstrated in the FGs through statements such as *"the thing with a mature Lean team is that they are fanatical about perfection"*. Not surprisingly, seeking perfection is identified within this study as an important element of Lean, since it plays a major role in the literature as the fifth principle of Lean thinking (perfection) (Womack and Jones, 2003). Comparatively, CI is found in Problem-solving & Learning, one of the 4 Ps defined by (Liker, 2004).

The strong relationship between performance improvement and LC maturity was emphasised within the FGs. Hence it was stated that *"being able to understand and manage the optimisation ... such that they give as easy as possible path to delivery of the corporate goals ... [is] part of the maturity of Lean"*. Therefore, a high level of performance improvement and *"competitiveness and reducing the cost of the delivery"* towards the corporate goals was illustrated as the performance of a more mature organisation in LC. This performance improvement contains everything below the corporate goals *"whether it be the sales, marketing activity, and engineering activity ... irrespective of where it is"*. Moreover, the employees have *"a passion to be constantly improving that performance, the performance against those [corporate] goals"*. That the employee motivation increases the focus on performance improvement within LC and this improvement effort is influenced by the corporate goals was equally pointed out in a performance improvement model of Aziz and Hafez (2013).

Not only was the association of LC maturity and the Lean philosophy identified from the interviews and the FGs, it was also illustrated by the group interview with the leading LC academics and specialists. In the FGs it was then pointed out that the people have to own Lean and that *"they're living it and ... they apply it in the workplace but they're probably applying it in their normal lives as well outside, so they just become all-encompassed"*.

Furthermore, it was argued that there is a need to understand that Lean is a way of thinking *"a philosophy for the whole business not just for the construction phase … and you can't just pick it up and use it"*. Therefore, the individuals and teams have to own Lean and they need to 'get it'. This was for instance explained as being passionate and fanatical about Lean in a positive way, so with more maturity *"they're totally living it"* and *"get that embedded"* in their *"DNA and then start to get fanatical about it"*. Accordingly, it was explained that there would have been a feeling of honesty, completeness and transparency amongst the people in more mature organisations. Hence it was associated that those organisations accept that Lean is a philosophy that enables them to deliver customer value. Equally, it was identified in the interviews that the immigration of the Lean philosophy throughout the organisation is embraced by LC maturity. A similar view of Lean as philosophy for the management is taken by Ballard and Tommelein (2012).

Furthermore, it was specified from the findings that it is crucial to not just apply tools and techniques without building the *"culture and behaviour alongside"* because *"it's not worth doing"*. Further, it was stated that culture and behaviour is actually *"more important than the tools and techniques"* and this culture and behaviour is created *"amongst the group, amongst the team, amongst your peers"*. As an example, it was explained that people often have that misconception *"if I'm doing LPS, I'm doing LC"*. Equally, Rybkowski *et al*. (2013) remind us that this is a misunderstanding of the culture of LC.

In addition, within this attribute the way mature organisations are *"behaving commercially"* was identified. Hence it was argued that the commercial approach of the organisation is important. The difference was stated in an interview: *"driven on price or driven on overall cost …[do we] worry just about the price of a package or do we think about the whole picture, the quality, the health and safety of all those aspects"*. Furthermore, it was argued that with increasing Lean maturity in the organisation the extent of using the cost (model) decreases, because it is not a main factor in delivering customer value.

The BG&P *"problem solving"* was further derived from both findings. Hence in the FGs it was argued that with more Lean maturity people would see failures as a trigger to solve occurring problems so that problems with those variables will be avoided in future. Further, it was stated that they would recognise occurring problems as symptoms and try to identify the root cause of those within the processes. Likewise, Pasquire (2012) reminds us in her literature review that the inclusion of workers in the problem-solving process is effective and connects it to Deming's Plan Do Check Act cycle. Equally, it was stated in the FGs that mature organisations realise that with every worker *"comes a free brain and we're going to use that brain"*.

Derived from this discussion, a purpose statement of 'Culture & Behaviour' has been defined, which is: ***'to establish and maintain a commitment and alignment of individuals and teams to engage actively through their behaviour in the transformation process.'*** Furthermore, nine BG&Ps have been developed, including their Ideal Statements, which are illustrated in Table 7-5.

Table 7-5: BG&Ps and its Ideal Statement of the Key Attribute – Culture & Behaviour

Behaviours, Goals & Practices	Ideal Statements
1. Communication	Everyone knows and understands the vision of their Lean journey and the value Lean offers for their role through a smooth flow of information.
2. Trust& Collaboration	Everyone understands trust and collaboration as an enabler for LC and deploys it on a daily basis, especially for the managing of risks and planning.
3. Constancy of Purpose & Vision	The purpose to be on a Lean Journey is published as a Lean strategic vision and signed off from management and they are striving constantly towards this strategic direction without changes.
4. Seeking Perfection	They are fanatical about perfection and practising systemic CI as an incremental on-going effort to improve the way customer value is delivered.
5. Performance Management	They have an intrinsic passion to constantly improve the performance of delivering the corporate goals.
6. Philosophy	They encompass Lean as a philosophy for the whole business including the design and construction phases so that this philosophy is part of the organisational DNA.
7. Culture vs. Tools & Techniques	They understand the importance of building a unique culture and behaviour side by side with the application of tools and techniques.
8. Commercial Approach	Their commercial behaviour focuses on the big picture consisting of the overall cost, quality, HSE and delivery of customer value.
9. Problem Solving	They recognise failure as a trigger for problem solving and effectively involve the workers and their inherent knowledge to identify the root cause to avoid the occurrence of problems in the future.

7.4.3.2 Key Attribute - Competencies

The importance of competence and expertise within LC maturity was elaborated within the FG discussions as well as the interviews. The following BG&Ps derived primarily from the consensus in the FG findings: Corporate Understanding, Terminology, and Performance. Hence it was explained that maturity comes down to the corporate understanding of Lean and what Lean is able to do for their business (business improvement). Further, it was explained that *"being able to understand and manage the optimisation ... [is] part of the maturity of Lean"*. A personal experience in this regard pointed out that having the understanding what Lean is able to do means nobody needs to tell you *"to do it, because I know if I do this I can blitz the competition"*. Furthermore, an example was stated that mature organisations move from an existing differentiation between a day job which *"we're employed to do"* and *"Lean initiatives"* to everything is a process and Lean is part of it. In addition, this is reflected within a *"true understanding of what is the real requirement from the construction system and the built environment"*.

In terms of the terminology, it was generally agreed in a FG that *"The most important thing is ... that everybody in one organisation talks the same language. So whatever language it is"*. As a result, mature organisations can have their unique *"detailed field-level language"* with common terms for LC or they can establish the Lean terminology as a common shared language. This common shared terminology about LC enables them to receive greater potential from LC (Marhani *et al*., 2012).

The rest of the BG&Ps have been developed from both findings, as for instance the knowledge. Most commonly, it was elaborated that the knowledge about Lean is part of LC maturity and *"in the sense of really knowing and applying Lean concepts on a daily basis"*. As a result, it was elaborated that people should have knowledge about the whole picture of LC and not just *"all about 5S and the seven wastes ... [which] is a tiny piece of the equation"*. Accordingly, it was illustrated that people should know that Lean involves – besides the five elements of Lean thinking, tools and techniques – also the culture and

behaviour. In this regard, it was stressed in the FGs that *"it is quite easy to have small pockets of excellence"*. An example of such a pocket of excellence was explained as when *"people struggle with defining what the difference between cost and value is"*. In addition, it was argued that due to these pockets we are not seeing a fast increase of support *"but when you mature it becomes the whole ... the mass of the whole organisation"*. Consequently, it was argued that we are getting some maturity when the whole organisation or teams and the supply chain work and have the required knowledge in Lean. Moreover, it was in particular described that some knowledge from the client is required to allow a moving *"into their world and understand what the business outcome is"*.

Visual management was generally acknowledged in both findings and further described as the visualisation of the progress and the visual indication of the contribution towards the overall value. Hence more maturity in LC was associated with the creation of visual indications through the contribution of the people towards the ultimate value. Furthermore, it was pointed out that more mature organisations rely less on numeric data than on visual management to indicate their vision. Hence those organisations visualise their processes while using *"kanban"* and other ways to indicate the vision across the operation in real time. In addition, it was stated that visual indications are a key part *"for people to see how [and] what they're doing fits in with everything else around ... because it's very easy, very visual and people can tell information really quickly"*. Equally, it was pointed out by Goodson (2002) that visual indications are an established part of assessing the Leanness. Goodson argues further that managers in particular could miss out vital information about the operation by favouring the numbers and not the visual indications.

Derived from this discussion, a purpose statement of 'Competencies' has been defined, which is: ***'to establish and maintain a foundation for individuals and teams to continuously improve the competencies required to drive the transformation towards LC.'*** Furthermore, four BG&Ps have been developed, including their Ideal Statements, which are illustrated in Table 7-6.

Table 7-6: BG&Ps and their Ideal Statement of the Key Attribute – Competencies

Behaviours, Goals & Practices	Ideal Statements
1. Corporate Understanding	They have a common understanding of Lean and what it is able to give them so that they see everything as a process and Lean is part of it.
2. Terminology	Everybody understands and uses a common and shared language for LC.
3. Knowledge	There are no pockets of excellence, because the mass of the people really knows and applies Lean including its tools, techniques, principles, culture, and behaviour on a daily basis.
4. Visual Management Systems	Visual management and indications are utilised so that progress towards the value delivery is visualised and everyone understands their contribution towards the ultimate value.

7.4.3.3 Key Attribute - Improvement Enablers

To enable the improvement and achievement of LC maturity a long-term journey and its acceptance is required. Accordingly, in both the supplementary data and the primary data it was identified that LC needs to be understood as a Journey. Hence in the group interview argued participant #1 that LC is a never-ending journey; equally, the majority of the interviewees identified LC as a journey, and the FGs stated that *"people have got to realise it's a journey"*. This is also reflected in the literature (Sage *et al*., 2012, Yu *et al*., 2013). Furthermore, it was argued in the FGs that more mature organisations build a real team for this Lean journey which shares the same ethics and values. Consequently, it was pointed out that methodologies, tools and techniques can support a moving along the journey but there is in addition the need for an *"internal capability ... to take you further along"*. Starting a journey towards more maturity in LC actually requires *"some maturity"* to be in existence, and *"the motivation to be religiously on a Lean journey is intrinsic"* within more mature organisations because they are passionate about Lean and know it is worth doing it. Therefore, accepting and understanding LC as a long-term journey with an intrinsic motivation to move along this journey towards more maturity in LC make it possible to improve their LC maturity.

The second BG&P focuses on effective knowledge sharing of solved problems and failures as an enabler of improvement. Within the FGs it was identified that the establishment of knowledge sharing and allowing everybody to effectively share knowledge about their

"teething problems" and what *"worked out well"* enables the improvement of LC maturity. Comparatively, Alves *et al*. (2010) argue that sharing failures and successes makes the transformation to LC more sustainable.

Accordingly, working together enables the improvement of maturity in LC. The FGs pointed out that improvement is achieved together with the people in the operation, and the understanding of the top management that Lean allows them to achieve their commercial goals. Hence more mature organisations utilise improvement with people, the management and what they know already. For instance, it was stated *"Do it to them and it doesn't work. Do it with them and it works … there's construction managers or project managers, etc., with 20/30 years' experience, they've got some good things they're doing already"*. In addition, it was stated that *"If people at the grassroots level are thinking about … and in addition the senior management team have the overall strategy being built in the process, at some point it's got to be successfully"*. Equal with the learning, working together in the *"study action teams"* was identified in the FGs as a powerful way of driving improvement.

Finally, it was identified in both findings that maturity in LC contains being able to prioritise what most needs to be improved. Hence it was stated that *"having a system in place"* to prioritise improvement efforts and measure the development of maturity on a *"routine basis"* is part of LC maturity. Hence mature organisations *"can make the value judgement as to which one matters most, which one most needs improvement, can interrogate the data behind it to determine and prioritise the pieces of our performance that are weakest"*. Therefore, the utilisation of for instance a maturity framework or a MM which enables them to prioritise their improvement effort (Project Management Institute, 2003, CMMI Product Team, 2010) is part of being mature in LC.

Derived from this discussion, a purpose statement of 'Improvement Enablers' has been defined, which is: ***'to make it possible for the people and the organisation to improve their LC maturity.'*** Furthermore, four BG&Ps have been developed, including their Ideal Statements, which are illustrated in Table 7-7.

Table 7-7: BG&Ps and their Ideal Statement of the Key Attribute – Improvement Enablers

Behaviours, Goals & Practices	Ideal Statements
1. Long-Term Journey	They understand LC as a journey and have an intrinsic motivation to move along this journey towards more maturity.
2. Knowledge Sharing	Everybody engages in sharing knowledge and experiences of success and failure in the most effective way.
3. Working Together	Improvement is accomplished through managers working together with the people at the grassroots and what they already know.
4. Prioritising	They have the ability to systemically analyse their gap within their development of LC maturity so that priorities for their improvement actions can be set accordingly.

7.4.4 Factor - Processes & System

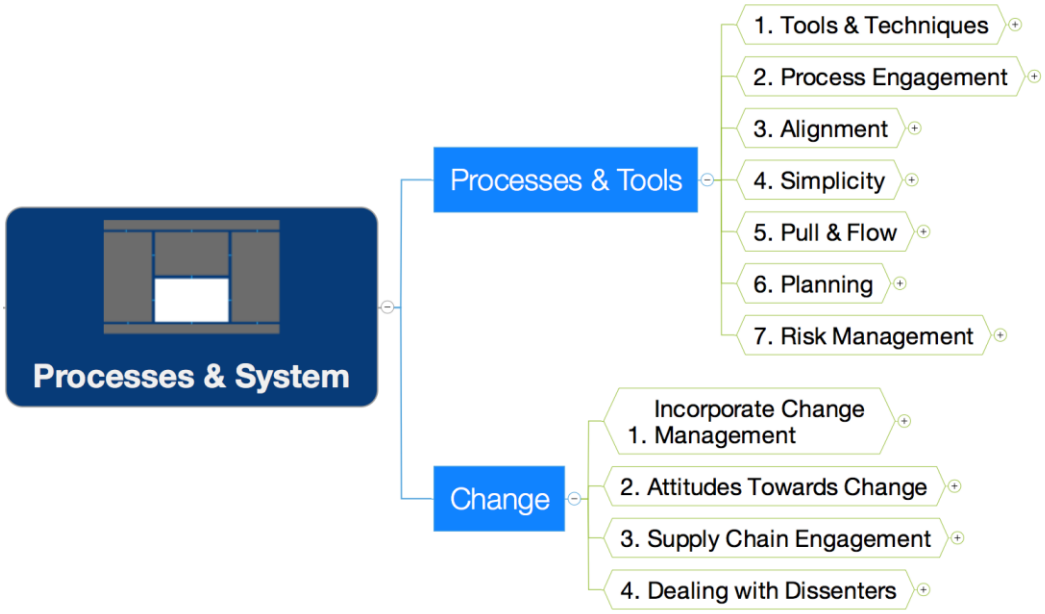


Figure 7-11: Factor - Processes & System with Key Attributes

7.4.4.1 Key Attribute - Processes & Tools

At the beginning of this study it was pointed out within the group interview that certain tools and best practices are inappropriate to identify maturity in LC. This was confirmed within the findings of the interviews and the FGs. Therefore, those participants expressed a general understanding that LC maturity is not about the tools and techniques in themselves, rather it is about people choosing tools and techniques to solve problems; therefore it was stated that people *"choose tools according to necessities ... the needs of the current process or the current organisation or project."* Hence organisations with more maturity really understand

when and where to select and apply the right tool and technique to support them. Furthermore, it was stated that it is important that tools and techniques "*create synergy in the process and in values"* and support people to address specific problems.

The engagement process received a strong indication within both the interviews and the FGs. As a result, it was demonstrated that LC maturity can be seen in the *"operating processes"*. Hence it was stated that the processes engage Lean in *"what the processes are and how people accept them, and behave with them"*. So for example are they using *"processes oriented work ... standard ways of processes and working"* and are those *"accepted or compliant with all in the business"*. In addition, it was pointed out that the processes of mature organisations really encourage Lean, because Lean must lead the processes.

Likewise, it was acknowledged that processes and tools need to be in alignment with the organisational definition of Lean. So was stated that maturity can be *"seen in all processes and [the processes] should reflect a Lean philosophy, Lean approach or Lean thinking*". Furthermore, it was argued that any deployed tool should be used in a Lean way and must be aligned with Lean thinking. This was further neatly summarised within an interview as *"a Lean philosophy or a Lean approach or Lean thinking should be reflected"* in every process and tool. Hence processes and tools of more mature organisations support the creation of internal and external customer value. In order to do so they are aligned with identified customer value, have flow and produce what the customer wants, when he wants it and the exact amount he wants of it, and those processes practise CI. This would for example reflect the five elements of Lean thinking (Womack and Jones, 1996).

Primarily identified by the FGs findings were simplicity and culture vs. tools & techniques. Moreover, simplicity was mentioned as a key part of Lean maturity. So it was stated that everything gets simpler when we are maturing in Lean. As an example, it was explained that the way we look at construction projects is simplified from "*building one-offs*" to *"we do very similar processes in different locations with different constraints"*. Koskela (1992) reminds us that simplicity is associated with LC and with the underlying principle of

improving the flow and processes by simplifying the processes. Consequently, these findings must be related back to the transparency of the processes through simplifying and standardising them to avoid interference (Liker and Convis, 2012).

The expertise about the five elements of Lean thinking: 1) identify customer value; 2) identify the value stream; 3) create flow; 4) create pull; 5) pursue perfection (Womack and Jones, 2003) was explicitly explained. And since elements 1, 2 and 5 are embedded within other BG&Ps, creating flow and pull must be taken on, as it was pointed out that mature organisations want to have people who actually know about and understand how to create flow and pull within the value stream. Hence processes within more mature organisations have a flow and produce what the customer wants, when he wants it and the exact amount he wants of it. So they are having the competence of deploying the third and fourth elements of Lean thinking: flow and pull (Womack and Jones, 1996). Further, Ng *et al*. (2013) demonstrated through a pull-driven approach the embedding of Lean into resource management which would enable organisations to allocate the right resources to the right activities and to avoid waste within the value stream.

Furthermore, in the FGs specific processes of planning were pointed out which have been experienced in more mature organisations. Hence planning as a BG&P has been included in this framework as more mature organisations arguably will perform this in collaboration and "*at the lowest possible level, rather than planning is done at a high level"*. In addition, it was pointed out in one validation interview (see section 7.5.1) that this needs to further differentiate between a collaborative programme planning and collaborative construction planning. Finally, this interviewee clarified that construction planning does not emerge in sequence with the design; rather a mature organisation would develop the construction planning alongside the design in collaboration between the stakeholders.

Finally, the FG revealed that more mature organisations managing risks collaboratively.

Derived from this discussion, a purpose statement of 'Processes & Tools' has been defined, which is: ***'to establish and maintain an improvement of the processes that deliver***

the ultimate value.' Furthermore, seven BG&Ps have been developed, including their Ideal Statements, which are illustrated in Table 7-8.

Table 7-8: BG&Ps and their Ideal Statement of the Key Attribute – Processes & Tools

Behaviours, Goals & Practices	Ideal Statements
1. Tools & Techniques	They choose the right tools and techniques to create synergy with the processes and the delivery of customer value so that they address specific problems and support people.
2. Process engagement	Processes contain standard ways of working to really encourage Lean thinking and be accepted throughout the organisation.
3. Alignment	Each process and tool exists to support the creation of internal and external customer value.
4. Simplicity	The processes and everything are simplified and standardised to improve whilst the value for the customer is maintained.
5. Pull and Flow	All processes have a flow and produce only what the customer wants, when he wants it and the exact amount he wants.
6. Planning	A: Programme planning is done collaboratively. B: Construction planning emerges alongside the design. C: Production planning is done at the lowest possible level.
7. Risk Management	The managing of risks is done in collaboration.

7.4.4.2 Key Attribute - Change

One of the most encompassed images of maturity within the FGs was change. So it was pointed out that change management is a fundamental part of maturity. This argument received particularly strong agreement from other group members. Accordingly, they argued that you must find something like a change management policy from senior management level as sign of maturity in LC. Furthermore, it must be obvious that the organisation is changing and not just a few individuals that influence the others. Moreover, it was pointed out in the interviews that *"people can see change"*. Hence the change must be incorporated in the organisation and in all sorts of things they do. This is summarised within the first BG&P, Incorporated change management.

Furthermore, mature organisations have less hindrance towards change. This received strong agreement, particularly in the FGs. It was stated that a low resistance towards change leads to sustainable change and is considered as mature. Furthermore, it was explained that with greater maturity people actually have less resistance to change because they understand *"what's in it for me"* – their individual value in the change. This was also identified as an

important driver for the success of LC in a case study from Bryde and Schulmeister (2012). Moreover, the participants stated that more mature organisations are agile in their behaviour towards adapting to change. As a result, this flexibility towards change in more mature organisations was described as *"they don't mind new techniques, new ways"*, and *"change is a way of life and everyone can deal with it"*. Accordingly, more mature organisations see changes as an opportunity to do things differently, as for instance technology changes. For example, it was stated, *"Lean allows you to say 'oh that's a new technology, how do I do things differently to make best use of that technology?' rather than 'how do I fit that technology into my traditional approach?'"*. Therefore, the focus on opportunities within changes increases with the maturity.

In addition, it was stated by both the interviews and the FGs that more mature organisations recognise and behave differently with the supply chain. So it was pointed out that they would behave with their supply chain in a way that brings them into the project team, under one umbrella, to improve the delivery of customer value. Furthermore, it was argued in the FGs that an early engaging with the supply chain prior to the construction phase is associated with maturity in LC. Hence more mature organisations are expected to involve their supply chain early in the project and they manage the supply chain to receive their commitment. A similar observation has been made within a study exploring the implementation of Lean procurement in construction (Baladhandayutham and Venkatesh, 2012). This study concluded that working with the supply chain and bringing it under one umbrella to overcome obstacles is most likely to achieve an improvement of the whole system. Additionally, Vrijhoef and Koskela (2000) remind us that supply chain management (SCM) emerged within the development of TPS and links therefore to JIT and Lean production. Further, their study identified four roles of the SCM, which include the improvement through creation of flow and reduction of variability and the avoidance of chaos within the supply chain. Presumably both can be achieved through an early commitment and integration of the supply chain.

Finally, it was identified that more mature organisations automatically overcome groups and people who are against changes and Lean. The experiences of the participants illustrated that mature organisations either have the *"ability to be able to detect it [people who are against Lean] and cope with it"* or those people/groups simply *"disappear"*. Hence teams have *"that momentum behind [them] ... to, instead of just living with that, you get rid of it"*. Moreover, it was pointed out that *"truly mature"* is when getting rid of dissenters happens automatically.

Derived from this discussion, a purpose statement of 'Change' has been defined, which is: ***'to establish and maintain a context by which the change towards LC is intrinsic.'*** Furthermore, four BG&Ps have been developed, including their Ideal Statements, which are illustrated in Table 7-9.

Table 7-9: BG&Ps and their Ideal Statement of the Key Attribute – Change

Behaviours, Goals & Practices	Ideal Statements
1. Incorporate Change Management	The senior management has adapted a course of action for the sake of becoming more mature in LC.
2. Attitudes towards Change	A: Their individuals understand what is in it for them so that they have a low resistance to change. B: For them change is a way of life because they are agile and have the flexibility to adapt to changes. C: They see changes as opportunities to do things differently and make the best use of them to deliver customer value.
3. Supply Chain Engagement	They bring the supply chain early under an umbrella to receive their commitment towards the customer value and create synergies with them.
4. Dealing With Dissenters	The organisation and their teams have the momentum and the ability to detect and deal with individuals and groups who are against changes and the strategic Lean vision.

7.4.5 Factor - Outcomes & Outputs

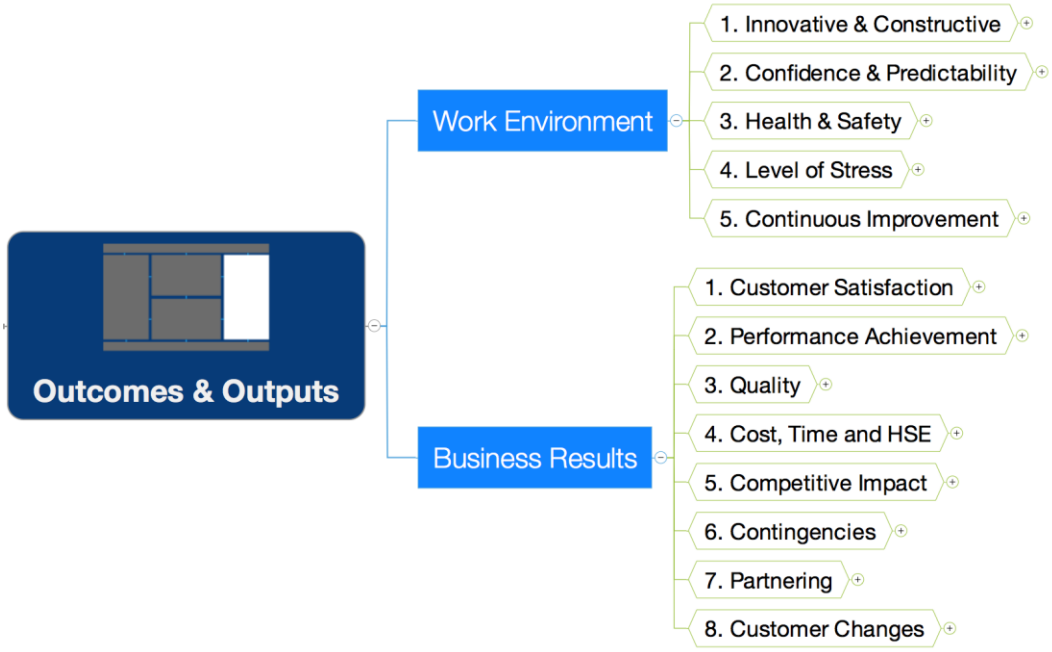


Figure 7-12: Factor - Outcomes & Outputs with Key Attributes

7.4.5.1 Key Attribute - Work Environment

The participants of the FGs experienced within LC maturity a strong change of the traditional environment. So it was firstly identified that with more maturity in LC a *"true constructive atmosphere"* and *"environment for innovation"* will be established. This was further described as much more *"proactive rather than reactive"* and *"less argumentative and more cooperative behaviour"*.

This environment change is derived as an outcome of more LC maturity, and contains in addition more confidence and predictability within construction projects. The increase of predictability within construction projects using Lean principles in particular for the managing of the workflow is illustrated by Brodetskaia *et al*. (2013) and strengthens the above arguments produced within the FGs.

In addition, it was pointed out in the FGs that the work environment within more mature LC organisations results in improved health and safety. One participant stated that: *"well-planned projects that are not continuously changing their programmes where people go and*

do things out of sequence and out of knowledge of themselves ... are safer and have fewer accidents". Equally, recent literature suggests that implementing LC results in improved health and safety and lower accident rates (Ogunbiyi *et al*., 2014). Further evidence provide Bernstein and Jones (2013) who report that improved safety is one of the biggest benefits when implementing LC. Similar results such as lower accident rates for LC projects are reported in the literature, as for instance from Thomassen *et al*. (2003) and Mauricio and Alarcon (2010). Thomassen *et al*. (2003) reminds us further that sound activities with accurate information for the craftspeople and activities completed within the sequence allow people to perform their roles within a sufficient time-span, and work-space on site. Hence a non-chaotic and smooth workflow has a good chance to avoid chaos and reduce risks. A similar study by Nahmens and Ikuma (2009), focusing on the relationship between LC and safety, reports a similar suggestion that implementing LC results in fewer safety issues. However, neither study delivers empirical evidence that more maturity in LC results in greater health and safety in the construction sector. Nevertheless, both studies and their findings underpin the statement of the FG in this research. Moreover delivers the report from Bernstein and Jones (2013) further evidence that LC results in improved safety, and Salem *et al*. (2005) showed in a case study similar improvements.

Another BG&P of being mature in LC was the decreasing level of stress for the people in the projects and within organisations. This was generally agreed within the FGs and is summarised by the following statement: *"Everyone from the labour to the project manager was experiencing less stress"*.

Practising CI using a systemic approach is a specific characteristic of a more mature organisation in LC. In the FGs it was acknowledged that someone *"would see in a mature Lean organisation, a systematic continuous improvement"*. Additionally, it was pointed out in the interviews that systematic CI is actually about *"how to fix or how you make corrections"* in particular about delivering customer value. This interviewee argued further that systemic CI is *"driven by the ability to understand customer value"*. Equally, it is argued in the literature that CI involves the incremental effort to improve (products or

services) customer value (Imai, 1986). Moreover, it was illustrated in both findings that systemic CI is linked with the ability to prioritise and judge which process or activity most needs to be improved.

Derived from this discussion, a purpose statement of 'Work Environment' has been defined, which is: ***'to establish and maintain working conditions that encourage individuals and teams.'*** Furthermore, five BG&Ps have been developed, including their Ideal Statements, which are illustrated in Table 7-10.

Table 7-10: BG&Ps and their Ideal Statement of the Key Attribute – Work Environment

Behaviours, Goals & Practices	Ideal Statements
1. Innovative & Constructive	The work environment is truly supporting innovation and cooperation.
2. Confidence & Predictability	Managers have the confidence that individuals and teams inevitably solve problems and deliver customer value.
3. Health & Safety	Their projects are well planned so that people can follow their sequence and do their work in a non-chaotic space and with greater health and safety.
4. Level of Stress	Everyone from the labour to the project manager experiences a reduced level of stress.
5. Continuous improvement	They are practising a constant and systemic continuous improvement.

7.4.5.2 Key Attribute - Business Results

Customer satisfaction is one of the most obvious outcomes of being mature in LC. Indeed the findings of the interviews as well as the FGs revealed that maturity in LC must be measured in terms of the satisfaction of customers. Similarly, it was found by Bernstein and Jones (2013) that one of the key benefits of adopting LC is greater customer satisfaction. So it can be argued that more mature organisations in LC satisfy their customers continuously. Therefore, it must be assumed that delivering customers' value – what they value, at the right time, to an appropriate amount of money (Womack and Jones, 1996) – results in satisfied customers.

Individuals and teams in more mature organisations are highly motivated to achieve and improve on the set performance criteria. Experiences of the FG participants have shown that people and teams in more mature organisations keep motivated with the setting of extreme

but still achievable targets. Similarly, the FG revealed examples of when teams and organisations achieved extreme challenges such as the reduction of the time to do one job within the railway construction from 54 hours to eight hours. The achievement of extreme improvement is also a common outcome associated with Lean. This is further supported from the interview findings that demonstrate that a Lean assessment of the Shingo Prize (The Shingo Prize, 2010) actually focuses as well on the achievement of performance criteria, and that within LC a focus on results is often lacking. However, reports of several studies illustrate that through LC, improvement of performance criteria can be delivered (Sage *et al*., 2012); such as, some evidence reported that projects in the UK and US utilising LC could be delivered 19% below market cost (Mossman *et al*., 2011).

Similarly, organisations with more maturity in LC challenge their set performance goals such as quality, cost, time, and Health and Safety and environmental impact. The achieving of targets and milestones as well as reducing the costs and increasing the profit have been identified as an obvious outcome of LC maturity from the FG participants. In general, the FG findings showed an acknowledgement that performance in terms of the *"quality"*, *"cost"*, time and *"Health and Safety and environmental impact"* is achieved as the customer expected. Hence the challenge is to keep to the original set criteria at least and not as programmes and specifications have been rewritten. Equally, it was stated that *"achieving 100% right [quality] first time"* and delivering the project *"cheaper, safer"* and with *"better quality*" are expected outcomes of more maturity in LC. However, being mature implies always improving on those original set criteria.

More maturity in LC results in greater competitive impact. Hence maturity in LC enables organisations not only to receive constant customer satisfaction but also an increase of their reputation and their order intake. So the FG findings showed a general acknowledgment that maturity in LC is associated with greater competitive impact. For instance, it was stated that maturity results ultimately in *"repeat business ... enhanced reputation"* and would in addition *"stimulate extra work"*. Furthermore, this is supported by the findings of in-depth

interviews with Lean experts that identified competitiveness as the overall result of adopting LC (Bernstein and Jones, 2013).

There is no doubt that contingency is undeniable within the construction sector, but organisations with more maturity reduce contingency and turn unused contingency into something the customer values. So it was argued in the FGs that organisations with more maturity in LC *"spend the contingency on additional value/scope rather than unknown unknowns"*. Additional value/scope is for instance then provided when additional features or services that the customer values have been delivered (Hines *et al*., 2004).

More maturity in LC reduces the amount of contract claims and contract litigation. A reduced amount of litigation and contract claims has been associated by the FGs as an outcome of being mature in LC. Further, the literature suggests that relational contracts are the suitable form of contracts to support LC, collaboration and the delivery of customer value (Ballard and Howell, 2005, Koskela *et al*., 2006, Darrington and Howell, 2011). So presumably maturity in LC results in a deep partnering supported by relational contracts and a reduced amount of litigation and contract claims.

More mature organisations reduce the amount of customer changes and are confident in dealing with those changes that remain. In particular the FG findings suggest that more mature organisations challenge customer changes through "*better collaborative planning*" and have the confidence to accept or deal with the remaining changes. Presumably, this will lead to the act of collaborating with fewer changes because, through their involvement in the collaboration, the customer is expected to be aware of the impact their change will have on the project delivery.

Derived from this discussion, a purpose statement of 'Business Results' has been defined, which is: ***'to enhance the alignment of performance criteria with the contribution of individuals and teams.'*** Furthermore, eight BG&Ps have been developed, including their Ideal Statements, which are illustrated in Table 7-11.

Table 7-11: BG&Ps and their Ideal Statement of the Key Attribute – Business Results

Behaviours, Goals & Practices	Ideal Statements
1. Customer satisfaction	They have happy clients and stakeholders through continually delivering what the customer wants, when he wants it and the exact amount he wants (customer value).
2. Performance achievement	They set extreme but achievable goals for performance criteria to motivate individuals and teams.
3. Quality	They achieve 100% quality the first time.
4. Cost, Time and HSE	They deliver customer value cheaper, safer, and with less environmental impact because they challenge the original set criteria.
5. Competitive Impact	They have an enhanced reputation so that they stimulate extra work.
6. Contingency	They spent unused contingency on additional features or services that the customer values.
7. Partnering	They reduce the amount of contract claims and contract litigation through deep collaboration and the use of relational contracts.
8. Customer changes	They challenge the amount of customer changes through better collaboration.

7.4.6 Factor – Learning

Figure 7-13: Factor - Learning with Key Attributes

7.4.6.1 Key Attribute - Training & Competency Development

One of the most interesting findings of the study was that learning was stressed within both findings as one of the critical parts of LC maturity. For instance, in the interview findings it was highlighted that the degree of learning within the individuals and the organisation is a critical indicator for LC maturity. Two different ways of learning have been identified: first the learning of individuals and second the learning of the organisation.

People in more mature organisations focus on learning, and demonstrate that they utilise lessons learned. The results of the FGs show that more maturity in LC is linked with genuinely *"utilising lessons learnt … and actually effectively using it [the learning]"*. It was

argued that individuals of more mature organisations feed all lessons they have learned throughout the processes back to support the systemic CI. Another important finding from the FGs was that more mature organisations have a focus on learning rather than a narrowed focus on results. Moreover, it has been stated that those organisations are particularly good at learning. Hence the interview findings further pointed out that LC maturity must capture *"is the organisation learning"* and *"are the individuals in the organisation learning"*.

Mature organisations are willing to learn and able to utilise their knowledge and lessons learned effectively. The FGs findings for instance suggest that A3s are great to motivate and communicate the learning amongst the people within the organisation because *"A3s, they have a physical form, they can be in a file, they can be on site ... as well as capturing all the knowledge that you've gained through the process"*. Furthermore, both findings connect organisational learning and action learning to LC maturity. Similarly, this is identified as an important approach within LC to engage the learning within the organisation (Hirota *et al*., 1999). However, Alves *et al*. (2010) pointed out that study action teams are very similar to action learning and those are deployed within organisational and individual learning of LC. Equally, the FG findings deliver evidence that study action teams are associated as an important part of organisational learning. According to Mills and Friesen (1992) it is important for organisational learning that organisations learn primarily through their individuals and follow three characteristics which enable them to learn: (1) the commitment to knowledge, (2) the mechanism for renewal within themselves, and (3) the openness to the outside world. Moreover, Alves *et al*. (2010) claim that learning LC requires a certain amount of unlearning. This is further supported by McGill and Slocum Jr (1993) who argue that: "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" (p. 78).

The leaders of the organisations need to deliver the training. According to both findings, mature organisations develop their people from the inside out through their managers and leaders who are *"coaching and mentoring their people rather than sending people on courses"*. Hence people are being developed internally by their leaders top-down and bottom-up. In addition, the interview findings suggest that the leaders who deliver the training need to deploy it quickly throughout the organisation. Hence it is important that the leaders understand and believe in LC. So leaders who deliver the training are the drivers for people development.

Finally, training which focuses on the organisational processes is important. Evidence revealed in the interview findings demonstrates that the whole training – its quality, how people engage with that training and how successfully they apply what they have learned including the feedback about the received training – would illustrate maturity in LC. Moreover, the findings suggest that mature organisations deliver specific training about their *"ways of working", "how to improve", "problem solving and Lean techniques"*.

Derived from this discussion, a purpose statement of 'Training & Competency Development' has been defined, which is: ***'to insure that individuals, teams and the organisation are constantly learning to enhance their skills, knowledge and competencies.'*** Furthermore, four BG&Ps have been developed, including their Ideal Statements, which are illustrated in Table 7-12.

Table 7-12: BG&Ps and their Ideal Statement of the Key Attribute – Training & Competency Development

Behaviours, Goals & Practices	Ideal Statements
1. Learning	They consistently demonstrate a focus on learning of individuals and really utilise lessons learned as fundamental for practising continuous improvement.
2. Organisational Learning	A: They conduct experiments to learn from failure and success. B: They have a commitment to unlearning, knowledge, openness to the outside world and mechanism for renewal within itself. C: They effectively utilise what the organisation has learned.
3. Development of People	Their leaders develop the people through coaching, mentoring and the delivery of internal training.
4. The Training	Training focuses on specific ways of working within the processes so that the developed competencies can be applied effectively.

7.5 Validation of the framework

The rationale for choosing member checks to validate this framework was explained in section 4.8. The validation of this framework further fulfils the fifth objective of this study, and the final step of the deployed analysing framework of the FG data (explained in section 4.7.2.2). This section presents the conducted member checks approach that was used to validate the framework. This member checks were conducted as the third element of the validation strategy presented in section 4.8.2. Creswell (2013) suggested that member checks in phenomenology studies are best conducted in the form of a FG. However, there are certain drawbacks with the use of a FG which consists of members of this study. It was obviously impractical to bring the international interview participants and members of the FG together. Another major problem with the member check method is that the participants who can be recruited are obviously restricted to the members involved in the study in the first place. Hence it was decided that the best way to approach this member check validation was to conduct three member checks as individual interviews via video phone calls and one FG with three members of this study, according to the suggestion of Creswell (2013). All of the participants were LC practitioners involved in Lean projects for between three and 19 years. The participants' sample comprised LC practitioners working in the operation such as contractors or in engineering companies and as a consultant. Their profile and professional experience as well as their involvement in the member check type is noted in Table 7-13 below.

Table 7-13: Participant profile of the member checks

Member Check	Country	Professional experience in LC	Total work experience	Role
Interview	Germany	3-9 years	10-19 years	Operational LP
Interview	UK	10-19 years	30-39 years	Consultive LP
Interview	USA	10-19 years	40-49 years	Operational LP
Focus group	UK	3-9 years	10-19 years	Operational LP
Focus group	UK	3-9 years	20-29 years	Consultive LP
Focus group	UK	3-9 years	20-29 years	Operational LP

7.5.1 Member check - Individual interviews

Semi-structured interviews were conducted as member checks with the three participants. These interviews took place as iteration following the FG member check. Hence the first draft of the developed framework was validated through the interview member checks. The additional information provided through the responses in the interviews has been used to improve the development of the framework. As a result, the improvement derived from the findings of the interview member checks, prior to the FG member check, was embedded in the development of the framework presented in sections 7.3 and 7.4.

7.5.1.1 Validation of the framework draft

The interviews had an approximate duration of one hour; and the participants received a document which described the developed framework and its elements with several figures prior to the interviews. Contemporaneous notes were taken of the comments made by the interviewees. At the beginning of the interviews the participants were talked through the developed framework, with support from the provided document, and it's containing figures. This resulted in a not too abstract presentation of the findings of this study to the participants in order to seek validity. The participants of these member check interviews were asked about the completeness and accurate reflection of the data they contributed to the study in the first place and if there was anything missing in the framework. The purpose of this question was to seek information about the validity of the framework in its first draft. Overall the interviewees were very happy about the framework and they responded that they generally agreed on the accurate reflection of their contribution to the framework. However, their responses indicated some additional information to improve the framework and its elements. These are:

- The knowledge, training and day-to-day 'doing' that it takes for an organisation to 'become Lean' should be brought in more. Therefore, a new Key Attribute was established – 'Training & Competency Development'

that contains all the BG&Ps addressing training and learning, which were part of other BG&Ps before;

- some participants suggested improving several wordings within the framework, as for instance the Key Attribute – 'The Thinking', which has been changed to 'Way of Thinking'. Equally, it was suggested to break down the BG&P – 'learning' into 'learning' and 'organisational learning'. These required modifications were undertaken; and
- one of the interviewees suggested that the detail of the BG&P – 'planning' should be increased in terms of the planning practices of more mature organisations, such as programme planning, construction planning, and production planning. These modifications have been taken on in the form of three Ideal Statements within the BG&P – 'planning' in the current framework.

7.5.1.2 Practical suitability of the framework

It was further important for the researcher to ask the interviewees about their views on the practical suitability of this framework. This question was posed to get an idea of the issues for the practical implementation, and the depth of this information is used to support the practical implication of this framework. The overall response to this question was very positive. All interviewees acknowledged that the framework is seen from a holistic lens suitable to implement in practice. Other responses to this question included further information to improve the framework, as follows.

Some participants expressed the belief that the framework needed to be simpler. One individual suggested that the Key Attributes should be rearranged in layers in order to achieve simplicity. Another commented that the framework should be benchmarked against: (1) order, (2) harmony, (3) simplicity, (4) beauty and elegance.

- In order to address this, the Top Layer and its six factors which were developed through the inspiration of the EFQM Excellence Model. As a

result, the order and the harmony of the framework were further improved and simplicity achieved. The beauty and elegance of the framework is perceived by the researcher as a subjective criterion. Hence from the researcher's perspective the improved framework achieves a sufficient beauty and elegance.

Two of those interviewed suggested that the framework needs to weight the Key Attributes because they are not all as equally important for LC maturity. One of them commented that for the practical implementation an organisation would like to know its overall maturity level.

- To take that point on it was decided to analytically determine the weighting of the Key Attributes in the validation FG (see section 7.5.2.3).

7.5.2 Member check - Focus group

The validation FG conducted as the member check consisted of three participants. The FG as member check was chosen to enhance accuracy and correctness of the findings (developed framework) and their interpretation (Creswell, 2013). This FG was conducted similar to the FGs conducted as primary data collection. Hence this validation FG took advantage of: an observer, a guideline, and a similar setting. However, notes were taken as contemporaneous notes on flipcharts rather than as audio recordings. These flipchart notes were verified by the participants at the end of the FG.

7.5.2.1 Validation of the framework elements

The developed framework illustrated in sections 7.3 and 7.4 (including the iterative improvement) was presented to the participants. To increase the credibility of the validation the framework was presented in sections rather than as a whole. These sections are: framework structure; Top Layer; and each single factor including its Key Attributes, BG&Ps as well as Ideal Statements. Finally, the maturity levels were considered including the practitioner-led assessment. This enabled a focus on all elements of the framework without

getting lost. The presentation took in total approximately thirty minutes, and used several figures and hand-outs to assure that the participants gained a simple access to and understanding of the information presented. Following this, the participants were asked for each section *Is this valid from your point of view?* The overall response to this question was very positive. All participants agreed that the developed framework with its factors, Key Attributes, BG&Ps, and Ideal Statements is valid. The responses of the participants with their additional information for each section are noted below. The meaningfulness of the responses has been further weighted by the researcher and required modifications were undertaken in the framework. Direct quotes from the participants are illustrated with quotation marks.

Top Layer: All respondents felt that the Top Layer was principally correct but graphically incomplete. The participants suggested that there is a need to show a direction or flow with arrows, etc. Two individuals stated that there are two entry points for the Top Layer: philosophy and coherent leadership.

Factor - Leadership: Two participants pointed out that within the Key Attribute – 'Lean Leadership' a BG&P is missing, *"true understanding of Lean, understanding the big picture is key"*. Another commented that the BG&P - 'Passion' *"is a good one"* and the group agreed that it should be linked with tenacity. One individual stated that it should be taken on that leaders make decisions with *"short-term pain for long-term gain"*.

Factor - Philosophy: Some participants felt that the BG&P – 'Understanding Customer Value' should take on that value can be intangible and different from each customer's perspective. Two individuals suggested further to add the BG&P 'long-term thinking' to the Key Attribute – 'Way of Thinking'; because short-term decisions (pain) do not affect the long-term goal.

Factor - People: One individual stated that the BG&P – 'Problem Solving' *"is a really good one, because they actively look to solve problems"*. Two participants pointed out that the Ideal Statement of the BG&P – 'Constancy of Purpose & Vision' needs to be rephrased,

because they argued *"Lean is not the vision, Lean is used to reach the vision"*. Equally, this would affect the BG&P – 'Communication' as it is important for everyone to understand the vision and the role Lean plays in that. Some participants expressed the belief that people are an integral and important part of the vision, so that in more mature organisations everyone would have clarity on their objectives and targets as well as their responsibilities. Moreover, all participants indicated that the BG&P – 'Visual Management System' belongs to the Key Attribute - 'Processes and Tools'; and further that the wording within the BG&P - 'Knowledge' needs to be rephrased to avoid the wording 'no pockets of excellence'. Some individuals stated that the BG&P – 'Knowledge Sharing' is in particular a good point which could be improved by taking on *"continuously"* or *"effectively utilising lessons learned"* in the Ideal Statement.

Factor - Processes & System: One individual stated that the BG&P – 'Simplicity' is really good. In agreement with the participants it was indicated that the *"integration of tools & techniques"* should be added as a second Ideal Statement in the BG&P – 'Tools & Techniques'.

Factor - Outcomes & Outputs: With general agreement the three participants suggested that the BG&P – 'Continuous Improvement' be extended so that the supply chain and the stakeholders are included in the CI. Furthermore, the participants expressed the belief that the wording *"cheaper"* in the BG&P – 'Cost, Time and HSE' should be avoided, or replaced by *"effectively"*, because it is about delivering customer value and the customer may not like 'cheaper'. Similarly, a better wording for 100% quality in the BG&P – 'Quality' was stated: *"expected quality first time"*. Moreover, all three members indicated their agreement on some additional Ideal Statements for the BG&P – 'Customer Satisfaction'. So it was stated that there is a need for an Ideal Statement that takes on intangible client experiences, long-term relationships with customers, supply chain, contractors and consultants, and that they want to work with this mature organisation. General agreement was further expressed for an additional Ideal Statement within the BG&P – 'Competitive Impact' which addresses the company's enhanced reputation and being customer recommended. Another commented on

the need to extend the Key Attribute – 'Work Environment' with a new BG&P, 'Supply Chain Relationships', because truly mature organisations work with their supply chain and stakeholders.

Factor - Learning: In response to this factor the participants were in agreement to insert a BG&P labelled 'Structured Approach' because more mature organisations have a structured plan/idea of what they want to achieve. Other responses to this question included the agreement in the group that the BG&P – 'Training' needs to take on another Ideal Statement which comprises that truly mature organisations have a plan/approach about how to get new people into their culture.

7.5.2.2 Views on practical implementation of the framework,

Similar to the member check with the individual interviews in section 7.5.2, it was important to seek issues of the practicability and suitability of the developed framework in practice. Hence the participants have been asked: *What are your views on the practical implementation of the framework?* In response to this question, all participants agreed that they see the framework as suitable for practice. In addition, the participants agreed that the framework offers a good methodology and definitely a good diagnostic tool to get from A to B in a Lean Journey. Two other individuals indicated that it seems practical to them that the framework enables you to see where you are, you look at your overall picture of your maturity, you see where your gaps are, and you are able to prioritise where you want to improve your Lean maturity. Furthermore, one individual stated that the framework is a very good tool to start a discussion about LC within the organisation. Moreover, all participants saw this framework as an enabler for organisations to create a plan to achieve more maturity in LC, although the participants indicated that it is quite possible that the prioritisation needs some more data analysis to prioritise those areas that are most important to the specific organisation.

The most striking result to emerge from the validation is that all participants agreed when one individual stated that this framework *"really deconstructs [simplifies] and explains Lean*

in a better way [than] something has it before". In addition, it was explained that the framework brings in a lot of aspects which explain the concept and philosophy in *"a very good way".*

Other responses to this question included the assessment of the framework. So it was agreed that assessors need to know what they are looking for, so a real understanding is needed for the assessment process. Further, it was indicated that this framework would be useful for consultants who would know what level 4 looks like. Both findings clearly underpin that it is important to assess the maturity through a practitioner-led assessment and not as a self-assessment tool, because the assessor really must know the framework and be an expert in LC. One participant expressed a concern that the level of infiltration necessary to get the right information for the assessment is achieved.

Finally, two participants indicated that despite the agreed practical suitability of the framework there are barriers. For instance, it was stated *"we need to generate a need and a want for this framework in the industry",* and another mentioned the belief that the *"leadership"* is a main barrier and breaking it down would be a good possibility to allow such a framework to be very useful for organisations. The validated framework with its modification derived from this member check validation FG is presented in section 7.5.2.4.

7.5.2.3 Determination of the weighting of the Key Attributes

The final topic of the validation FG was the analytical determination of the weighting of the Key Attributes. This was carried out to address the issue raised within the interview member checks, that not all Key Attributes are equally important for LC maturity. Hence an analytical hierarchy process (AHP) was performed with the participants. The AHP is a multi-criteria decision-making approach that determines the hierarchy of the criteria (Saaty, 1990). This approach compares each criterion pairwise to determine the relative importance of the criteria into an overall hierarchy structure. The participants followed the instructions of the researcher and determined the importance of the Key Attributes on an AHP matrix. With the determined weights for the 11 Key Attributes from the three individuals an average

weighting factor for each Key Attribute was calculated. These weighting factors show that the Key Attribute Lean Leadership is four times more weighted than the Key Attribute Business Results. All factors are presented in Table 7-14.

Table 7-14: Key Attributes and their weights

Hierarchy	Key Attribute	weighting factor
1	Lean Leadership	4
2	Culture & Behaviour	4
3	Way of Thinking	3
4	Customer Focus	3
5	Change	2
6	Competencies	2
7	Improvement Enablers	2
8	Work Environment	2
9	Processes & Tools	2
10	Learning & Competency Development	2
11	Business Results	1

What is surprising is that, similar to in the FGs, Lean Leadership is mentioned as the most important Key Attribute within LC maturity. However, with such a small sample size, caution must be applied, as the determined weights might not be generalisable. Nevertheless, these findings may help us to understand the factors of the Top Layer in more detail and in particular that the flow of the Top Layer starts with the Key Attributes organised within the factors to the left and ends with the least important Key Attribute, Business Results, on the right. The determined weights further provide the opportunity to calculate an overall maturity level for the organisation.

7.6 Revised and validated framework

The current framework has been revised and improved on the basis of the outcome of the validation FG (see section 7.5.2.1). The validated framework comprises a Top Layer with six factors; those are labelled as: (1) Leadership; (2) Philosophy; (3) People; (4) Processes & System; (5) Outcomes & Outputs; and (6) Learning. This Top Layer was modified in accordance to the validation with an indication of the flow and is shown in Figure 7-14.

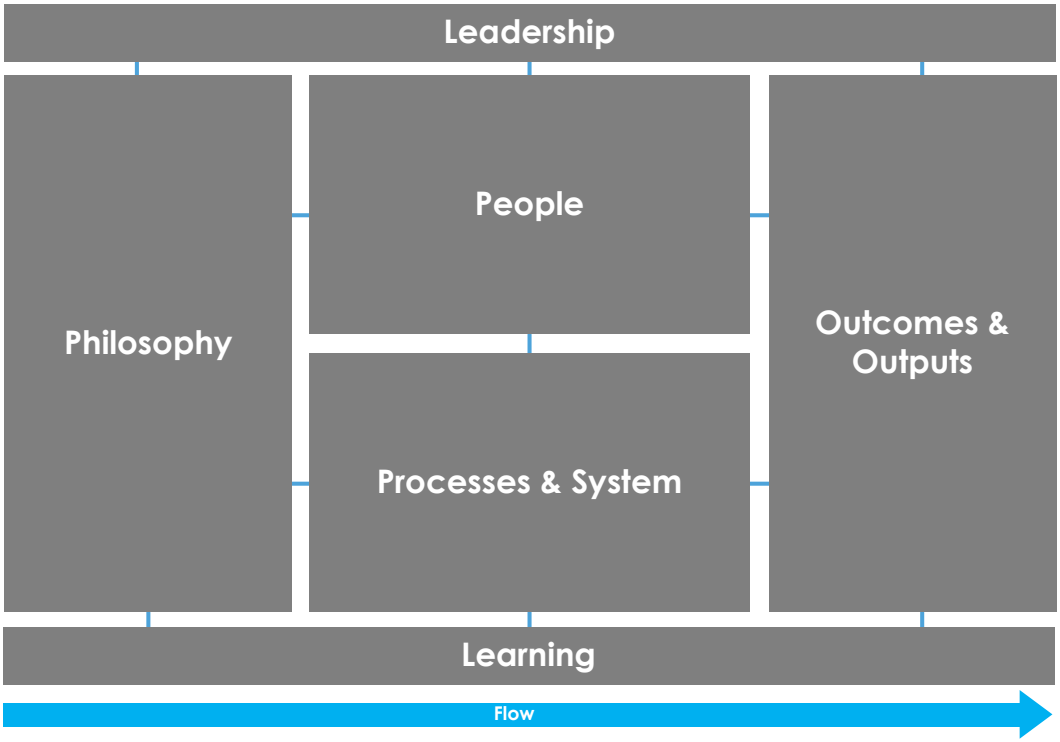


Figure 7-14: Validated Top Layer of the framework, inspired by EFQM (2012)

Within this Top Layer the developed 11 Key Attributes were organised. Those in turn are described by 60 BG&Ps in total. Each BG&P is defined by one or more Ideal Statements, which condense an ideal behaviour, goal or practice that more mature organisations in LC will display in terms LC maturity and the BG&P. In total the validated framework comprises 75 Ideal Statements. The validated framework is presented in the following sections, and the particular modifications undertaken are illustrated and further highlighted in yellow. The relationship between the framework and the modelling of maturity is further together with the structure, maturity levels, and maturity assessment procedure described in the final three sections.

7.6.1 Factor - Leadership

The suggestions regarding the Key Attribute – 'Lean Leadership' have been addressed by the creation of a new BG&P – 'True Understanding' with two Ideal Statements that address the behaviour of the decision making and the understanding of the big picture.

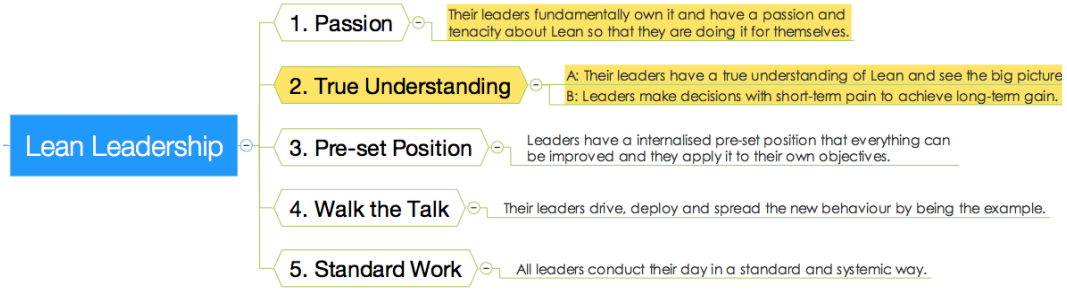


Figure 7-15: Validated factor - Leadership

7.6.2 Factor - Philosophy

Both suggestions identified for this factor have been judged to be required modifications and were undertaken in the current framework.

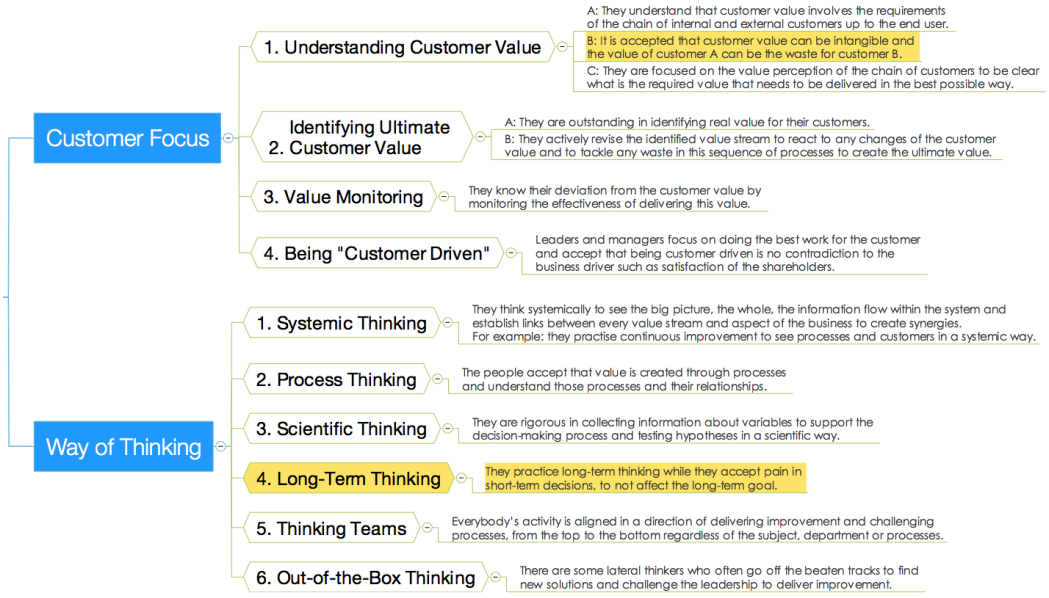


Figure 7-16: Validated factor - Philosophy

7.6.3 Factor - People

All the proposed modifications from the validation FG regarding the factor people have been taken into the current framework and are illustrated below.

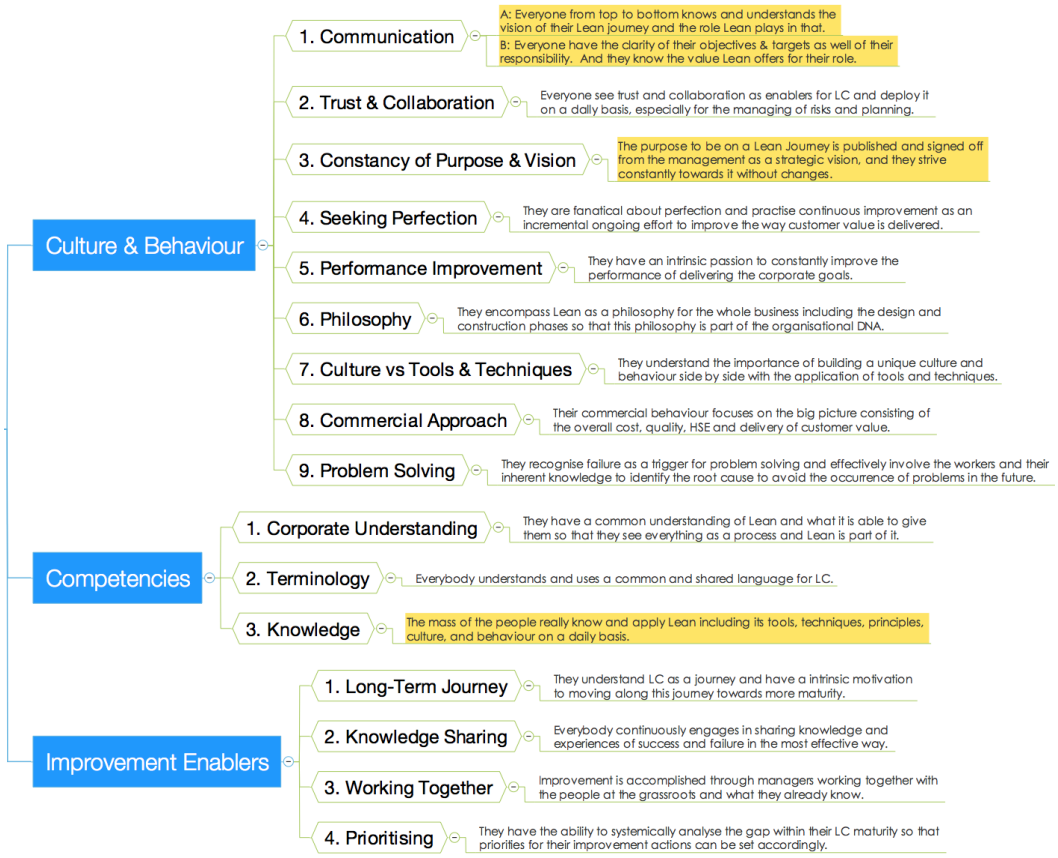


Figure 7-17: Validated factor - People

7.6.4 Factor - Process & System

Within this factor a second Ideal Statement was added to the BG&P – 'Tools & Technique', and the BG&P – 'Visual Management System' was relocated from the BG&P – 'Competencies'.

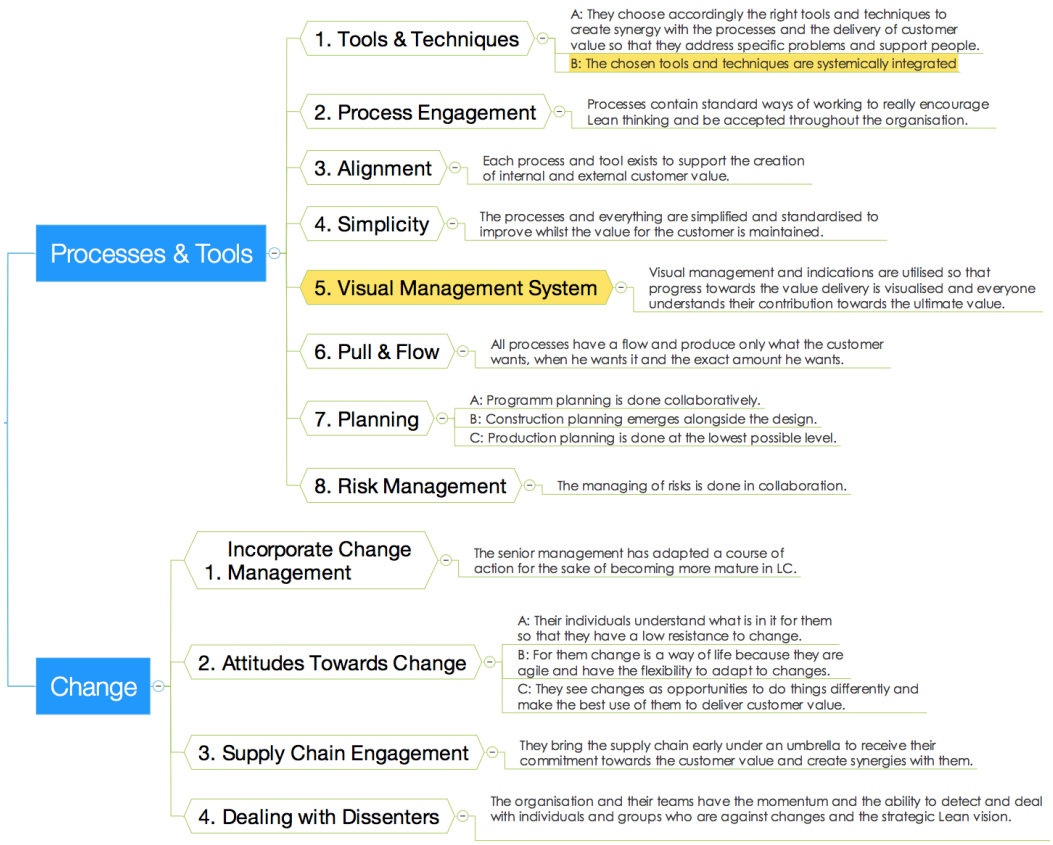


Figure 7-18: Validated factor - Processes & System

7.6.5 Factor - Outcome & Outputs

The researcher decided to undertake the following modifications in this factor: (1) amend the Ideal Statement of the BG&P – 'Continuous Improvement', 'Cost, Time and HSE', and 'Competitive Impact'; (2) extend the BG&P – 'Partnering' with a new Ideal Statement (B:). Not taken into the validated framework were the suggestions regarding the BG&P – 'Customer Satisfaction', because these suggestions are too subjective and different to the original definition of this BG&P and the literature, from the researcher's perspective.

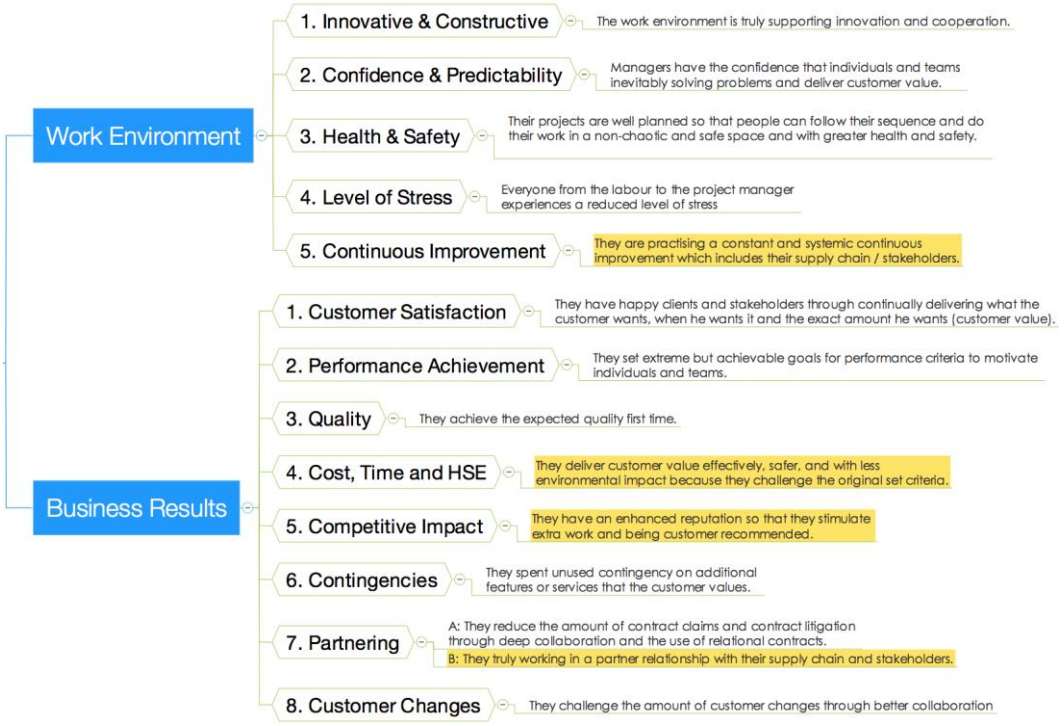


Figure 7-19: Validated factor - Outcome & outputs

7.6.6 Factor - Learning

The recommendation in the validation in terms of an additional BG&P was not followed, because it is much more consistent to capture this *structured approach* under the BG&P – 'Learning' and create an additional Ideal Statement for that. As suggested, a new Ideal Statement in the BG&P – 'Training' was established. Moreover, the name of the Key Attribute was changed to illustrate the focus on learning.

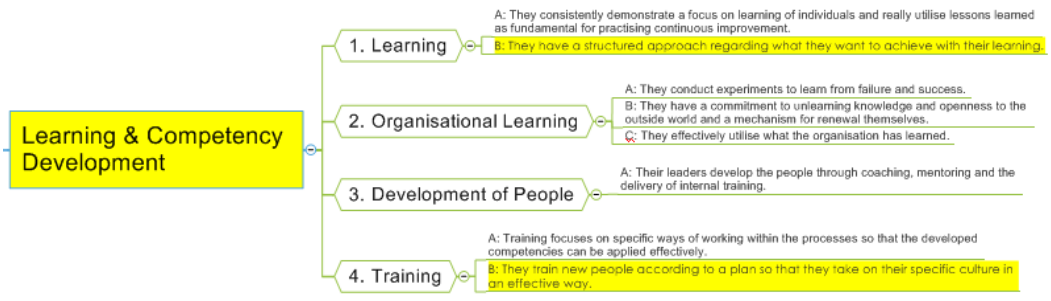


Figure 7-20: Validated factor - Learning

7.6.7 Relationship between framework and modelling of LC maturity

The validated framework for LC maturity has been developed around the identified essence of LC maturity described in 6.2.6.8 and comprises of: 1) a Top Layer; 2) Key Attributes; 3) BG&P's; 4) Ideal Statements; 5) Maturity Levels; and 6) a Maturity Assessment Procedure. Figure 7-21 illustrates this and further that the framework includes also a model component which enables the modelling of LC maturity within organisations, which are in the process of embedding LC or about to do so. Therefore the framework for LC maturity can be used to model LC maturity (hence this framework is labelled as LCMM) which is used for instance:

- to gather an holistic overview of an organisation's current state of LC maturity and generate awareness of the current state;
- to identify strengths and weaknesses and gaps within LC maturity;
- to support and guide an organisation on their transformation/Lean journey; and
- to support the prioritisation of planned improvement actions.

However this is just the model component and the framework is not limited to this as there are many ways to make use out of this framework without the model component such as:

- kick-off a Lean journey and initiate a cultural change through discussing the elements included in the framework;
- stimulate a discussion in terms of LC and what LC maturity comprises of;
- establish a common and shared language for LC; and
- support the sustained embedment of LC.

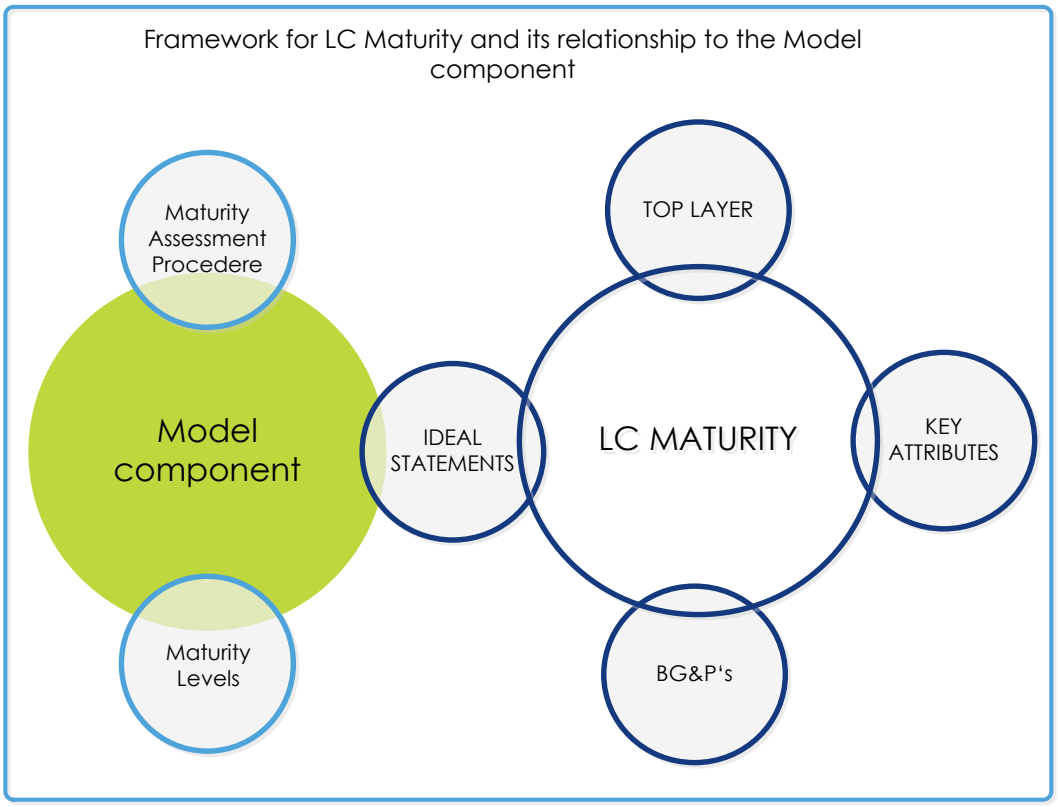


Figure 7-21: Framework and its relationship to the model component

As a result, can the relationship between the framework and modelling of maturity summarised as, a framework which describes LC maturity through Factors, Key Attributes, BG&P's and Ideal Statements. This framework can be used to support organisations to improve their maturity in LC through the defined maturity levels and the maturity assessment procedure which models (measures) where an organisation is currently are in terms of their LC maturity. Both the model component and the validated framework with its LC maturity elements are described in the following sections.

7.6.7.1 Validated framework of LC maturity

TOP LAYER of the LCMM

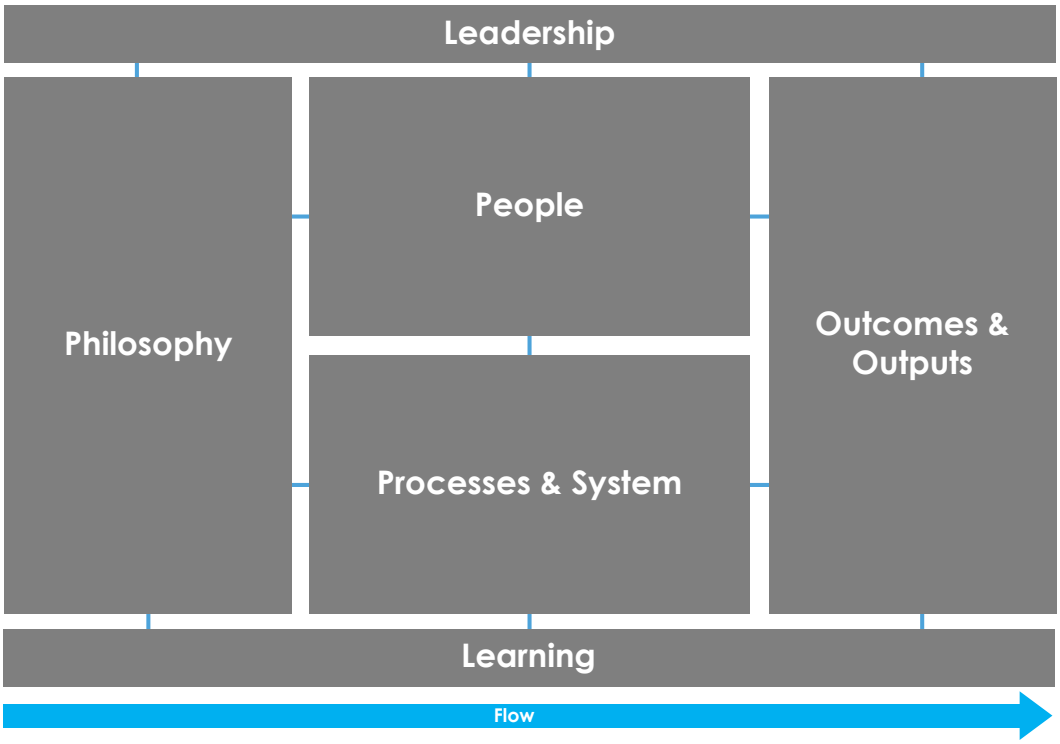


Figure 7-22: Top Layer with Factors

The Top Layer and its comprising Factors have been developed around the essence of LC maturity and serve as containers for the related Key Attributes and BG&Ps in terms of LC maturity. Furthermore, this Top Layer establishes a flow and direction from left to right which indicates that Philosophy, Leadership Learning, People and Processes & System must be in place before the right Outcomes & Outputs can be achieved.

Key Attributes

The Key Attributes are illustrated and mapped to their belonging Factors of the Top Layer see

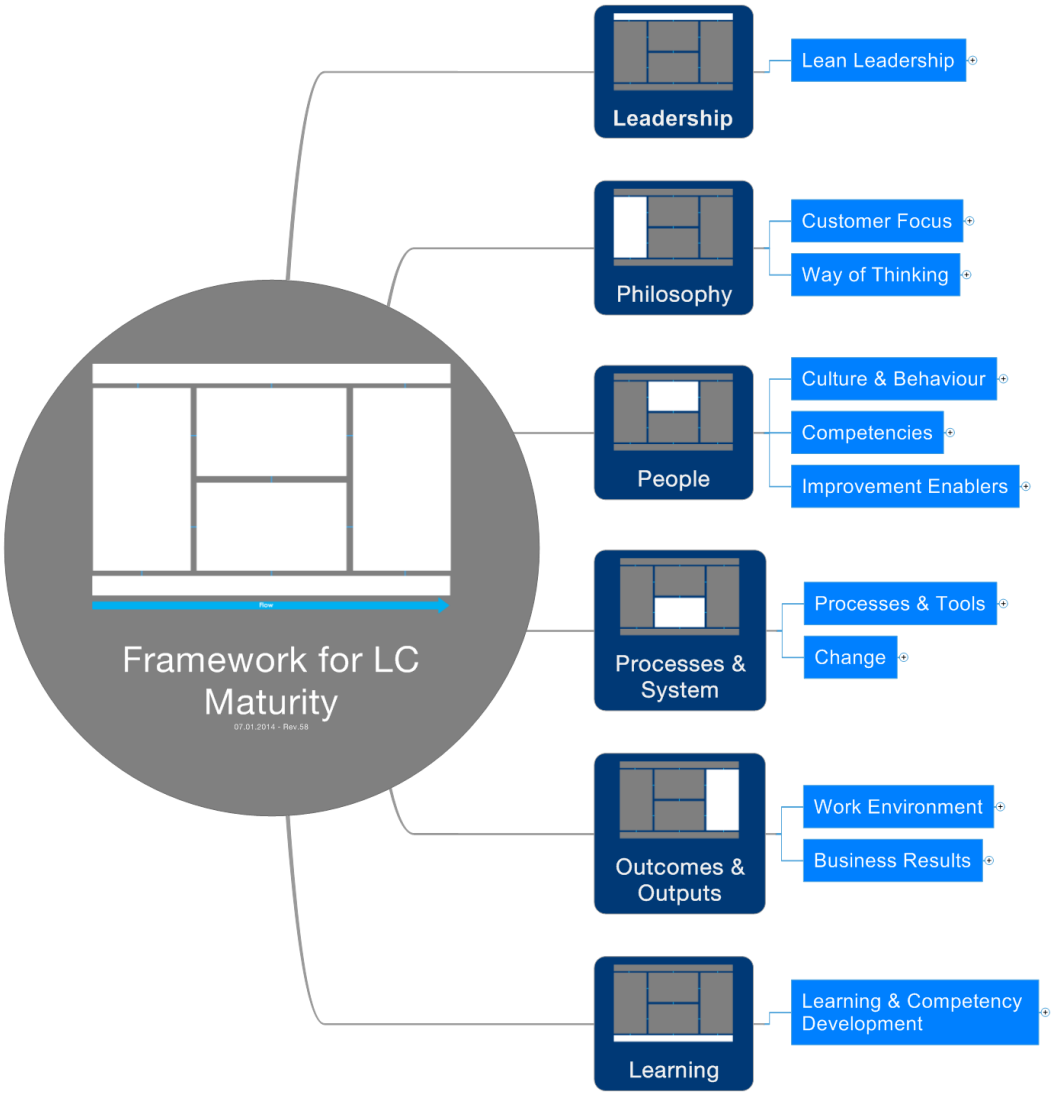


Figure 7-23: Framework with Factors and Key Attributes

Figure 7-23.

The LCMM simplifies LC maturity into 11 Key Attributes which each serves a specific purpose that is illustrated on the following page.

Lean Leadership

The purpose of Lean Leadership is to establish and maintain leaders who actively encourage and drive individuals and teams towards more maturity in LC.

Customer Focus

The purpose of Customer Focus is to establish and maintain an understanding and focus on both internal and external customer value.

Way of Thinking

The purpose of Way of Thinking is to establish and maintain a holistic approach of thinking that supports LC maturity.

Culture & Behaviour

The purpose of Culture & Behaviour is to establish and maintain a commitment and alignment of individuals and teams to engage actively through their behaviour in the transformation process.

Competencies

The purpose of Competencies is to establish and maintain a foundation for individuals and teams to continuously improve the competencies required to drive the transformation towards LC.

Improvement Enablers

The purpose of Improvement Enablers is to make it possible for the people and the organisation to improve their LC maturity.

Processes & Tools

The purpose of Processes & Tools is to establish and maintain an improvement of the processes that deliver the ultimate value.

Change

The purpose of Change is to establish and maintain a context by which the change towards LC is intrinsic.

Work Environment

The purpose of Work Environment is to establish and maintain working conditions that encourage individuals and teams.

Business Results

The purpose of Business Results is to enhance the alignment of performance criteria with the contribution of individuals and teams.

Learning & Competency Development

The purpose of Learning & Competency Development is to insure that individuals, teams and the organisation are constantly learning to enhance their skills, knowledge and competencies.

BG&P's and Ideal Statements

The 60 BG&Ps serve as an informative component that recognises: *Behaviours* associated with LC maturity; common *Goals* and characteristics of mature organisations; and *Practices* of activities which are crucial for LC maturity. Each BG&P encompasses one or more Ideal Statements which a more mature organisation in LC exemplifies. For the framework add the Ideal Statements a further element of information around LC maturity.

On the next page is the validated framework with its Factors, Key Attributes and BG&P's presented in a DIN A3 format.

Validated Framework LCMM

Framework for LC Maturity

07.01.2014 - Rev.58

Leadership

- Lean Leadership
  1. Passion
  2. True Understanding
  3. Pre-set Position
  4. Walk the Talk
  5. Standard Work

Philosophy

- Customer Focus
  1. Understanding Customer Value
  2. Identifying Ultimate Customer Value
  3. Value Monitoring
  4. Being "Customer Driven"
- Way of Thinking
  1. Systemic Thinking
  2. Process Thinking
  3. Scientific Thinking
  4. Long-Term Thinking
  5. Thinking Teams
  6. Out-of-the-Box Thinking

People

- Culture & Behaviour
  1. Communication
  2. Trust & Collaboration
  3. Constancy of Purpose & Vision
  4. Seeking Perfection
  5. Performance Improvement
  6. Philosophy
  7. Culture vs Tools & Techniques
  8. Commercial Approach
  9. Problem Solving
- Competencies
  1. Corporate Understanding
  2. Terminology
  3. Knowledge
- Improvement Enablers
  1. Long-Term Journey
  2. Knowledge Sharing
  3. Working Together
  4. Prioritising

Processes & System

- Processes & Tools
  1. Tools & Techniques
  2. Process Engagement
  3. Alignment
  4. Simplicity
  5. Visual Management System
  6. Pull & Flow
  7. Planning
  8. Risk Management
- Change
  1. Incorporate Change Management
  2. Attitudes Towards Change
  3. Supply Chain Engagement
  4. Dealing with Dissenters

Outcomes & Outputs

- Work Environment
  1. Innovative & Constructive
  2. Confidence & Predictability
  3. Health & Safety
  4. Level of Stress
  5. Continuous Improvement
- Business Results
  1. Customer Satisfaction
  2. Performance Achievement
  3. Quality
  4. Cost, Time and HSE
  5. Competitive Impact
  6. Contingencies
  7. Partnering
  8. Customer Changes

Learning

- Learning & Competency Development
  1. Learning
  2. Organisational Learning
  3. Development of People
  4. Training

7.6.7.2 Model component

Ideal Statements

The Ideal Statements are the crucial element to measure LC maturity therefore these 75 statements are the required components of the LCMM whose evidence of being present in the organisation is evaluated through the five maturity levels. An example of one Key Attribute including its BG&P and Ideal Statements is shown in the figure below.

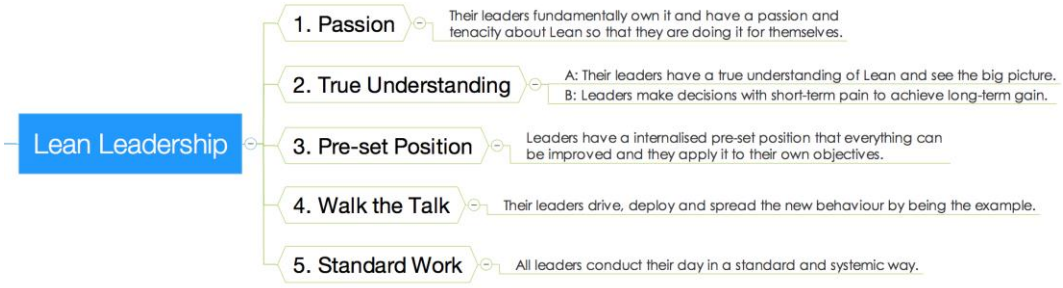


Figure 7-24: Example Key Attribute with BG&P's and Ideal Statements

Maturity Levels and assessment procedure

Figure 7-25: Maturity Levels

The maturity levels are utilised for the maturity assessment. Hence the five defined 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-led 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 the Ideal Statement is hardly evidenced in its actions then it would be classed as maturity level (0) – which is called 'uncertain'. If the Ideal Statement is systemically evidenced in actions it is classed as maturity level (2) – 'systematic'. An overview of the definition of each maturity level is shown in Table 7-15.

Table 7-15: Definitions 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

Each Key Attribute is represented through one maturity level which is calculated by the lowest shared (*this is also the lowest maturity level assigned*) maturity level amongst all BG&Ps within this Key Attribute. The screenshots in the figures below demonstrates this within an Excel tool.

Factors/Key Attributes		Ideal Statements	Maturity level
Leadership			
	Lean Leadership		**3**
	1. Passion	Their leaders fundamentally own it and have a passion and tenacity about Lean so that they are doing it for themselves.	3
	2. True Understanding	A: Their leaders have a true understanding of Lean and see the big picture.	3
		B: Leaders make decisions with short-term pain to achieve long-term gain.	4
	3. Pre-set Position	Leaders have a internalised pre-set position that everything can be improved and they apply it to their own objectives.	3
	4. Walk the Talk	Their leaders drive, deploy and spread the new behaviour by being the example.	3
	5. Standard Work	All leaders conduct their day in a standard and systemic way.	3
Philosophy			
	Customer Focus		**2**
	1. Understanding Customer Value	A: They understand that customer value involves the requirements of the chain of internal and external customers up to the end user.	3
		B: It is accepted that customer value can be intangible and the value of customer A can be the waste for customer B.	2
		C: They are focused on the value perception of the chain of customers to be clear what is the required value that needs to be delivered in the best possible way.	3
	2. Identifying Ultimate Customer Value	A: They are outstanding in identifying real value for their customers.	4
		B: They actively revise the identified value stream to react to any changes of the customer value and to tackle any waste in this sequence of processes to create the ultimate value.	2
	3. Value Monitoring	They know their deviation from the customer value by monitoring the effectiveness of delivering this value.	3
	4. Being "Customer Driven"	Leaders and managers focus on doing the best work for the customer and accept that being customer driven is no contradiction to the business driver such as satisfaction of the shareholders.	2
	Way of Thinking		**2**
	1. Systemic Thinking	They think systemically to see the big picture, the whole, the information flow within the system and establish links between every value stream and aspect of the business to create synergies. For example: they practise continuous improvement to see processes and customers in a systemic way.	2
	2. Process Thinking	The people accept that value is created through processes and understand those processes and their relationships.	3
	3. Scientific Thinking	They are rigorous in collecting information about variables to support the decision-making process and testing hypotheses in a scientific way.	3
	4. Long-Term Thinking	They practice long-term thinking while they accept pain in short-term decisions, to not affect the long-term goal.	3
	5. Thinking Teams	Everybody's activity is aligned in a direction of delivering improvement and challenging processes, from the top to the bottom regardless of the subject, department or processes.	2
	6. Out-of-the-Box Thinking	There are some lateral thinkers who often go off the beaten tracks to find new solutions and challenge the leadership to deliver improvement.	2

Figure 7-26: LCMM assessment spreadsheet page 1 of 4

Factors/Key Attributes		Ideal Statements	Maturity level
People			
Culture & Behaviour			**1**
	1. Communication	A: Everyone from top to bottom knows and understands the vision of their Lean journey and the role Lean plays in that.	2
		B: Everyone have the clarity of their objectives & targets as well of their responsibility. And they know the value Lean offers for their role.	3
	2. Trust & Collaboration	Everyone see trust and collaboration as enablers for LC and deploy it on a dally basis, especially for the managing of risks and planning.	2
	3. Constancy of Purpose & Vision	The purpose to be on a Lean Journey is published and signed off from the management as a strategic vision, and they strive constantly towards it without changes.	1
	4. Seeking Perfection	They are fanatical about perfection and practise continuous improvement as an incremental ongoing effort to improve the way customer value is delivered.	3
	5. Performance improvement	They have an intrinsic passion to constantly improve the performance of delivering the corporate goals.	2
	6. Philosophy	They encompass Lean as a philosophy for the whole business including the design and construction phases so that this philosophy is part of the organisational DNA.	2
	7. Culture vs. Tools & Technique	They understand the importance of building a unique culture and behaviour side by side with the application of tools and techniques.	2
	8. Commercial Approach	Their commercial behaviour focuses on the big picture consisting of the overall cost, quality, HSE and delivery of customer value.	3
	9. Problem Solving	They recognise failure as a trigger for problem solving and effectively involve the workers and their inherent knowledge to identify the root cause to avoid the occurrence of problems in the future.	2
Competencies			**2**
	1. Corporate Understanding	They have a common understanding of Lean and what it is able to give them so that they see everything as a process and Lean is part of it.	2
	2. Terminolgy	Everybody understands and uses a common and shared language for LC.	3
	3. Knowledge	Knowledge The mass of the people really know and apply Lean including its tools, techniques, principles, culture, and behaviour on a daily basis.	2
Improvement Enablers			**1**
	1. Long-Term Journey	They understand LC as a journey and have a intrinsic motivation to moving along this journey towards more maturity.	1
	2. Knowledge Sharing	Everybody continuously engages in sharing knowledge and experiences of success and failure in the most effective way.	2
	3. Working Together	Improvement is accomplished through managers working together with the people at the grassroots and what they already know.	3
	4. Prioritising	They have the ability to systemically analyse the gap within their LC maturity so that priorities for their improvement actions can be set accordingly.	2

Figure 7-27: LCMM assessment spreadsheet page 2 of 4

Factors/Key Attributes		Ideal Statements	Maturity level
Processes & System			
Processes & Tools			**2**
	1. Tools & Techniques	A: They choose accordingly the right tools and techniques to create synergy with the processes and the delivery of customer value so that they address specific problems and support people.	2
		B: The chosen tools and techniques are systemically integrated.	3
	2. Process Engagement	Processes contain standard ways of working to really encourage Lean thinking and be accepted throughout the organisation.	2
	3. Alignment	Each process and tool exists to support the creation of internal and external customer value.	3
	4. Simplicity	The processes and everything are simplified and standardised to improve whilst the value for the customer is maintained.	3
	5. Visual Management System	Visual management and indications are utilised so that progress towards the value delivery is visualised and everyone understands their contribution towards the ultimate value.	3
	6. Pull & Flow	All processes have a flow and produce only what the customer wants, when he wants it and the exact amount he wants.	4
	7. Planning	A: Programm planning is done collaboratively.	3
		B: Construction planning emerges alongside the design.	2
		C: Production planning is done at the lowest possible level.	3
	8. Risk Management	The managing of risks is done in collaboration.	2
Change			**2**
	1. Incorporate Change Management	The senior management has adapted a course of action for the sake of becoming more mature in LC.	2
	2. Attitudes Towards Change	A: Their individuals understand what is in it for them so that they have a low resistance to change.	3
		B: For them change is a way of life because they are agile and have the flexibility to adapt to changes.	4
		C: They see changes as opportunities to do things differently and make the best use of them to deliver customer value.	3
	3. Supply Chain Engagement	They bring the supply chain early under an umbrella to receive their commitment towards the customer value and create synergies with them.	2
	4. Dealing with Dissenters	The organisation and their teams have the momentum and the ability to detect and deal with individuals and groups who are against changes and the strategic Lean vision.	3

Figure 7-28: LCMM assessment spreadsheet page 3 of 4

Factors/Key Attributes		Ideal Statements	Maturity level
Outcomes & Outputs			
Work Environment			**2**
	1. Innovative & Constructive	The work environment is truly supporting innovation and cooperation.	2
	2. Confidence & Predictability	Managers have the confidence that individuals and teams inevitably solving problems and deliver customer value.	3
	3. Health & Safety	Their projects are well planned so that people can follow their sequence and do their work in a non-chaotic and safe space and with greater health and safety.	2
	4. Level of Stress	Everyone from the labour to the project manager experiences a reduced level of stress	3
	5. Continuous Improvement	They are practising a constant and systemic continuous improvement which includes their supply chain / stakeholders.	2
Business Results			**2**
	1. Customer Satisfaction	They have happy clients and stakeholders through continually delivering what the customer wants, when he wants it and the exact amount he wants (customer value).	2
	2. Performance Achievement	They set extreme but achievable goals for performance criteria to motivate individuals and teams.	3
	3. Quality	They achieve the expected quality first time.	2
	4. Cost, Time and HSE	They deliver customer value effectively, safer, and with less environmental impact because they challenge the original set criteria.	3
	5. Competitive Impact	They have an enhanced reputation so that they stimulate extra work and being customer recommended.	2
	6. Contingencies	They spent unused contingency on additional features or services that the customer values.	3
	7. Partnering	A: They reduce the amount of contract claims and contract litigation through deep collaboration and the use of relational contracts.	2
		B: They truly working in a partner relationship with their supply chain and stakeholders.	3
	8. Customer Changes	They challenge the amount of customer changes through better collaboration	3
Learning			
Learning & Competency Development			**2**
	1. Learning	A: They consistently demonstrate a focus on learning of individuals and really utilise lessons learned as fundamental for practising continuous improvement.	3
		B: They have a structured approach regarding what they want to achieve with their learning.	3
	2. Organisational Learning	A: They conduct experiments to learn from failure and success.	2
		B: They have a commitment to unlearning knowledge and openness to the outside world and a mechanism for renewal themselves.	3
		C: They effectively utilise what the organisation has learned.	3
	3. Development of People	A: Their leaders develop the people through coaching, mentoring and the delivery of internal training.	2
	4. Training	A: Training focuses on specific ways of working within the processes so that the developed competencies can be applied effectively.	3
		B: They train new people according to a plan so that they take on their specific culture in an effective way.	2

Figure 7-29: LCMM assessment spreadsheet page 4 of 4

Through using the Excel spreadsheet will be each Ideal Statement evaluated with the maturity levels so that the result can be illustrated in a spider diagram (Figure 7-30). This diagram visualises the assigned maturity level to each of the 11 Key Attributes. Furthermore, an overall maturity level can be calculated (see Table 7-16) through the multiplication of the maturity level of each Key Attribute with a weighting factor whose total sum is divided by the total sum of the weighting factors, to generate a single score from 0-4 for the organisation's total maturity in LC. However as pointed out earlier the weighting factors need to be further refined with a bigger sample. Finally must be stressed that the use of these weighting factors and the overall maturity level cannot stand in conflict with the Lean philosophy which does not support a blame culture.

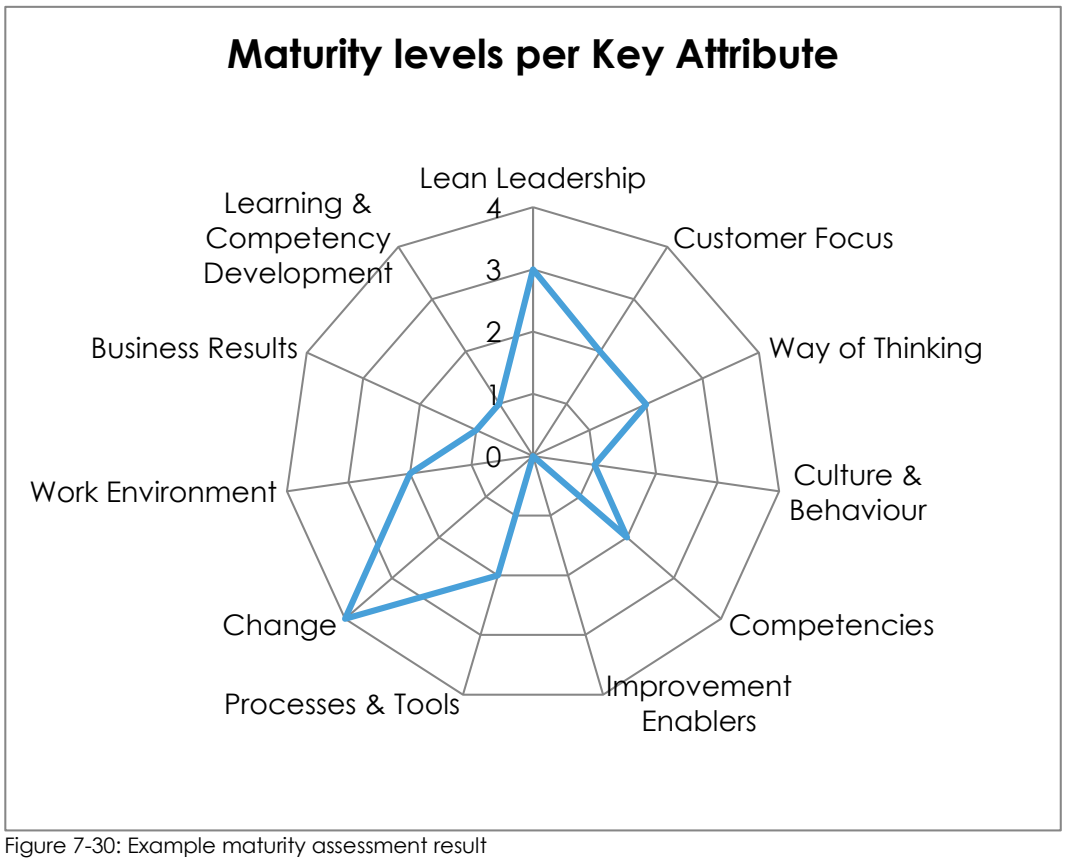


Figure 7-30: Example maturity assessment result

Table 7-16: Example of the executive summary and overall maturity level

No.	Key Attribute	Initial level	Weighting factor	result	Total matuirty level
1	Lean Leadership	3	4	12	
2	Customer Focus	2	3	6	
3	Way of Thinking	2	3	6	
4	Culture & Behaviour	1	4	4	
5	Competencies	2	2	4	
6	Improvement Enablers	0	2	0	
7	Processes & Tools	2	2	4	
8	Change	4	2	8	
9	Work Environment	2	2	4	
10	Business Results	1	1	1	
11	Training & Competency Development	1	2	2	**2**
		Total:	*27*	*51*	*1,9*

Four step maturity assessment procedure:

The maturity assessment procedure involves four major steps which are also illustrated in Figure 7-31.

- Analysing and collecting evidence for the current state of LC maturity in the organisation.
- Comparison of the gathered evidence against the Ideal Statements and evaluation with the maturity levels.
- Developing of an improvement/change plan which is subsequently prioritised through the strategy of the organisation at any given time, before it will be deployed in a systematic way.
- Re-assessment of the deployed improvement efforts to monitor changes and identify achieved maturing and learning

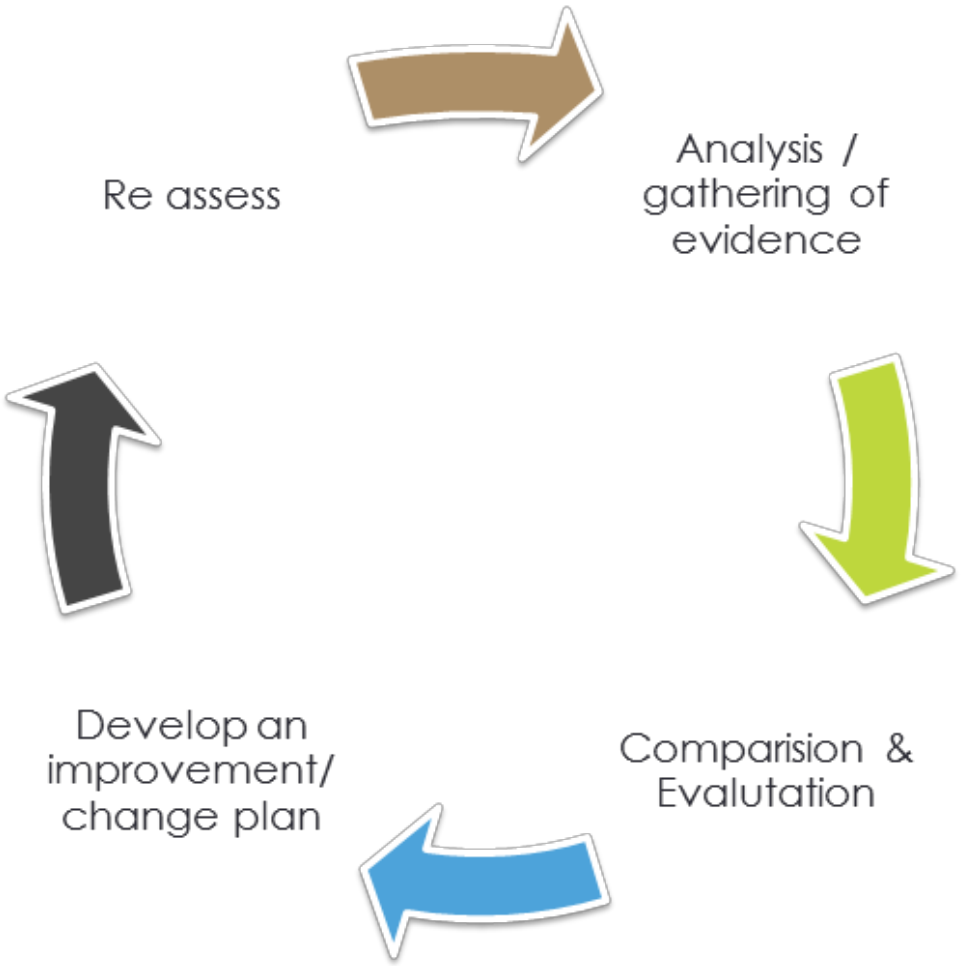


Figure 7-31: Assessment procedure

7.7 Potential practical implications and limitations

The main applicability of this framework for LC maturity within the construction sector is expected through the use within organisations which are either planning to embed LC or those who are within their Lean journey. This includes organisations such as: clients, contractors, and sub-contractors. Organisations as for instance architects and engineers also expected to benefit through the utilisation of this framework. This may applies as well for quantity surveyors, however this needs to be further investigated.

The results of this study indicate that the developed framework enables entities to get a systemic and holistic overview of the current state of maturity in LC. The evidence from this study further suggests that the framework is able to identify strengths and weaknesses in terms of LC maturity. Hence the framework including its assessment illustrates gaps and areas with high maturity within the current state of LC maturity. Furthermore, it is suggested that the framework provides organisations with guidance for their transformation, and support in the prioritising of planned improvement actions towards greater maturity. This information can be used for instance to develop targeted interventions and workshops aimed at improving the maturity of a particular BG&P in the framework. In general, therefore, the use of the framework can establish a common language and awareness of LC within the transforming entity.

Another important practical implication is the simplification of LC presented in the framework. Hence it is very likely that the understanding of Lean concepts and the philosophy of the organisation and its individuals will be enhanced by interacting with the framework. Equal to the statement in the validation, it is expected that the deployment of the framework will stimulate discussions about LC within the organisation.

However, caution must be applied, as the implications might not be transferable to the use of the framework within short-term construction projects and temporary organisations, because the value generated through the framework is debatable. A further limitation of the practical

implications of this framework is the fact that the assessors need to know the framework and LC very well in order to achieve the desired results. A reasonable approach to tackle this issue could be the training of assessors by the researcher. A final limitation of this framework is the risk of an inappropriate use of the organisational assessment tool. Since the Key Attribute Culture & Behaviour of the framework seeks to establish Trust and Collaboration, it would be absolutely inappropriate to use this framework and its assessment ability to blame other divisions or organisations. This is not the intention of this framework nor of the researcher, because a blame culture is not aligned with the underpinning philosophy of Lean and can prevent CI.

7.8 Chapter summary

This chapter has presented the process of the development of a validated framework for assessing LC maturity, labelled Lean Construction Maturity Model (LCMM). This framework is supporting organisations in their transformation towards greater maturity in LC, through assessing their current state of LC maturity. The findings of the supplementary and the primary data analysis of this research, presented in Chapters five and six, have been combined and linked back to the literature to develop this framework. In particular, the findings were used to simplify LC into 11 Key Attributes with a lens of a more mature organisation. These Key Attributes have been further organised into six factors. The discussion of these findings further derived 60 BG&Ps which describe the 11 Key Attributes. These BG&Ps further contain 75 Ideal Statements, which will be evident in a more mature organisation. In order to assess the maturity of an entity in terms of LC, this framework defines a maturity assessment method utilising five maturity levels.

The proposed framework has been validated through three individual interviews and a FG with three participants. This validation assigned the framework its usability for practice and identified the implications and limitations. The performed validation contributes further to the overall validity of this research and its objectives. The validated framework enables

organisations to get a systemic and holistic overview of their current state of maturity in LC, and supports them to plan and direct their transformation towards greater maturity in LC. Finally, this chapter has illustrated that the research objectives one to five have been successfully achieved.

CHAPTER EIGHT

CONCLUSIONS AND RECOMMENDATIONS

8 Conclusions and recommendations

8.1 Introduction

This last chapter encapsulates the research endeavour with its main findings, implications, limitations and recommendations for further work. The next section provides a brief summary of the research. This is followed by conclusions of the overall research and how it achieved its aim and objectives, the presentation of the original contribution to knowledge and the research limitations as well as recommendations for further work.

8.2 Summary of the research endeavour

This thesis and respectively the research endeavour were divided into eight chapters. Chapter one provided the introduction to the research, its background and problem, as well as the explanation of the research question, aim and objectives. This chapter further provided an overview of the entire thesis and how the objectives are linked to the chapters. Chapter two presented a comprehensive understanding of the current 'state of knowledge' as the main outcome of a critical literature review focusing on LC and MMs. The chapter justifies the need for this research and builds a solid theoretical background as the foundation for it. This included learning from previous research experiences, both positive and negative in nature. Finally, the knowledge that was gained directed the development of the framework (called LCMM) for assessing LC maturity which is predominantly inspired by the CMMI.

The third chapter reviewed the research: philosophy, logic, methodological choices and approaches in order to combine those into a conceptual research framework that allows answering of the research question and achieving the aim and its objectives. Subsequently, the fourth chapter presented the utilised methodology and the justification for each method deployed in this research. Further, this chapter demonstrated the procedures for the data

analysis and organisation as well as the developed validation strategy to achieve reliable and valid research results.

The analysis and findings of the collected data from LC key informants through a group interview and 11 individual interviews was presented in Chapter five; and from two FGs in Chapter six. Both chapters present this qualitative data in a similar structure, with the exception of the group interview findings which have been discussed and presented in Chapter five because of coherence and the nature of a pilot study. All other findings have been discussed in Chapter seven alongside the presentation of the development of the LCMM. In addition, this chapter highlights the deployed validation of the developed framework and presents a valid version of this framework together with the expected implications. Finally, Chapter eight presents the summary of the main findings, implications, limitations and recommendations for further work and the original contribution to knowledge made through this research.

8.2.1 The research aim, objectives and research question

In this research, the aim was to develop a framework that enables organisations to measure the gap between where they currently are and where they want to be, in terms of their LC maturity. In order to achieve this aim supportive objectives were formed and addressed throughout the research endeavour. A summary of the completion of those objectives is illustrated in Table 8-1, p. 321. The following sections present a summary of the findings in relation to each objective, which together form a coherent completion of the research aim and the research problem and question presented in Chapter one.

Table 8-1: Completion of the research objectives

Research objective	Mode of achievement	Relevant chapter
1. To integrate the 'LC' and 'MM' literature to provide a sound theoretical basis for a framework for assessing LC maturity	Literature review and qualitative data from a group interview	Chapters two and five
2. To identify attributes towards LC maturity amongst industry key informants	Qualitative data from a group interview, individual interviews and focus groups	Chapters five, six, and seven
3. To simplify LC through defining Key Attributes that describe LC maturity		
4. To propose a framework which can be used to measure the current state of LC maturity in organisations	Literature review and qualitative data from a group interview, individual interviews and focus groups	Chapters two, five, six and seven
5. To validate the proposed framework	Validation through Individual interviews and a focus group	Chapter seven

8.2.1.1 Objective #1: To integrate the 'LC' and 'MM' literature to provide a sound theoretical basis for a framework for assessing LC maturity

The first objective of this research was achieved through the literature review and the findings of the group interview (see Table 8-1). From the literature review, it emerged that LC as a management philosophy becomes more and more the vehicle to achieve improvement in the industry. The increasing theoretical background including the reporting of remarkable improvements through LC further supports the major global role of LC. Nevertheless, it has been shown that achieving effective results through LC requires certain changes in thinking, culture, and behaviour of individuals and organisations. Thus, transformation requires the support of organisational assessments, which are limited in the LC literature. It has been explained that such support is provided through MMs, which claim

to deliver numerous benefits for various disciplines including construction and Lean in aerospace. Further, it was shown that MMs share commonalities and assessment procedures which are important to consider.

In meeting this first objective it has been shown that MMs provide a number of benefits which are useful for the transformation towards greater maturity in LC, e.g. support of a common language, build an understanding of the current state of maturity, identify strengths and weaknesses, and generate crucial information to plan and direct future improvement. Additionally, the findings of the group interview demonstrated the feasibility of the possible integration of MMs and LC. Furthermore, these findings demonstrated that a MM for LC must capture the behaviour, understanding, and the outcome of a more mature organisation in order to provide appropriate dimensions for a maturity assessment in LC. The completion of this first objective builds the theoretical foundation to achieve the research aim.

8.2.1.2 Objective #2: To identify attributes towards LC maturity amongst industry key informants

This objective was achieved through the findings of the qualitative mixed-method design [QUAL $^{(\text{phenomenology-FG})}$ + qual $^{(\text{group interview})}$ + qual $^{(\text{individual interviews})}$] (see Table 8-1, p. 321). These different sources identified the attributes that LC key informants felt were important for LC maturity. Different attributes towards LC maturity emerged throughout the findings of those three analysed data sets. The group interview predominantly indicated some perception towards LC maturity; as such LC maturity was perceived as the path of LC evolution: maturity is not an endpoint but a direction, and what is more mature and what is immature can be recognised. Some of the attributes that emerged are for instance customer focus, thinking, culture and behaviour, and Lean leadership. It was explicitly identified through the FGs that LC maturity is dominated by the culture and behaviour, Lean leadership, Lean competencies, a specific way of thinking, and a low resistance to change. These attributes have been captured and described in various themes presented in Chapters five and

six. The completion of this objective not only serves the achievement of the research aim, it was also a prerequisite for the next objective.

8.2.1.3 Objective #3: To simplify LC through defining Key Attributes that describe LC maturity

Since the aim of this research was to propose a framework which allows the assessment of LC maturity, LC itself had to be simplified in order to indicate different levels of maturity and fit in with the commonalities of MMs. This was significant because, in comparison to other MMs that take on an existent body of knowledge with defined best practices (e.g. OPM3 which is based on the PMI best practices), something similar and widely accepted does not exist and would be inappropriate for LC. The third objective addressed this and was achieved through encapsulating the outcome of the second objective to define 11 Key Attributes that simplified LC with the lens of a more mature organisation. Hence through integrating the findings of all three data sources the completion of this objective was achieved. This is presented within Chapter seven as the simplification of LC into 11 Key Attributes which serve as a direct element of the LCMM.

8.2.1.4 Objective #4: To propose a framework which can be used to measure the current state of LC maturity in organisations

This objective was achieved through the development of a framework called LCMM, that was proved to measure organisations' current state of LC maturity. This is predominantly presented in Chapter seven but contributions towards the development can also be found in Chapters two, five and six (see Table 8-1, p. 321). The proposed framework emerged through a combination of the outcomes from meeting the previous objectives in this study. The development is based on the sound theoretical integration of LC and MMs in the literature review which have been linked to the findings of the data analysis of all three different sources. One of the major elements of this framework forms the defined 11 Key Attributes that simplified LC. In the framework these Key Attributes were described

through 60 Behaviours, Goals & Practices, and 75 Ideal Statements of more mature organisations that have been identified through linking the results of the data analysis with the literature in a discussion. Generally, this framework provides organisations with a systemic and holistic overview of the current state of maturity in LC, and supports them to plan and direct their transformation towards greater maturity in LC.

8.2.1.5 Objective #5: To validate the proposed framework

Having assembled all the outputs of the previous objectives into a framework, the fifth objective required the validation of the proposed framework (LCMM). The validation was further part of the overall validation strategy which was deployed to ensure validity, correctness, and accuracy of the research findings. The objective was achieved through the validation in the form of three individual interviews and a FG that validated and identified the practical limitations and implications of the framework. This validation procedure further gave members who had been involved in the data collection the opportunity to point out potential adaptations that would improve the framework. The opinions expressed have been considered to revise and improve the framework. In summary, this validation process assigned the validity and usability of the framework. The validation process and the revised valid framework have been illustrated in Chapter seven.

8.2.2 The research question

Through the systematic and rigorously qualitative mixed-method design [QUAL $^{(\text{phenomenology-FG})}$ + qual $^{(\text{group interview})}$ + qual $^{(\text{individual interviews})}$] involving three different methods 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?'*** can be answered as follows. It was identified that the concept of maturity together with MMs can be applied to LC, which allows the assessment of the current LC maturity in an entity. This was achieved through the development of a framework and the simplification of LC into 11 Key Attributes that more mature organisations will show. Therefore, the research question is

answered through the achieved aim of developing a framework called LCMM that was proved to measure the current state of maturity and provide guidance towards greater maturity in LC.

8.3 Conclusion

In general terms the following conclusions can be drawn from this study:

- The LC literature neglected organisational assessments in particular in the form of MMs as identified through the literature review. Nevertheless, industry key informants and policy makers such as the Highways Agency in the UK have acknowledged the benefits and opportunities offered by MMs, which is shown by the development of the HALMAT maturity assessment grid for LC as well as other practitioner LC maturity grids developed from organisations of key informants involved in the 11 international interviews conducted within this study;
- presently, the maturity of LC in the UK is considered to be low, as the findings of the conducted FGs with LC practitioners identified. However, it appeared through the findings of this research that it is crucial for the industry to assess the current state of maturity and be able to measure sought improvement;
- it was identified that assessing LC maturity requires appropriate dimensions such as behaviour, practices and attributes which are aligned with the underpinning philosophy of Lean. Moreover, it was demonstrated that the use of certain tools and techniques are not appropriate to assess LC maturity;
- from the research findings, 11 Key Attributes emerged that allow the measuring of LC maturity. These attributes simplified LC through a lens from a more mature organisation and enabled the development of a framework for assessing LC maturity;

- it was concluded that the essence of LC maturity can be explained through: Lean leadership; the focus of culture and behaviour; knowledge about Lean; and the low resistance to change;
- from the research findings and the literature review, and largely on the basis of the widely recognised CMMI, a framework called LCMM was proposed that measures LC maturity through 75 Ideal Statements that define 60 different Behaviours, Goals & Practices within the 11 Key Attributes, which will be evaluated by five maturity levels; and
- finally, the proposed LCMM including its assessment has been verified to enable organisations to enhance their LC maturity. Further, this framework was proved to contribute towards a successful transformation to greater maturity in LC through a systemic and holistic overview of the current state, and the strengths and weaknesses of LC maturity.

8.4 Contribution to knowledge

The research contributes to the knowledge in two ways, as follows.

8.4.1 Contribution to theory

This thesis has contributed to our knowledge in LC and MMs through the development of a framework (LCMM) that has been verified to measure the current state of LC maturity, and subsequently enhance the awareness and understanding of LC in organisations. In the light of this, the research has identified Lean leadership; the focus of culture and behaviour; knowledge about Lean; and the low resistance to change as the essence of the phenomenon 'LC maturity'.

As part of this, the thesis provides an original contribution to knowledge. Originality in this thesis is judged in the light of the RAE2008 through: the development of innovative theories and understanding; new integrations, and frameworks; addressing new questions; producing new evidence and insights; and developing new syntheses of existing work (Johnston, 2008).

The original contribution to knowledge is achieved in the following points:

- A comprehensive literature review that is original through a new integration of LC and MMs;
- the identification of current gaps in our knowledge with regard to LC and the utilising of organisational assessments in particular by MMs, which is original through addressing new questions in terms of LC maturity;
- a new synthesis of MMs to LC as a management philosophy, to bridge the gap of industrial practices of maturity grids for LC;
- the simplification of LC to 11 Key Attributes that have been proven to capture LC maturity and explain LC in a unique and simple way. This is original through the development of an innovative understanding of LC maturity and LC;
- the production of new insights through a phenomenology study that provides an exhaustive description of the essence of LC maturity and what more mature organisations in LC are expected to look like;
- demonstrating original new evidence and insights in terms of realising reported benefits from MMs within a new area such as LC through a new framework;
- developing a new innovative framework to measure LC maturity; and
- above all, this thesis provides a unique opportunity to examine the LC evolution and process of maturing within organisations.

This original contribution to knowledge serves as a solid foundation on which to build further work in the area of LC and MMs in the future.

8.4.2 Contribution to practice

From a practical perspective this thesis has contributed to the support sought for the transformation to greater maturity in LC. According to the practitioners involved in the validation of the proposed LCMM, this framework is a remarkable 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 this framework is predominantly expected to be used within entities such as: clients, contractors, sub-contractors, and others in the supply chain; and maybe long-term projects that are implementing LC.

Another proven innovative aspect from the framework is the establishing of discussions amongst teams and individuals about LC which establish an effective practical method to enhance the understanding and awareness of Lean. Finally, the framework provides a unique opportunity to improve the LC capability in organisations.

These contributions to practice will help to increase the LC maturity and the importance of measuring sought improvement in the construction industry.

8.5 Research limitations

All research projects suffer from limitations; to acknowledge this a number of important limitations relevant to this research need to be considered:

- The research focused on two domains: LC and MMs, yet the involved key informants have mainly quality experience in LC. This is considered to be a certain limitation. However, it seemed to be more appropriate to concentrate on LC key informants rather than to interview MM informants from outside the industry without experience in LC. The researcher did provide the participants in both interview types with a clear summary of MMs prior to the interviews, to ensure a base level of understanding about MMs and the concept of maturity;
- the validated framework and its ability to model LC maturity has not been tested (applied in a real-case scenario). An application to a case study in an organisation or a long-term project is therefore expected to deliver further

improvement for the framework and is a key recommendation for further work (see next section);

- as pointed out by two interviewees in the validation of the proposed framework, there is a requirement to weight the Key Attributes; because they are not all as equally important for LC maturity. Hence a weighting factor for each Key Attribute was determined in the validation FG. These factors are based on a limited sample which needs refinement through a wider investigation;
- the findings of the validation FG highlighted that participants would expect to see further analysis of the information provided from the framework towards prioritising what the particular organisation should improve first.
- the qualitative methodology adopted for this research has strength and weaknesses as pointed out in chapter three. So while the combination of three different qualitative methods and a strong validation strategy seem highly sufficient for this research, it must be recognised that a combination with a quantitative method may could reduce the subjectivity within the qualitative nature. However, since the phenomenon LC maturity is yet not widely recognised, one must accept that a quantitative survey with a sufficient number of responses to claim the generalisability of its results is more difficult and therefore maybe not appropriate for this study: and
- an element worth sharing is, the personal learning in terms of conducting focus groups. So there is the importance of the moderator skills, which are required to ensure that the group keeps its discussion focused on the topic of interest. In addition was recognised through conducting both focus groups that a group size of five or six participants which have a wealth of knowledge and experience about the topic of interest (in this case LC) can be challenging to manage even with good moderator skills.

8.6 Importance and recommendations for further work

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. Thus, the findings of this research provide a solid foundation to investigate potential implications of the application of the concept of MMs to LC with the proposed framework. Further work needs to be done to test and strengthen further proof of the whole range of benefits, and implications of the proposed framework. This should be considered within a case study-driven research. Additionally, the generalisation of the emerged explanation of LC maturity as well as the 11 Key Attributes of LC can be further confirmed or disconfirmed through further empirical evidence. Further research also needs to consider investigating the implementation of the framework in a project environment with different durations to explicitly identify the limits of the suitability of this framework within projects. Similar is further required to verify through implementation and use of the framework within different types of organisations such as quantity surveyors its wider applicability within the sector. The research suggested correlations amongst the identified themes of LC maturity that emerged out of the FGs. These relationships need further investigation to identify their impact on LC maturity and possibly identify additional relations. More specifically, it needs to be investigated how the proposed framework could be extended to deliver more precise prioritisation for future improvement actions through considering the individual strategic direction of the organisation which is assessed.

8.7 Chapter summary

This chapter has summarised the research endeavour – its main findings, implications, and limitations – and provided recommendations for further work. This research has answered the research question and its aim through proposing a validated framework for assessing LC maturity called LCMM. This framework was developed through the findings that emerged

in this qualitative mixed-method design research. The proposed LCMM provides an original contribution to knowledge and has been proven to measure the current state of LC maturity, which can lead to an enhanced awareness and understanding of LC within organisations. Moreover, this thesis strengthens our knowledge about LC through the simplification of LC into 11 Key Attributes and an exhaustive description of the phenomenological investigation into LC maturity.

Finally, it was outlined how this thesis and the proposed framework LCMM could promote LC and therefore the improvement required in the construction industry as well as further investigations into LC maturity.

References

Abdel-Wahab, M. and Vogl, B. (2011). Trends of productivity growth in the construction industry across Europe, US and Japan. *Construction Management and Economics* V.29(6), pp.635-644.

Abdelhamid, T. S. (2004). The self-destruction and renewal of Lean construction theory: A prediction from Boyd's theory. *Proceedings of the 12th Annual Conference of the International Group for Lean Construction*. Helsingør, Denmark, 3-5 August 2004, pp.1-19.

Abduh, M. and Roza, H. A. (2006). Indonesian contractors' readiness towards Lean construction. *Proceedings of the 14th Annual Conference of the International Group for Lean Construction*. Santiago, Chile, 25-27 July 2006, pp.543-549.

Ahern, D., Bate, R. and Konrad, M. (2000). *CMMI for Systems Engineering/Software Engineering, Version 1. 02,* Software Engineering Institute, Carnegie Mellon University, Pittsburgh.

Alarcón, L. F. and Serpell, A. (1996). Performance measuring benchmarking, and modelling of construction projects. *Proceedings of the 4th Annual Conference of the International Group for Lean Construction*. Birmingham, UK, 1996, pp.1-10.

Albrecht, T. L., Johnson, G. M. and Walter, J. B. (1993). Understanding communication processes in focus groups. *In:* Morgan, D. L. (eds.) *Successful Focus Groups : Advancing the State of Art*. London: Sage.

Almeida, J. C. and Salazar, G. F. (2003). Strategic issues in Lean construction. *Proceedings of the 11th Annual Conference of the International Group for Lean Construction*. Blacksburg, Virginia, USA, 22-24 July 2003, pp.1-10.

AlSehaimi, A. O., Fazenda, P. T. and Koskela, L. (2014). Improving construction management practice with the Last Planner System: A case study. *Engineering, Construction and Architectural Management* V.21(1), pp.55-64.

Alves, T. C. L., Milberg, C. and D.Walsh, K. (2010). Exploring Lean construction practice, research, and eductation. *Proceedings of the 18th Annual Conference of the International Group of Lean Construction*. Haifa, Israel, 14-16 July 2010, pp.435-444.

Amaratunga, D., Baldry, D., Sarshar, M. and Newton, R. (2002a). Quantitative and qualitative research in the built environment: application of "mixed" research approach. *Work Study* V.51(1), pp.17-31.

Amaratunga, D., M., S. and D., B. (2002b). Process improvement in facilities management: the SPICE approach. *Business Process Management Journal* V.8(4), pp.318-337.

Andersen, E. S. and Jessen, S. A. (2003). Project maturity in organisations. *International Journal of Project Management* V.21(6), pp.457-461.

REFERENCES

Anderson, E. H. and Spencer, M. H. (2002). Cognitive representations of AIDS: A phenomenological study. *Qualitative Health Research* V.12(10), pp.1338-1352.

Angen, M. J. (2000). Evaluating interpretive inquiry: Reviewing the validity debate and opening the dialogue. *Qualitative Health Research* V.10(3), pp.378-395.

Anthes, G. H. (1997). Capable and mature. *Computerworld* V.31(50), pp.76-76.

Apostel, L. (1960). Towards the formal study of models in the non-formal sciences. *Synthese* V.12(2), pp.125-161.

Aris, R. and Penn, M. (1980). The mere notion of a model. *Mathematical Modelling* V.1(1), pp.1-12.

Atwater, J. B. and Pittman, P. H. (2006). Facilitating Systemic Thinking in Business Classes. *Decision Sciences Journal of Innovative Education* V.4(2), pp.273-292.

Aziz, R. F. and Hafez, S. M. (2013). Applying Lean thinking in construction and performance improvement. *Alexandria Engineering Journal* V.52(4), pp.679-695.

Babbie, E. R. (2012). *The practice of social research,* 13th ed, Belmont, USA: Wadsworth Publishing Company.

Bach, J. (1994). The immaturity of the CMM. *American Programmer* V.7(9), pp.13-18.

Baiden, B. K. and Price, A. D. F. (2011). The effect of integration on project delivery team effectiveness. *International Journal of Project Management* V.29(2), pp.129-136.

Baiden, B. K., Price, A. D. F. and Dainty, A. R. J. (2006). The extent of team integration within construction projects. *International Journal of Project Management* V.24(1), pp.13-23.

Baladhandayutham, T. and Venkatesh, S. (2012). An analysis on application of Lean supply chain concept for construction projects. *Synergy* V.x(1), pp.25-36.

Ballard, G. (1997). Lean construction and EPC performance improvement. *In:* Alarcon, L. (eds.) *Lean Construction*. Rotterdam: A.A.Balkema.

Ballard, G. (2002). Managing work flow on design projects: A case study. *Engineering Construction and Architectural Management* V.9(3), pp.284-291.

Ballard, G. (2008). The Lean Project Delivery System: An update. *Lean Construction Journal* V.1(1), pp.1-19.

Ballard, G., Hammond, J. and Nickerson, R. (2009). Production control principles. *Proceedings of the 17th Annual Conference of the International Group for Lean Construction*. Taipei, Taiwan, 13-15 July 2009, pp.489-500.

Ballard, G. and Howell, G. (1998). Shielding production: An essential step in production control. *Journal of Construction Engineering and Management* V.124(1), pp.11-17.

Ballard, G. and Howell, G. (2003). Lean project management. *Building Research & Information* V.31(2), pp.119-133.

Ballard, G. and Howell, G. A. (2005). Relational contracting and Lean construction. *Lean Construction Journal* V.2(1), pp.1-4.

REFERENCES

Ballard, G. and Tommelein, I. (2012). Lean management methods for complex projects. *Engineering Project Organization Journal* V.2(1-2), pp.85-96.

Ballard, H. G. (2000). *The Last Planner® System of Production Control*. Ph.D. thesis, The University of Birmingham.

Bartlett, G. (2001). Systemic Thinking: A simple thinking technique for gaining systemic focus. *The International Conference on Thinking" Breakthroughts*. Auckland, NZ, 2001, pp.1-14.

Beckerleg, S. E., Lewando-Hundt, G. A., Borkan, J. M., Abu Saad, K. J. and Belmaker, I. (1997). Eliciting local voices using natural group interviews. *Anthropology & Medicine* V.4(3), pp.273-288.

Bergmiller, G. G. and McCright, P. R. (2009). Lean manufacturers' transcendence to green manufacturing. *Industrial Engineering Research Conference 2009*. Miami, FL, USA, 30 May-3 June 2009, pp.1-6.

Bernstein, H. M. and Jones, S. A. (2013). *Lean construction: Leveraging collaboration and advanced practices to increase project efficency*, Design and Construction Intelligence, McGraw Hill Construction, Bedford, MA.

Bhasin, S. and Burcher, P. (2006). Lean viewed as a philosophy. *Journal of Manufacturing Technology Management* V.17(1), pp.56-72.

Bhaskar, R. (2008). *A realist theory of science*, London, UK: Routledge.

Biton, N. and Howell, G. (2013). The journey of Lean construction theory: Review and reinterpretation. *Proceedings of the 21st Annual Conference of the International Group of Lean Construction*, Volume 1, Fortaleza, Brazil, Fortaleza. *Federal University of Ceará*, ed. by Formoso, C. T. & Tzortzopoulos, P. pp.125-132.

Blaikie, N. W. H. (2010). *Designing social research : The logic of anticipation*, 2nd ed, Cambridge, UK: Polity Press.

Blismas, N. G. and Dainty, A. R. J. (2003). Computer-aided qualitative data analysis: Panacea or paradox? *Building Research & Information* V.31(6), pp.455-463.

Brady, D. A., Tzortopoulos, P. and Rooke, J. (2012). Using design science to further develop visual management application in construction. *Proceedings of the 20th Annual Conference of the International Group for Lean Construction*. San Diego, USA, 2012 / 01 / 01 / 2012, pp.10p.

Braun, T., Glänzel, W. and Schubert, A. (2005). A Hirsch-type index for journals. *The scientist* V.19(22), pp.8.

Britten, N. (1995). Qualitative interviews in medical research. *BMJ* V.311(6999), pp.251-253.

Brodetskaia, I., Sacks, R. and Shapira, A. (2013). Stabilizing production flow of interior and finishing works with reentrant flow in building construction. *Journal of Construction Engineering and Management* V.139(6), pp.665-674.

Bronfenbrenner, U. (1976). The experimental ecology of education. *Educational Researcher* V.5(9), pp.5-15.

REFERENCES

Bryde, D. J. and Schulmeister, R. (2012). Applying Lean principles to a building refurbishment project: experiences of key stakeholders. *Construction Management and Economics* V.30(9), pp.777-794.

Bryman, A. (2008). *Social research methods,* 3rd ed, Oxford: Oxford University Press.

Bryman, A. (2012). *Social research methods,* 4th ed, Oxford: Oxford University Press.

Buzan, T. and Buzan, B. (2006). *The Mind Map Book*, Essex, UK: BBC Active.

Caffyn, S. (1999). Development of a continuous improvement self-assessment tool. *International Journal of Operations & Production Management* V.19(11), pp.1138-1153.

Chesworth, B., London, K. and Gajendran, T. (2010). Diffusing cultural awareness and maturity in Lean managed organizations. *26th Annual ARCOM Conference*, Leeds, UK, 6-8 September. *Association of Researchers in Construction Management*, ed. by Egbu, C. pp.461-469.

Chesworth, B. L. (2013). *Cultural Maturity Modelling for Lean Organisations*. PhD Research Higher Degree Thesis, University of Newcastle.

Chia, F. C., Skitmore, M., Runeson, G. and Bridge, A. (2012). An analysis of construction productivity in Malaysia. *Construction Management and Economics* V.30(12), pp.1055-1069.

Choo, H. J., Tommelein, I. D., Ballard, G. and Zabelle, T. R. (1999). WorkPlan: Constraint-Based database for work package scheduling. *Journal of Construction Engineering and Management* V.125(3), pp.151-160.

Chrissis, M. B., Konrad, M. and Shrum, S. (2004). *CMMI guidlines for process integration and product improvement,* Boston: Addison-Wesley.

CIRIA (2013). *Implementing Lean in construction: Overview of CIRIA's guides. A brief introduction to Lean,* CIRIA, London, UK.

CMMI Product Team (2010). *CMMI for services, version 1.3,* Software Engineering Institute, Carnegie Mellon University, Pittsburgh.

Colaizzi, P. (1978). Psychological research as the phenomenologist's view it. *In:* Valle, R. S. (eds.) *Existential-phenomenological alternatives for psychology*. New York, USA: Oxford University Press.

Collins Dictionary (2011). *Collins Dictionary & Thesaurus of the English Language,* 5th ed, Glasgow: HarperCollins.

Cooke-Davies, T. J. (2004). Measurement of organizational maturity. *In:* Slevin, D. P., Cleland, D. I. & Pinto, J. K. (eds.) *Innovations-Project management research 2004*. Newtown Square: PMI.

Cooke-Davies, T. J. (2007). Project management maturity models. *In:* Morris, P. W. G. & Pinto, J. K. (eds.) *The Wiley Guide to Managing Projects*. Hoboken, New Jersey: John Wiley & Sons, Inc.

Cooke-Davies, T. J. and Arzymanow, A. (2003). The maturity of project management in different industries: An investigation into variations between project management models. *International Journal of Project Management* V.21(6), pp.471-478.

Cooke-Davies, T. J., Schlichter, J. and Bredillet, C. (2001). Beyond the PMBOK guide. *Annual Project Management Institute Seminar & Symposium*, 32th, Nashvill, USA, 7-10 November. *PMI*, ed. by Project Management Institute.

Cooper, H. M. (1989). *Integrating research: A guide for literature reviews,* 2nd ed, Newbury Park: Sage.

Crawford, P. and Vogl, B. (2006). Measuring productivity in the construction industry. *Building Research & Information* V.34(3), pp.208-219.

Creswell, J. W. (2009). *Research design : Qualitative, quantitative and mixed methods approaches,* 3rd ed, London: Sage.

Creswell, J. W. (2013). *Qualitative inquiry & research design : Choosing among five approaches,* 3rd ed, London: Sage.

Crichton, S. and Kinash, S. 2003. Virtual ethnography: Interactive interviewing online as method *Canadian Journal of Learning and Technology* [Online], 29.

Available at: http://cjlt.csj.ualberta.ca/index.php/cjlt/article/view/40/37

[Accessed 25th October].

Crosby, P. B. (1979). *Quality is free : The art of making quality certain,* New York: McGraw-Hill.

Crotty, M. (1998). *The foundations of social research : Meaning and perspective in the research process*, London: Sage.

Curtis, B. (1994). A mature view of the CMM. *American Programmer* V.7(9), pp.19-28.

Curtis, B., Hefley, B. and Miller, S. (2009). *People Capability Maturity Model (P-CMM) Version 2.0,* Software Engineering Institute, Carnegie Mellon University, Pittsburgh.

Curtis, B., Hefley, W. E. and Miller, S. A. (2001). *People Capability Maturity Model (P-CMM),* Software Engineering Institute, Carnegie Mellon University, Pittsburgh.

Darrington, J. W. and Howell, G. A. (2011). Motivation and incentives in relational contracts. *Journal of Financial Management of Property and Construction* V.16(1), pp.42.

Dave, B., Koskela, L., Kiviniemi, A., Tzortzopoulos, P. and Owen, R. (2013). *Implementing Lean in construction: Lean construction and BIM,* CIRIA, London, UK.

Davidson, F. (1996). *Principles of statistical data handling*, London: Sage.

Deming, W. E. (1986). *Out of the crisis : Quality, productivity and competitive position,* Cambridge: Cambridge University Press.

Denzin, N. K. and Lincoln, Y. S. (1998). *Strategies of qualitative inquiry,* London: Sage.

Denzin, N. K. and Lincoln, Y. S. (2003). *The landscape of qualitative research: Theories and issues,* 2nd ed, London: Sage.

Department for Business, Innovation & Skills, (2013). *Construction 2025: Industrial strategy for construction - government and industry in partnership,* HMSO, London.

REFERENCES

Department of Trade and Industry (1998). *Rethinking Construction [Egan Report]*, HMSO, London.

Dukes, S. (1984). Phenomenological methodology in the human sciences. *Journal of Religion and Health* V.23(3), pp.197-203.

Eadie, R., Perera, S. and Heaney, G. (2011). Key process area mapping in the production of an e-capability maturity model for UK construction organisations. *Journal of Financial Management of Property and Construction* V.16(3), pp.197-210.

Eadie, R., Perera, S. and Heaney, G. (2012). Capturing maturity of ICT applications in construction processes. *Journal of Financial Management of Property and Construction* V.17(2), pp.176-194.

Easterby-Smith, M., Thorpe, R. and Jackson, P. (2012). *Management research*, 4th ed, London: Sage.

Easterby-Smith, M., Thorpe, R. and Lowe, A. (1991). *Management research: An introduction*, London: Sage.

Easterby-Smith, M., Thorpe, R. and Lowe, A. (2002). *Management research: An introduction*, 2nd ed, London: Sage.

EFQM. 2012. An Overview of the EFQM Excellence Model.

Available at: http://www.efqm.org/sites/default/files/overview_efqm_2013_v1.pdf

[Accessed 4th January 2014].

Eisner, E. W. (1991). *The enlightened eye: Qualitative inquiry and the enhancement of educational practice*, 2nd ed, New York: Macmillan.

El-Gohary, K. M. and Aziz, R. F. (2014). Factors influencing construction labor productivity in Egypt. *Journal of Management in Engineering* V.30(1), pp.1-9.

Elwood, S. A. and Martin, D. G. (2000). "Placing" interviews: location and scales of power in qualitative research. *The Professional Geographer* V.52(4), pp.649-657.

Ely, M. (1991). *Doing qualitative research: Circles within circles*, London: Falmer Press.

Emblemsvåg, J. and Bras, B. (2000). Process thinking-a new paradigm for science and engineering. *Futures* V.32(7), pp.635-654.

Emmitt, S., Sander, D. and Christoffersen, A. K. (2005). The value universe: Defining a value based approach to Lean construction. *Proceedings of the 13th Annual Conference of the International Group of Lean Construction*. Sydney, Australia, 19-21 July 2005, pp.57-64.

Erikshammar, J. J., Björnfot, A. and Gardelli, V. (2010). The ambiguity of value. *Proceedings of the 18th Annual Conference of the International Group of Lean Construction*. Haifa, Israel, 14-16 July 2010,

Erlandson, D. A. (1993). *Doing naturalistic inquiry : A guide to methods*, London: Sage.

Fellows, R. (2009). Advanced research methods on the built environment. *Construction Management and Economics* V.27(6), pp.605-611.

Fellows, R. and Liu, A. (2008). *Research methods for construction*, 3rd ed, Oxford: Wiley-Blackwell.

Fern, E. F. (2001). *Advanced focus group research*, London: Sage.

Fielding, N. G. and Fielding, J. L. (1986). *Linking data*, London: Sage.

Fisher, D. J. (1997). The Knowledge Process. *In:* Alarcon, L. (eds.) *Lean Construction*. Rotterdam: A.A.Balkema.

Fontana, A. and Frey, J. H. (1994). The art of science. *In:* Denzin, N. & Lincoln, Y. (eds.) *Handbook of Qualitative Research*. London: Sage.

Fraser, P., Moultrie, J. and Gregory, M. (2002). The use of maturity models/grids as a tool in assessing product development capability. *Engineering Management Conference*. Cambridge, UK, 18-20 August 2002, pp.244-249.

Frey, J. H. and Fontana, A. (1993). The group interview in social research. *In:* Morgan, D. L. (eds.) *Successful focus groups : Advancing the state of art*. London: Sage.

Frigg, R. and Hartmann, S. 2006. Models in science *The Standford Encyclopedia of Philosophy* [Online].

Available at: http://plato.stanford.edu/archives/spr2012/entries/models-science/

[Accessed 21st June, 2012].

Fritz, R. (1999). *The path of least resistance for managers: Designing organisations to succeed*, San Francisco, USA: Berrett-Koehler.

Glaser, B. G. and Strauss, A. L. (1967). *Discovery of grounded theory: Strategies for qualitative research*, New Jersey, USA: Aldine.

Glazer, H., Dalton, J., Anderson, D., Konrad, M. D. and Shrum, S. (2008). *CMMI or Agile: Why not embrace both!*, Software Engineering Institute, Carnegie Mellon University, Pittsburgh.

Goodson, R. E. (2002). Read a plant-Fast. *Harvard Business Review* V.80(5), pp.105-113.

Graetz, F. (2000). Strategic change leadership. *Management Decision* V.38(8), pp.550-562.

Grant, K. P. and Pennypacker, J. S. (2006). Project management maturity: An assessment of project management capabilities among and between selected industries. *IEEE Transactions on Engineering Management* V.53(1), pp.59-68.

Green, S. D. (1999). The missing arguments of Lean construction. *Construction Management and Economics* V.17(2), pp.133-137.

Green, S. D. (2000). The future of Lean construction: A brave new world. *Proceedings of the 8th Annual Conference of the International Group for Lean Construction*. Brighton, UK, 17-19 July 2000, pp.1-11.

Green, S. D. (2002). The human resource management implications of Lean construction: Critical perspectives and conceptual chasms. *Journal of Construction Research* V.3(01), pp.147-165.

REFERENCES

Green, S. D., Harty, C., Elmualim, A. A., Larsen, G. D. and Kao, C. C. (2008). On the discourse of construction competitiveness. *Building Research & Information* V.36(5), pp.426-435.

Green, S. D. and May, S. C. (2005). Lean construction: Arenas of enactment, models of diffusion and the meaning of 'Leanness'. *Building Research & Information* V.33(6), pp.498-511.

Green, S. D. and Moss, G. (1998). Value management and post-occupancy evaluation: Closing the loop. *Facilities* V.16(1/2), pp.34-39.

Greenbaum, T. L. (1998). *The handbook for focus group research,* 2nd ed, London: Sage.

Grix, J. (2010). *The foundations of research*, 2nd ed, Basingstoke: Palgrave Macmillan.

Hamdi, O. and Leite, F. (2012). BIM and Lean interactions from the BIM capability maturity model perspective: A case study. *Proceedings of the 20th Annual Conference of the International Group for Lean Construction*, Volume 1, San Diego, USA, *San Diego State University*,, ed. by Tommellein, I. D. & Pasquire, C. L. pp.151-160.

Hammer, M. (2007). The process audit. *Harvard Business Review* V.85(1), pp.11-123.

Harland, C. M., Lamming, R. C., Walker, H., Philips, W. E., Caldwell, N. D., Johnsen, T. E., Knight, L. A. and Zheng, J. (2006). Supply management: Is it a discipline? *International Journal of Operations & Production Management* V.26(7), pp.730-753.

Harmon, P. (2004). Evaluating an organisation's business process maturity. *Business Process Trends* V.2(3), pp.1-11.

Hartman, F. and Skulmoski, G. (1998). Project management maturity. *International Project Management Journal* V.4(1), pp.74-78.

Harzing, A.-W. and van der Wal, R. (2009). A Google Scholar h-index for journals: An alternative metric to measure journal impact in economics and business. *Journal of the American Society for Information Science and Technology* V.60(1), pp.41-46.

Henrich, G., Abbott, C. and Koskela, L. (2006). Drivers for innovation in production management. *Proceedings of the 14th Annual Conference of the International Group of Lean Construction*. Santiago, Chile, 25-27 July 2006, pp.533-541.

Herbsleb, J., Zubrow, D., Goldenson, D., Hayes, W. and Paulk, M. (1997). Software quality and the capability maturity model. *Communications of the ACM* V.40(6), pp.30-40.

Highways Agency (2010). *Highways Agency Lean Maturity Assessment Toolkit (HALMAT),* Highways Agency Publications, Birmingham, UK.

Hines, P., Francis, M. and Found, P. (2006). Towards Lean product lifecycle management: A framework for new product development. *Journal of Manufacturing Technology Management* V.17(7), pp.866-887.

Hines, P., Holweg, M. and Rich, N. (2004). Learning to evolve: A review of contemporary Lean thinking. *International Journal of Operations & Production Management* V.24(10), pp.994-1011.

Hines, P. and Rich, N. (1997). The seven value stream mapping tools. *International Journal of Operations & Production Management* V.17(1), pp.46-64.

REFERENCES

Hirota, E. H., Lantelme, E. M. V. and Formoso, C. T. (1999). Learning how to learn Lean construction concepts and principles. *Proceedings of the 7th Annual Conference of the International Group of Lean Construction IGLC*, 7, Berkeley, CA, USA, 26-28 July. ed. by Tommelein, I. D. pp.411-422.

Hirsch, J. E. (2005). An index to quantify an individual's scientific research output. *Proceedings of the National Academy of Sciences of the United States of America* V.102(46), pp.16569-16572.

Hofacker, A., Fernandes de Oliveira, B., Gehbaur, F., Carmo Duarte Freitas, M. D., Mendes Jr, R., Santos, A. and Kirsch, J. (2008). Rapid Lean construction-quality rating model (LCR). *Proceedings of the 16th Annual Conference of the International Group for Lean Construction*. Manchester, UK, 16-18 July 2008,

Hogan, R. and Roberts, B. W. (2004). A socioanalytic model of maturity. *Journal of Career Assessment* V.12(2), pp.207-217.

Höök, M. and Stehn, L. (2008). Applicability of Lean principles and practices in industrialized housing production. *Construction Management and Economics* V.26(10), pp.1091-1100.

Horta, I. M., Camanho, A. S., Johnes, J. and Johnes, G. (2013). Performance trends in the construction industry worldwide: An overview of the turn of the century. *Journal of Productivity Analysis* V.39(1), pp.89-99.

Howell, G. (1999). What Is Lean Construction. *Proceedings of the 7th Annual Conference of the International Group for Lean Construction*, Berkley, California, USA, 26-28 July. *University of California Berkley*, ed. by Tommelein, I. D. pp.1-10.

Howell, G. and Ballard, G. (1997a). Implementing Lean construction: Improving downstream performance. *In:* Alarcon, L. (eds.) *Lean Construction*. Rotterdam: A.A.Balkema.

Howell, G. and Ballard, G. (1997b). Implementing Lean construction: Reducing inflow variation. *In:* Alarcon, L. (eds.) *Lean Construction*. Rotterdam: A.A.Balkema.

Howell, G. and Ballard, G. (1997c). Implementing Lean construction: Stabilizing work flow. *In:* Alarcon, L. (eds.) *Lean Construction*. Rotterdam: A.A.Balkema.

Howell, G. and Ballard, G. (2011). *Greg's & Glenn's awards speech* [online video].

Available at: http://vimeo.com/31006220

[Accessed 12th October 2013].

Howell, G., Ballard, G. and Hall, J. (2001). Capacity utilization and wait time: A primer for construction. *Proceedings of the 9th Annual Conference of the International Group of Lean Construction* Singapore, 6-8 August 2001, pp.6-8.

Howell, G., Macomber, H., Koskela, L. and Draper, J. (2004). Leadership and project management: time for a shift from Fayol to Flores. *Proceedings of the 12th Annual Conference of the International Group for Lean Construction*. Helsingor, Denmark, 3-5 August 2004, pp.22-29.

Howell, G. A. (2011). New operating system for project management: Consequences and opportunities. *Journal of Construction Engineering and Management* V.137(10), pp.882-886.

REFERENCES

Humphrey, W. S. (1989). *Managing the software process*, Boston: Addison-Wesley.

Humphrey, W. S. (1993). *Introduction to software process improvement*, Software Engineering Institute, Carnegie Mellon University, Pittsburgh.

Humphrey, W. S. (2002). Three process perspectives: Organizations, teams, and people. *Annals of Software Engineering* V.14(1), pp.39-72.

Ibbs, C. W. and Kwak, Y. H. (2000). Assessing project management maturity. *Project Management Journal* V.31(1), pp.32-43.

Imai, M. (1986). *Kaizen: The key to Japanese competitive success*, New York: McGraw-Hill.

Jacobs, F., Folkestad, J. E. and Glick, S. (2012). Review of construction Lean research studies in support of Lean transformation to the construction operating platform. *Journal of Enterprise Transformation* V.2(3), pp.157-176.

Järvensivu, T. and Törnroos, J.-Å. (2010). Case study research with moderate constructionism: Conceptualization and practical illustration. *Industrial Marketing Management* V.39(1), pp.100-108.

Jesson, J., Mattheson, L. and Lacey, F. M. (2011). *Doing your literature review: Traditional and systematic techniques*, London: Sage.

Johnson, P. and Duberley, J. (2003). Reflexivity in management research. *Journal of Management Studies* V.40(5), pp.1279-1303.

Johnston, R. (2008). On structuring subjective judgements: Originality, significance and rigour in RAE2008. *Higher Education Quarterly* V.62(1-2), pp.120-147.

Jones, C. (1995). Software benchmarking. *Computer* V.28(10), pp.102-103.

Jørgensen, B. (2006). *Integrating Lean design and Lean construction: Processes and methods*. Ph.D. thesis, The Technical University of Denmark.

Jørgensen, B. and Emmitt, S. (2008). Lost in transition: The transfer of Lean manufacturing to construction. *Engineering Construction and Architectural Management* V.15(4), pp.383-398.

Kaplan, R. S. and Norton, D. P. (1996). Using the Balanced Scorecard as a Strategic Management System. *Harvard Business Review* V.74(1), pp.75-85.

Kemmer, S., Koskela, L. and Nykänen, V. (2013). *Towards a Lean model for production management of refurbishment projects*, VTT Technical Research Centre of Finland, VTT Technology.

Kent, D. C. and Becerik-Gerber, B. (2010). Understanding construction industry experience and attitudes toward integrated project delivery. *Journal of Construction Engineering and Management* V.136(8), pp.815-825.

Ketokivi, M. and Mantere, S. (2010). Two strategies for inductive reasoning in organizational research. *Academy of Management Review* V.35(2), pp.315-333.

Khan, M. and Manderson, L. (1992). Focus groups in tropical diseases research. *Health policy and planning* V.7(1), pp.56-66.

Khoshgoftar, M. and Osman, O. (2009). Comparison of maturity models. *2nd IEEE International Conference on Computer Science and Information Technology*. 8-11 August 2009, pp.297-301.

Khosrowshahi, F. and Arayici, Y. (2012). Roadmap for implementation of BIM in the UK construction industry. *Engineering Construction and Architectural Management* V.19(6), pp.610-635.

Kitzinger, J. (1995). Introducing focus groups. *BMJ* V.311(7000), pp.299-302.

Klimko, G. (2001). Knowledge management and maturity models: Building common understanding. *Proceedings of the 2nd European Conference on Knowledge Management (ECKM)*. Bled, Slovenia, 2001, pp.269-278.

Knight, A. and Ruddock, L. (2008). *Advanced research methods in the built environment,* West Sussex, UK: Wiley-Blackwell.

Knodel, J. (1993). The design and analysis of focus group studies: A practical approach. *In:* Morgan, D. L. (eds.) *Successful focus groups: Advancing the state of the art*. London: Sage.

Kohoutek, H. J. (1996). Reflections on the capability and maturity models of engineering processes. *Quality & Reliability Engineering International* V.12(3), pp.147-155.

Koskela, L. (1992). *Application of the new production philosophy to construction,* CIFE Centre For Integrated Facility Engineering, Stanford University, Palo Alto.

Koskela, L. (2000). *An exploration towards a production theory and its application to construction*. PhD thesis, Helsinki University of Technology.

Koskela, L. (2004). Making do - the eight category of waste. *Proceedings of the 12th Annual Conference of the International Group for Lean Construction*. Copenhagen, Denmark, 3-5 August 2004, pp.1-10.

Koskela, L. and Ballard, G. (2012). Is production outside management? *Building Research & Information* V.40(6), pp.724-737.

Koskela, L., Bølviken, T. and Rooke, J. (2013). Which are the wastes of construction? *Proceedings of the 21st Annual Conference of the International Group of Lean Construction*, Volume 1, Fortaleza, CE, Fortaleza. *Federal University of Ceará*, ed. by Formoso, C. T. & Tzortzopoulos, P. pp.3-12.

Koskela, L., Howell, G., Ballard, G. and Tommelein, I. D. (2002). The foundation of Lean construction. *Design and Construction: Building in Value*, Sydney, AU, *Butterworth Heinemann*, ed. by Best, R. & de Valence, G. pp.211-226.

Koskela, L., Howell, G. and Lichtig, W. (2006). Contracts and production. *Proceedings of CIB W92 Symposium on Sustainability and Value through Construction Procurement*. 2006, pp.332-339.

Koskenvesa, A., Tolonen, T., Sahlstedt, S. and Koskela, L. (2010). Waste and labor productivity in production planning case finnish construction industry. *Proceedings of the 18th Annual Conference of the International Group for Lean Construction*. Haifa, Israel, 14-16 July 2010, pp.477-486.

Krafcik, J. (1988). Triumph of the Lean Production System. *Sloan Management Review* V.30(1), pp.41-52.

REFERENCES

Krueger, R. A. (1993). Quality control in focus group research. *In:* Morgan, D. L. (eds.) *Successful focus groups: Advancing the state of the art*. London: Sage.

Krueger, R. A. (1998a). *Developing questions for focus groups*, London: Sage.

Krueger, R. A. (1998b). *Moderating focus groups*, London: Sage.

Krueger, R. A. and Casey, M. A. (2000). *Focus groups: A practical guide for applied research*, 3rd ed, London: Sage.

Krueger, R. A. and Casey, M. A. (2009). *Focus groups: A practical guide for applied research*, 4th ed, London: Sage.

Kujala, J. and Artto, K. (2000). Criteria for project performance in business context. *International Project Management Journal* V.6(1), pp.46-53.

Kundu, G. K., Manohar, B. M. and Bairi, J. (2011). A comparison of Lean and CMMI for services (CMMI-SVC v1.2) best practices. *Asian Journal on Quality* V.12(2), pp.144.

Kvale, S. (1996). *Interviews : An introduction to qualitative research interviewing*, London: Sage.

Kvale, S. (2007). *Doing interviews*, London: Sage.

Kwak, Y. H. and Ibbs, C. W. (2000). The Berkeley project management process maturity model: Measuring the value of project management. *Proceedings of the 2000 IEEE Engineering Management Society*. Albuquerque, NM, USA, 13-15 August 2000, pp.1-5.

Kwak, Y. H. and Ibbs, C. W. (2002). Project management process maturity (PM) model. *Journal of Management in Engineering* V.18(1), pp.150-155.

Larsson, J., Eriksson, P. E., Olofsson, T. and Simonsson, P. (2013). Industrialized construction in the Swedish infrastructure sector: Core elements and barriers. *Construction Management and Economics* pp.1-14.

Latham, M. (1994). *Constructing the team, joint review of procurement and contractual arrangements in the United Kingdom construction industry [Latham Report]*, Department of the Environment, HMSO, London.

Lean Advancement Initiative. 2012. LAI Enterprise Self-Assessment Tool (LESAT) V. 2 Facilitator's Guide, 2nd.

Available at: http://hdl.handle.net/1721.1/84694

[Accessed 10th Februar 2014].

Lean Construction Forum AGC. (2014) *What is Lean?*

Available at: http://agcleanforum.org/about/]

[Accessed 2nd April, 2014].

Lean Construction Institute. (2014) *What is Lean construction?*

Available at: http://www.leanconstruction.org/about-us/what-is-lean-construction/]

[Accessed 2nd April, 2014].

REFERENCES

Lewis, R. B. (1998). ATLAS/ti and NUD* IST: A comparative review of two leading qualitative data analysis packages. *Cultural Anthropology Methods* V.10(3), pp.41-47.

Liker, J. K. (2004). *The Toyota way: 14 management principles from the world's greatest manufacturer*, New York: McGraw-Hill.

Liker, J. K. and Convis, G. L. (2012). *The Toyota way to lean leadership, achieving and sustaining excellence through leadership development*, New York, US: MC Graw-Hill.

Lincoln, Y. S. and Guba, E. G. (1985). *Naturalistic inquiry*, London: Sage.

Liu, M., Ballard, G. and Ibbs, W. (2011). Work flow variation and labor productivity: Case study. *Journal of Management in Engineering* V.27(4), pp.236-242.

Lockamy III, A. and McCormack, K. (2004). The development of a supply chain management process maturity model using the concepts of business process orientation. *Supply Chain Management: An International Journal* V.9(4), pp.272-278.

Macomber, H. and Howell, G. (2004). Two great wastes in organizations. *Proceedings of the 12th Annual Conference of the International Group for Lean Construction*. Copenhagen, Denmark, 3-5 August 2004, pp.1-10.

Maier, A. M., Moultrie, J. and Clarkson, P. J. (2012). Assessing organizational capabilities: Reviewing and guiding the development of maturity grids. *IEEE Transactions on Engineering Management* V.59(1), pp.138-159.

Male, S. (1998). *Value management : The value management benchmark : A good practice framework for clients and practitioners*, London: Thomas Telford.

Mao, X. and Zhang, X. (2008). Construction process reengineering by integrating Lean principles and computer simulation techniques. *Journal of Construction Engineering and Management* V.134(5), pp.371-381.

Marhani, M. A., Jaapar, A. and Bari, N. A. A. (2012). Lean construction: Towards enhancing sustainable construction in Malaysia. *Procedia - Social and Behavioral Sciences* V.68(0), pp.87-98.

Marshall, C. and Rossman, G. B. (2011). *Designing qualitative research*, 5th ed, London: Sage.

Massachusetts Institute of Technology (2012). LAI enterprise self-assessment tool LESAT, Version 2.0. Cambridge, USA: MIT.

Mauricio, L. and Alarcon, L. F. (2010). Quantifying impacts of Last Planner implementation in industrial mining projects. *Proceedings of the 18th Annual Conference of the International Group of Lean Construction*. Haifa, Israel, 14-16 July 2010, pp.1-10.

McCuen, T. L., Suermann, P. C. and Krogulecki, M. J. (2012). Evaluating award-winning BIM projects using the national building information model standard capability maturity model. *Journal of Management in Engineering* V.28(2), pp.224-230.

McElroy, W. (1996). Implementing strategic change through projects. *International Journal of Project Management* V.14(6), pp.325-329.

McGill, M. E. and Slocum Jr, J. W. (1993). Unlearning the organization. *Organizational Dynamics* V.22(2), pp.67-79.

McGrath-Champ, S. and Rosewarne, S. (2009). Organizational change in Australian building and construction: Rethinking a unilinear 'leaning' discourse. *Construction Management and Economics* V.27(11), pp.1111-1128.

Meiling, J., Backlund, F. and Johnsson, H. (2012). Managing for continuous improvement in off-site construction: Evaluation of lean management principles. *Engineering, Construction and Architectural Management* V.19(2), pp.141-158.

Meredith, J. (1993). Theory building through conceptual methods. *International Journal of Operations & Production Management* V.13(5), pp.3-11.

Merriam-Webster (1984). *Dictionary of Synonyms,* Springfield: Merriam-Webster, Incorporated.

Merton, R. K., Fiske, M. and Kendall, P. L. (1990). *Focused interview: A manual of problems and procedures*, 2nd ed, New York: Free Press.

Merton, R. K. and Kendall, P. L. (1946). The focused interview. *American Journal of Sociology* V.51(6), pp.541-557.

Miles, M. B. and Huberman, A. M. (1994). *Qualitative data analysis : An expanded sourcebook*, 2nd ed, London: Sage.

Miller, D. C. and Salkind, N. J. (2002). *Handbook of research design and social measurement*, 5th ed, London: Sage.

Mills, D. Q. and Friesen, B. (1992). The learning organization. *European Management Journal* V.10(2), pp.146-156.

Morgan, D. L. (1996). Focus groups. *Annual review of sociology* V.22(pp.129-152.

Morgan, D. L. (1997). *Focus groups as qualitative research*, 2nd ed, London: Sage.

Morgan, D. L. and Krueger, R. A. (1993). When to use focus groups and why. *In:* Morgan, D. L. (eds.) *Successful focus groups : Advancing the state of art*. London: Sage.

Morse, J. M. (2003). Principles of mixed methods and multimethod research design. *In:* Tashakkori, A. & Teddlie, C. (eds.) *Handbook of mixed methods in social & behavioral research*. London: Sage.

Morse, J. M. (2010). Simultaneous and sequential qualitative mixed method designs. *Qualitative Inquiry* V.16(6), pp.483-491.

Morse, J. M., Niehaus, L., Wolfe, R. R. and Wilkins, S. (2006). The role of the theoretical drive in maintaining validity in mixed-method research. *Qualitative Research in Psychology* V.3(4), pp.279-291.

Mossman, A. (2009). Why isnt't the UK construction industiry going Lean with gusto? *Lean Construction Journal* V.5(1), pp.24-36.

Mossman, A., Ballard, G. and Pasquire, C. (2011). The growing case for Lean construction. *Construction Research and Innovation* V.2(4), pp.30-34.

Moustakas, C. (1994). *Phenomenological research methods*, London: Sage.

REFERENCES

Mulvihill, D. F. (1956). Book review: The focused interview by R. K. Merton; Marjorie Fisk; P. L. Kendall. *Journal of Marketing* V.21(2), pp.254-255.

Nahmens, I. and Ikuma, L. (2009). An empirical examination of the relationship between Lean construction and safety in the industrialized housing industry. *Lean Construction Journal* V.5(1), pp.1-12.

Nahmens, I. and Mullens, M. (2009). The impact of product choice on lean homebuilding. *Construction Innovation: Information, Process, Management* V.9(1), pp.84-100.

Nesensohn, C. and Bryde, D. J. (2012). A review of the evolution of Lean construction. *Creative Construction Conference 2012*, Hungary, Budapest, 30 June - 3 July. *Diamond Congress*, ed. by Hajdu, M. & Skibniewski, M. J. pp.468-476.

Nesensohn, C., Bryde, D. J., Ochieng, E. G. and Fearon, D. J. (2014). Maturity and maturity models in Lean construction *Australasian Journal of Construction Economics and Building* V.14(1), pp.45-59. http://creativecommons.org/licenses/by/4.0/

Nesensohn, C., Demir, S. T. and Bryde, D. J. (2013). Developing the True North route map as a navigational compass in a construction project management organisation. *Lean Construction Journal* V.2013(1), pp.1-18. http://creativecommons.org/licenses/by-nc-nd/3.0/

Ng, S. T., Zheng, D. X. M. and Xie, J. Z. (2013). Allocation of construction resources through a pull-driven approach. *Construction Innovation: Information, Process, Management* V.13(1), pp.77-97.

Nightingale, D. J. and Mize, J. H. (2002). Development of a Lean enterprise transformation maturity model. *Information Knowledge Systems Management* V.3(1), pp.15-30.

Novick, G. (2008). Is there a bias against telephone interviews in qualitative research? *Research in nursing & health* V.31(4), pp.391-398.

Ochieng, E. and Hughes, L. (2013). Managing project complexity in construction projects: The way forward. *J Archit Eng Tech* V.2(1), pp.e111.

Office of Government Commerce (2010a). *Portfolio, programme and project management maturity model (P3M3®): Introduction and guide to P3M3®* [online] Cabinet Office of Rosebery Court.

Available at: http://www.p3m3-officialsite.com/P3M3Model/Model_mhtry.aspx

[Accessed 4th July, 2012].

Office of Government Commerce (2010b). *Portfolio, programme and project management maturity model (P3M3®): P3M3® – project model* [online] Cabinet Office of Rosebery Court.

Available at: http://www.p3m3-officialsite.com/P3M3Model/Model_mhtry.aspx

[Accessed 4th July, 2012].

Ogunbiyi, O., Oladapo, A. and Goulding, J. (2014). An empirical study of the impact of lean construction techniques on sustainable construction in the UK. *Construction Innovation* V.14(1), pp.88-107.

Ohno, T. (1988). *Toyota Production System, beyond large-scale production*, New York: Productivity Press.

Outhwaite, W. (2003). *The Blackwell dictionary of modern social thought*, 2nd ed, Malden, Mass. ; Oxford: Blackwell.

Pasquire, C. (2012). Positioning Lean within an exploration of engineering construction. *Construction Management and Economics* V.30(8), pp.673-685.

Patton, M. Q. (1987). *How to use qualitative methods in evaluation,* London: Sage.

Paulk, M. C. (2009). A history of the capability maturity model for software. *ASQ Software Quality Professional* V.1(1), pp.5-19.

Paulk, M. C., Bill, C., Chrissis, M. B. and Weber, C. V. (1993a). *Capability maturity model for software*, Software Engineering Institute, Carnegie Mellon University, Pittsburgh.

Paulk, M. C., Curtis, B., Chrissis, M. B. and Weber, C. V. (1993b). Capability maturity model, version 1.1. *Software, IEEE* V.10(4), pp.18-27.

Paulk, M. C., Weber, C. V., Curtis, B. and Chrissis, M. B. (1995). *The capability maturity model: Guidelines for improving the software process,* Boston: Addison-Wesley.

Pedler, M., Boydell, T. and Burgoyne, J. (1989). The learning company. *Studies in Continuing Education* V.11(2), pp.91-101.

Pennypacker, J. S. (2005). *Project portfolio management maturity model*, Pennsylvania, USA: Center for Business Practices.

Perkins, L. N., Abdimomunova, L., Valerdi, R., Shields, T. and Nightingale, D. (2010a). Insights from enterprise assessment: How to analyze LESAT results for enterprise transformation. *Information Knowledge Systems Management* V.9(3/4), pp.153-174.

Perkins, L. N., Initiative, L. A., Valerdi, R., Nightingale, D. and Rifkin, S. (2010b). Organizational assessment models for enterprise transformation. *Proceedings of INCOSE International Symposium*, Chicago, USA, ed. by

Pope, C., Ziebland, S. and Mays, N. (2000). Analysing qualitative data. *BMJ* V.320(7227), pp.114-116.

Project Management Institute (2003). *Organizational Project Management Maturity Model OPM3 Knowledge Foundation,* 2nd ed, Pennsylvania, USA: PMI.

QSRInternational (2011). *NVivo and framework demonstration* [online video].

Available at: http://www.youtube.com/watch?v=5U8JPo_sef4&feature=player_embedded

[Accessed 1st December, 2012].

QSRInternational. (2012) *What is the Framwork method?*

Available at: http://www.qsrinternational.com/support_faqs_detail.aspx?view=1056]

[Accessed 2nd April, 2014].

Remenyi, D., Williams, B., Money, A. and Swartz, E. (1998). *Doing research in business and management: an introduction to process and method,* London: Sage.

Richardson, G. L. (2010). *Project management theory and practice*, Boston: Auerbach Pub./CRC Press.

REFERENCES

Richmond, B. (1993). Systems thinking: Critical thinking skills for the 1990s and beyond. *System Dynamics Review* V.9(2), pp.113-133.

Ritchie, J., Lewis, J. and Elam, G. (2003a). Designing and selecting samples. *In:* Ritchie, J. & Lewis, J. (eds.) *Qualitative research practice: A guide for social science students and researchers*. London: Sage.

Ritchie, J. and Spencer, L. (2002). Qualitative data analysis for applied policy research. *In:* Bryman, A. & Burgess, R. G. (eds.) *Analzing qualitative data*. London: Routledge.

Ritchie, J., Spencer, L. and O'Connor, W. (2003b). Carrying out qualitative analysis. *In:* Ritchie, J. & Lewis, J. (eds.) *Qualitative research practice: A guide for social science students and researchers*. London: Sage.

Ritchie, J., Spencer, L. and O'Connor, W. (2003c). Generalising from qualitative research. *In:* Ritchie, J. & Lewis, J. (eds.) *Qualitative research practice: A guide for social science students and researchers*. London: Sage.

Rosenbaum, S., Toledo, M. and González, V. (2014). Improving Environmental and Production Performance in Construction Projects Using Value-Stream Mapping: Case Study. *Journal of Construction Engineering and Management* V.140(2), pp.1-10.

Rother, M. (2010). *TOYOTA KATA: Management people for improvement, adaptiveness, and superior results*, New York: McGraw-Hill.

Royce, W. 2002. CMM vs. CMMI: From conventional to modern software management *The Rational Edge* [Online].

Available at: http://www.ibm.com/developerworks/rational/library/content/RationalEdge/feb02/ConventionalToModernFeb02.pdf

[Accessed 15th June, 2012].

Ruddock, L. and Ruddock, S. (2011). Evaluation of trends in the UK construction industry using growth and productivity accounts. *Construction Management and Economics* V.29(12), pp.1229-1239.

Rybkowski, Z. K., Abdelhamid, T. S. and Forbes, L. H. (2013). On the back of a cotcktail napkin: An exploration of graphic definitions of Lean construction. *Proceedings of the 21st Annual Conference of the International Group of Lean Construction*, Volume 1, Fortaleza, Brazil, Fortaleza. *Federal University of Ceará*, ed. by Formoso, C. T. & Tzortzopoulos, P. pp.83-92.

Saaty, T. L. (1990). How to make a decision: The analytic hierarchy process. *European Journal of Operational Research* V.48(1), pp.9-26.

Sacks, R., Esquenazi, A. and Goldin, M. (2007). LEAPCON: Simulation of Lean construction of high-rise apartment buildings. *Journal of Construction Engineering and Management* V.133(7), pp.529-539.

Sacks, R., Koskela, L., Dave, B. A. and Owen, R. (2010). Interaction of Lean and building information modeling in construction. *Journal of Construction Engineering and Management* V.136(9), pp.968-980.

Sage (2009). *David Morgan on Research Methods* [online video].

Available at: http://www.youtube.com/watch?v=CzkmPLMUv9o

[Accessed 2nd August, 2012].

Sage, D., Dainty, A. and Brookes, N. (2012). A 'strategy-as-practice' exploration of Lean construction strategizing. *Building Research & Information* V.40(2), pp.221-230.

Saiedian, H. and Kuzara, R. (1995). SEI capability maturity model's impact on contractors. *Computer* V.28(1), pp.16-26.

Salem, O., Solomon, J., Genaidy, A. and Luegring, M. (2005). Site implementation and assessment of Lean construction techniques. *Lean Construction Journal* V.2(2), pp.1-21.

Salem, O., Solomon, J., Genaidy, A. and Minkarah, I. (2006). Lean construction: From theory to implementation. *Journal of Management in Engineering* V.22(4), pp.168-175.

Salvatierrra-Garrido, J. and Pasquire, C. (2011). Value theory in Lean construction. *Journal of Financial Management of Property and Construction* V.16(1), pp.8-18.

Sampson, H. (2004). Navigating the waves: The usefulness of a pilot in qualitative research. *Qualitative Research* V.4(3), pp.383-402.

Sams, J. (1999). *Dancing the dream: The seven sacred paths of human transformation*, San Francisco: HarperCollins.

Sarshar, M., Haigh, R. and Amaratunga, D. (2004). Improving project processes: Best practice case study. *Construction Innovation* V.4(2), pp.69-82.

Sarshar, M., Haigh, R., Finnemore, M., Aouad, G., Barrett, P., Baldry, D. and Sexton, M. (1999). SPICE: Is a capability maturity model applicable in the construction industry. *International Conference on Durability of Building Materials and Components*, 8th, Vancouver, Canada, 30 May. *National Research Council Canada*, ed. by Lacasse, M. A. & Vanier, D. J. pp.2836-2843.

Sarshar, M., Haigh, R., Finnemore, M., Aouad, G., Barrett, P., Baldry, D. and Sexton, M. (2000). SPICE: A business process diagnostics tool for construction projects. *Engineering Construction and Architectural Management* V.7(3), pp.241-250.

Saunders, M., Lewis, P. and Thornhill, A. (2007). *Research methods for business students*, 4th ed, Harlow: FT Prentice Hall.

Saunders, M., Lewis, P. and Thornhill, A. (2012). *Research methods for business students*, 6th ed, Harlow: Pearson.

SCAMPI Upgrade Team (2006). *Appraisal requirements for CMMI®, Version 1.2 (ARC, V1.2)*, Software Engineering Institute, Carnegie Mellon University, Pittsburgh.

Schlichter, J. (1999). Surveying project management capabilities. *PM NETWORK* V.13(1), pp.39-40.

Schwandt, T. A. (1999). On understanding understanding. *Qualitative Inquiry* V.5(4), pp.451-464.

Schwandt, T. A. (2001). *Dictionary of qualitative inquiry*, 2nd ed, London: Sage.

REFERENCES

Seddon, J. and Caulkin, S. (2007). Systems Thinking, Lean production and action learning. *Action Learning: Research and Practice* V.4(1), pp.9-24.

Senaratne, S. and Ekanayake, S. (2012). Evaluation of application of Lean principles to precast concrete bridge beam production process. *Journal of Architectural Engineering* V.18(2), pp.94-106.

Seuring, S. and Müller, M. (2008). From a literature review to a conceptual framework for sustainable supply chain management. *Journal of Cleaner Production* V.16(15), pp.1699-1710.

Sevilla, C. G., Ochave, J. A., Punsalan, T. G., Regala, B. P. and Uriarte, G. G. (2007). *Reserach methods,* Quezon City: REX.

Shehu, Z. and Akintoye, A. (2010). Major challenges to the successful implementation and practice of programme management in the construction environment: A critical analysis. *International Journal of Project Management* V.28(1), pp.26-39.

Shewhart, W. A. (1931). *Economic control of quality of manufactured product,* New York: D. Van Nostrand company, Inc.

Shingo, S. (1989). *A study of the Toyota Production System from an industrial engineering viewpoint,* Rev. ed, Portland, Oregon: Productivity Press.

Sim, J. (1998). Collecting and analysing qualitative data: Issues raised by the focus group. *Journal of Advanced Nursing* V.28(2), pp.345-352.

Siriwardena, M. L., Kagioglou, M., Jeong, K. S., Haigh, R. and Amaratunga, D. (2005). SPICE 3: Facilitating organisational process improvement through good practice sharing. *Salford Centre for Research and Innovation (SCRI) 2nd International Symposium*. University of Salford, Greater Manchester., 2005, pp.434-448.

Skulmoski, G. (2001). Project maturity and competence interface. *Cost Engineering* V.43(6), pp.11-18.

Smith, B. (2008a). Ontology. *The Blackwell Guide to the Philosophy of Computing and Information*. Oxford: Blackwell.

Smith, J. A. (2008b). *Qualitative psychology : A practical guide to research methods,* 2nd ed, London: Sage.

Smithson, J. (2000). Using and analysing focus groups: Limitations and possibilities. *International Journal of Social Research Methodology* V.3(2), pp.103-119.

Smithson, J. (2008). Focus Groups. *In:* Alasuutari, P., Bickman, L. & Brannen, J. (eds.) *The Sage Handbook of Social Research Methods*. London: Sage.

Snape, D. and Spencer, L. (2003). The foundations of qualitative research. *In:* Ritchie, J. & Lewis, J. (eds.) *Qualitative research practice: A guide for social science students and researchers*. London: Sage.

Srivastava, A. and Thomson, S. B. (2009). Framework analysis: A qualitative methodology for applied policy research. *Journal of Administration & Governace* V.4(2), pp.72-9.

Stewart, D. W., Rook, D. W. and Shamdasani, P. N. (2006). *Focus groups: Theory and practice,* London: Sage.

REFERENCES

Strategic Forum for Construction. (2003a) *About the Toolkit*.

Available at: http://www.strategicforum.org.uk/sfctoolkit2/home/about_toolkit.html]

[Accessed 07th August, 2012].

Strategic Forum for Construction. (2003b) *Maturity Assessment Grid*.

Available at: http://www.strategicforum.org.uk/sfctoolkit2/help/maturity_model.html#intro]

[Accessed 03rd August, 2012].

Strategic Forum for Construction. (2003c) *The ten most frequently asked questions*.

Available at: http://www.strategicforum.org.uk/sfctoolkit2/home/QA.html]

[Accessed 07th August, 2012].

Sturges, J. E. and Hanrahan, K. J. (2004). Comparing telephone and face-to-face qualitative interviewing: a research note. *Qualitative Research* V.4(1), pp.107-118.

Suddaby, R. (2006). From the editors: What grounded theory is not. *Academy of Management Journal* V.49(4), pp.633-642.

Suhr, J. (1999). *The choosing by advantages decisionmaking system,* Westport, CT: Quorum Books.

Sun, M. and Oza, T. (2008). A benefit measurement framework for an online contract change management system. *Tsinghua Science & Technology* V.13, Supplement 1(0), pp.205-210.

Sun, M., Vidalakis, C. and Oza, T. (2009). A change management maturity model for construction projects. *Association of Researchers in Construction Management*. Nottingham, UK, 7-9 September 2009, pp.803-812.

Sweet, L. (2002). Telephone interviewing: Is it compatible with interpretive phenomenological research? *Contemporary Nurse* V.12(1), pp.58-63.

Tapia, R. S., Daneva, M., van Eck, P. and Wieringa, R. (2008). Towards a business-IT aligned maturity model for collaborative networked organizations. *12th Enterprise Distributed Object Computing Conference Workshops*. 16-16 September 2008, pp.276-287.

Teicholz, P. (2001). U.S. Construction labor productivity trends, 1970–1998. *Journal of Construction Engineering and Management* V.127(5), pp.427-428.

Teicholz, P. (2013). Labor-productivity declines in the construction industry: Causes and remedies (another look). *AECbytes Viewpoint*

Terry, A. and Smith, S. (2011). *Build Lean: Transforming construction using Lean Thinking,* CIRIA, London, UK.

The Shingo Prize (2010). *The Shingo Prize for operational excellence,* Jon M. Huntsman School of Business, University, U. S., Utah, USA.

The Shingo Prize (2013a). *Model & application guidelines,* Jon M. Huntsman School of Business, Utah, USA.

The Shingo Prize. (2013b) *SCOPE: Shingo cultural online performance evaluation*.

Available at: http://shingoprize.org/scope-online-assessment.html#Details]

[Accessed 2nd April, 2014].

The Shingo Prize (2013c). *The Shingo Model,* Jon M. Huntsman School of Business, Utah, USA.

Thomas, H. R., Horman, M. J., Minchin Jr., R. E. and Chen, D. (2003). Improving labor flow reliability for better productivity as Lean construction principle. *Journal of Construction Engineering and Management* V.129(3), pp.251-261.

Thomassen, M. A., Sander, D., Barnes, K. A. and Nielsen, A. (2003). Experience and results from implementing Lean construction in a large Danish contracting firm. *Proceedings of the 11th Annual Conference of the International Group for Lean Construction*. Blacksburg, Virginia, USA, 22-24 July 2003, pp.644-55.

Thomson, D. S., Austin, S. A., Devine-Wright, H. and Mills, G. R. (2003). Managing value and quality in design. *Building Research & Information* V.31(5), pp.334-345.

Tommelein, I. D., Riley, D. R. and Howell, G. A. (1999). Parade Game: Impact of work flow variability on trade performance. *Journal of Construction Engineering and Management* V.125(5), pp.304-310.

Tufford, L. and Newman, P. (2012). Bracketing in qualitative research. *Qualitative Social Work* V.11(1), pp.80-96.

Vaidyanathan, K. and Howell, G. (2007). Construction Supply Chain Maturity Model - Conceptual Framework. *Proceedings of the 15th Annual Conference of the International Group for Lean Construction*, Michigan, USA, 18-20 July. *IGLC*, ed. by Pasquire, C. L. & Tzortzopoulos, P. pp.171-180.

Van Looy, A., De Backer, M. and Poels, G. (2011). Defining business process maturity. A journey towards excellence. *Total Quality Management & Business Excellence* V.22(11), pp.1119-1137.

Van Maanen, J., Sørensen, J. B. and Mitchell, T. R. (2007). The interplay between theory and method. *Academy of Management Review* V.32(4), pp.1145-1154.

Van Manen, M. (1990). *Researching lived experience: Human science for an action sensitive pedagogy*, New York, USA: State University of New York Press.

Veldman, J. and Klingenberg, W. (2009). Applicability of the capability maturity model for engineer-toorder firms. *International Journal of Technology Management* V.48(2), pp.219-239.

Viana, D. D., Formoso, C. T. and Kalsaas, B. T. (2013). Waste in construction: A systematic literatur review on empirical studies. *Proceedings of the 20th Annual Conference of the International Group of Lean Construction*, Volume 1, San Diego, USA, *San Diego State University*, ed. by Tommelein, I. D. & Pasquire, C. L. pp.351-360.

Vidal, R. V. V. (2006). Chuck Frey, power tips and strategies for mind mapping software, learn how to think better, improve your productivity and communicate with greater impact! *European Journal of Operational Research* V.174(2), pp.1348-1349.

REFERENCES

Vrijhoef, R. and Koskela, L. (2000). The four roles of supply chain management in construtcion. *European Journal of Purchasing & Supply Management* V.6(2000), pp.169-178.

Wang, J., Xiao, J., Li, Q. and Li, K. (2011). Knowledge management maturity models: A systemic comparison. *Proceedings - 2011 4th International Conference on Information Management, Innovation Management and Industrial Engineering, ICIII 2011*. Shenzhen, China, 26-27 November 2011, pp.606-609.

Wendler, R. (2012). The maturity of maturity model research: A systematic mapping study. *Information and software technology* V.54(12), pp.1317-1339.

Whittemore, R., Chase, S. K. and Mandle, C. L. (2001). Validity in qualitative research. *Qualitative Health Research* V.11(4), pp.522-537.

Whittock, M. (2002). Women's experiences of non-traditional employment: Is gender equality in this area a possibility? *Construction Management and Economics* V.20(5), pp.449-456.

Wilkinson, S. (1998). Focus group methodology: A review. *International Journal of Social Research Methodology* V.1(3), pp.182-203.

Willis, C. J. and Rankin, J. H. (2010). Measuring the maturity of Guyana's construction industry using the construction industry macro maturity model (CIM3). *Journal of Construction in Developing Countries* V.15(2), pp.87-116.

Willis, C. J. and Rankin, J. H. (2012). The construction industry macro maturity model (CM3): Theoretical underpinnings. *International Journal of Productivity and Performance Management* V.61(4), pp.382-402.

Wolstenholme, A., Austin, S. A., Bairstow, M., Blumenthal, A., Lorimer, J., McGuckin, S., Rhys Jones, S., Ward, D., Whysall, D., Le Grand, Z., Guthrie, W. and Davies, R. (2009). *Never waste a good crisis: A review of progress since rethinking construction and thoughts for our future,* Constructing Excellence, London.

Womack, J. P. (2011). *Gemba walks,* Cambridge, MA: Lean Enterprise Institute, Inc.

Womack, J. P. and Jones, D. T. (1996). *Lean thinking: Banish waste and creat wealth in your corporation,* New York: Simon & Schuster.

Womack, J. P. and Jones, D. T. (2003). *Lean thinking: Banish waste and create wealth in your corporation,* 2nd ed, London: Simon & Schuster.

Womack, J. P., Jones, D. T., Roos, D. and M.I.T (1990). *The machine that changed the world,* New York: Rawson.

Wongrassamee, S., Gardiner, P. D. and Simmons, J. E. L. (2003). Performance measurement tools: the Balanced Scorecard and the EFQM Excellence Model. *Measuring Business Excellence* V.7(1), pp.14-29.

Yan, L. I. and Chunlu, L. I. U. (2010). Malmquist indices of total factor productivity changes in the Australian construction industry. *Construction Management and Economics* V.28(9), pp.933-945.

Yu, H., Al-Hussein, M., Al-Jibouri, S. and Telyas, A. (2013). Lean transformation in a modular building company: A case for implementation. *Journal of Management in Engineering* V.29(1), pp.103-111.

REFERENCES

Yu, H., Tweed, T., Al-Hussein, M. and Nasseri, R. (2009). Development of Lean model for house construction using value stream mapping. *Journal of Construction Engineering and Management* V.135(8), pp.782-790.

Zhang, L., He, J. and Zhou, S. (2013). Sharing tacit knowledge for integrated project team flexibility: Case study of integrated project delivery. *Journal of Construction Engineering and Management* V.139(7), pp.795-804.

Zimina, D., Ballard, G. and Pasquire, C. (2012). Target value design: Using collaboration and a Lean approach to reduce construction cost. *Construction Management and Economics* V.30(5), pp.383-398.

APPENDICES

APPENDIX A: Example of the consent form and interview participant information sheet

LIVERPOOL JOHN MOORES UNIVERSITY

CONSENT FORM

Research Project:

LeCMM – Lean Construction Maturity Model - A New Innovative Maturity Model For Lean Construction Organisations

Name of the Researcher and School/Faculty

Claus Nesensohn, School of Built Environment, Faculty of Technology and Environment, Liverpool John Moores University.

1.	I confirm that I have read and understand the information provided for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily	☐
2.	I understand that my participation is voluntary and that I am free to withdraw at any time, without giving a reason and that this will not affect my legal rights.	☐
3.	I understand that any personal information collected during the study will be anonymised and remain confidential	☐
4.	I understand that the interview will be audio recorded and I am happy to proceed.	☐
5.	I understand that parts of the discussion may be used verbatim in future publications or presentations but that such quotes will be anonymised.	☐
6.	I agree to take part in the above study	☐

_____	_____	_____
Name of Participant	Date	Signature
_____	_____	_____
Name of Researcher	Date	Signature
_____	_____	_____
Name of Person taking consent *(if different from researcher)*	Date	Signature

Note: When completed 1 copy for participant and 1 copy for researcher

LIVERPOOL JOHN MOORES UNIVERSITY

INTERVIEW
PARTICIPANT INFORMATION SHEET

Research Project:

LeCMM – Lean Construction Maturity Model - A New Innovative Maturity Model For Lean

Construction Organisations

Name of the Researcher and School/Faculty

Claus Nesensohn,
School of Built Environment, Faculty of Technology and Environment,
Liverpool John Moores University

Name of the Director of Studies

David Bryde PhD MSc BSc (Hons) MAPM, MBCS, CITP

Professor in Project Management
Built Environment and Sustainable Technologies (BEST) Research Institute
School of the Built Environment, Faculty of Technology and Environment
Liverpool John Moores University

You are being invited to take part in a research study. Before you decide it is important that you understand why the research is being undertaking and what it involves. Please take time to read the following information. Ask us if there is anything that is not clear or if you would like more information. Finally, take time to decide if you want to take part or not.

1. What is the purpose of the study?

The purpose of this study is to develop a framework for a new process improvement approach for the construction industry to measure the gap between where the organisation currently are and where they want to be, in terms of Lean Construction and the improvement of their implementation and performance.

The Research Question:
How can the maturity of Lean Construction in construction project organisations be measured and improved?

In order to answer this question this study aims to develop a solid background to link

the theory with the experience in practise through an expert interview.

2. Do I have to take part?

No. It is up to you to decide whether or not to take part. If you do you will be given this information sheet and asked to sign a consent form. You are still free to withdraw at any time and without giving a reason.

3. What will happen to me if I take part?

- You will be involved in an interview
- Which will take not more than 45 minutes
- The interview will be voice recorded
- The results will be used in the framework of the PhD
- The data will be treated with anonymity and confidentiality

4. Are there any risks / benefits involved?

There are NO risks involved in participating in this study.
On the study of the participants copies of the thesis or a summary of the major findings will be forwarded at the end of the study.

5. Will my taking part in the study be kept confidential?

All data will be coded and anonymised so that no individuals can be identified in future reports and publications of the findings.

Contact Details of Researcher

Please retain a copy of this information sheet with a copy of the signed consent form. If you have any questions, please do not hesitate to contact me.

Yours sincerely

Claus Nesensohn M.Eng. B.Eng.

Researcher

Built Environment and Sustainable Technologies (BEST) Research Institute
School of the Built Environment
Faculty of Technology and Environment
Liverpool John Moores University
Henry Cotton Building
15-21 Webster street
Liverpool L3 2ET

t: +44 (151) 231 4149
e: C.Nesensohn@2012.ljmu.ac.uk

APPENDIX B: Example of the consent form and focus group participant information sheet

LIVERPOOL JOHN MOORES UNIVERSITY

CONSENT FORM

Research Project:

LeCMM – Lean Construction Maturity Model - A New Innovative Maturity Model For Lean Construction Organisations

Name of the Researcher and School/Faculty

Claus Nesensohn, School of Built Environment, Faculty of Technology and Environment, Liverpool John Moores University.

1. I confirm that I have read and understand the information provided for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily ☐
2. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving a reason and that this will not affect my legal rights. ☐
3. I understand that any personal information collected during the study will be anonymised and remain confidential ☐
4. I understand that the interview will be audio recorded and I am happy to proceed. ☐
5. I understand that parts of the discussion may be used verbatim in future publications or presentations but that such quotes will be anonymised. ☐
6. I agree to take part in the above study ☐

_____	_____	_____
Name of Participant	Date	Signature
_____	_____	_____
Name of Researcher	Date	Signature
_____	_____	_____
Name of Person taking consent *(if different from researcher)*	Date	Signature

Note: When completed 1 copy for participant and 1 copy for researcher

LIVERPOOL JOHN MOORES UNIVERSITY

FOCUS GROUP PARTICIPANT INFORMATION SHEET

Research Project:

LeCMM – Lean Construction Maturity Model, A New Innovative Maturity Model For Lean Construction Organisations

Name of the Researcher and School/Faculty

Claus Nesensohn,
School of Built Environment, Faculty of Technology and Environment,
Liverpool John Moores University

Name of the Director of Studies

David Bryde PhD MSc BSc (Hons) MAPM, MBCS, CITP

Reader in Project Management
Built Environment and Sustainable Technologies (BEST) Research Institute
School of the Built Environment, Faculty of Technology and Environment
Liverpool John Moores University

You are being invited to take part in a research study. Before you decide it is important that you understand why the research is being done and what it involves. Please take time to read the following information. Ask us if there is anything that is not clear or if you would like more information. Take time to decide if you want to take part or not.

6. What is the purpose of the study?

The purpose of this research is to develop a new process improvement approach for the construction industry to measure the gap between where the organisation currently are and where they want to be, in terms of Lean construction and the improvement of their processes and performance.

The Research Question:

How can the level of Lean Construction Maturity in a construction project organisation be measured and improvement provides?

In order to answer this question this study aims to develop a solid background to link the theory with the practise of the basis of primary data through conducting a focus group.

7. Do I have to take part?

No. It is up to you to decide whether or not to take part. If you do you will be given this information sheet and asked to sign a consent form. You are still free to withdraw at any time and without giving a reason.

8. What will happen to me if I take part?

- You will be involved in a focus group discussion with max. 10 participants
- Which will take 2-3 hours
- The discussion will be video/audio recorded
- The discussion will be observed trough an assistant to collect nonverbal behaviour of the participants
- Refreshments and a proper meeting room will be provided to you.
- All results will be analysed in the software NIVO
- The results will be used in the Framework of the PhD, discussion
- The data will be treated with anonymity and confidentiality

9. Are there any risks / benefits involved?

There are NO risks / the participants will get the results of the findings at the end of the PhD period.

10. Will my taking part in the study be kept confidential?

You will be asked to sign a consent form. Transcripts (Flipchart) will be coded and anonymised so that no individuals can be identified in future documents. The publication of direct quotes from the discussion will not show any identity of the.

Contact Details of Researcher

Please retain a copy of this information sheet with a copy of the signed consent form. If you have any questions, please do not hesitate to contact me.

Yours sincerely

Claus Nesensohn M.Eng. B.Eng.

Researcher

Built Environment and Sustainable Technologies (BEST) Research Institute
School of the Built Environment
Faculty of Technology and Environment
Liverpool John Moores University
Henry Cotton Building
15-21 Webster Street
Liverpool L3 2ET

t: +44 (151) 231 4149
e:C.Nesensohn@2012.ljmu.ac.uk

APPENDIX C: Example of the interview guide: individual interview

Interview guide for the individual interviews

Interviewer: Claus Nesensohn

Description of yourself:

a) Education/title?
b) Total work experience?
c) Experience in Lean Construction?
d) Do you work in a role as a consultant/owner representative? Or operative for a contractor?

Introduction to maturity models:

- *Maturity models describe the evolution over a defined period of time for an organisation.*
- *The role of a maturity model in general is to assess the maturity of an organisation in terms of a subject like Project Management.*
- *A maturity model identifies the characteristics of processes and evaluates the maturity of an organisation in terms of how many of these characters are satisfied.*
- *Maturity levels in maturity models can be viewed as part of an implementation ladder.*
- *Maturity models help to implement a change or improvement strategy in a structured way.*
- *Mature organisations are identifiable through there automatically behaviours, systematic processes, clear defined roles, responsibility's and ways to doing things and their constantly achieving of their planned goals.*
- *Famous Maturity models are: The CMM, OPM3, P3M3, and the SPICE.*

My research is proposing a framework for a LCMM which could:

e) Assess the organisations maturity in terms of LC (to see how mature they are)
f) Identifying strengths and weaknesses of the organisation in terms of LC
g) Enable the organisation to measure the progress of their LC implementation and there long term goal.
h) Support the improvement of the understanding of LC in the organisation towards a more mature organisation.

Questions:

i) What do you think about the term maturity in context with Lean; is maturity a suitable name to describe the improving understanding of Lean Construction?

j) Do you think such a LCMM framework would be useful a construction project organisations?
   i) Why do you think that?

k) Who should be the focus in a LCMM framework?
   i) The owner/customer?
   ii) The Contractors?
   iii) To both (the whole project organisation)?

l) Do you think maturity in terms of Lean Construction can be measured or recognised?

m) In which areas would you think can the maturity and immaturity of Lean Construction be recognised?
   (for instance communication, information)

n) What else do you think about this research? Any comments?

APPENDIX D: Example of the transcripts of the individual interviews

Appendix D

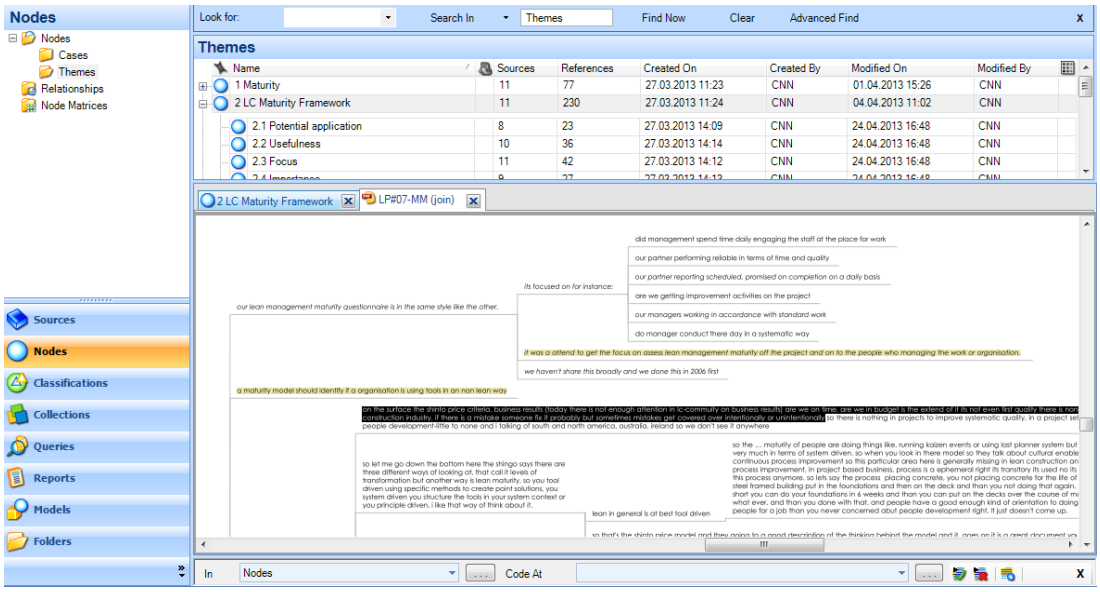
Transcript LP#10

- Introduction to maturity models
- My research is proposing a framework for a LCMM to:
- Description of yourself
  - 1) Your education/title? → bsc in civil engineering
  - 2) Your total work experience? (years) → 17 and 10 as project manager
  - 3) Your experience in Lean Construction? (years) → 4-5
  - 4) Would you describe your work as 1-Consultant/owner representative? or 2-operative/for a contractor → in the operative level
- Questions:
  - a) What do you think about the term maturity in context with Lean; is maturity a suitable name to describe the improving understanding and doing Lean Construction?
    - yes absolutely and i see this is an interesting topic or a challenging topic world wide to all the companies trying to apply the concepts coming from the automotive industry and make it happen in a company
      - my mind maturity in context of lc means how deeply the company immigrated the principles and the philosophy of lean in their operations in the entire company structure. so as further the company its deployed throughout all levels of the company if its the bottom or the top management the further its deployed the further is the maturity of the company. this is how i see it.
  - b) Do you think such a LCMM framework would be useful for a construction project organisation? and why do you think that?
    - yes i think that would be helpful.
      - because then you create a kind of a measure tool which you could measure how far you really matured with your company regarding applying lean principles, if you don't have any measurement you can measure against then you running into the fog or into nowhere.
      - so i think its a good opportunity to measure how far you are with your lean journey.
  - c) Who should be the focus in a LCMM framework? i-the owner/customer?, ii-The Contractors?, iii-To both?
    - i think mainly that it supports the company itself and look at all the people in the company
    - but holistically to get some other measurements independently from inside the company it is important to look into specific on projects
    - and in the project it would be important to look at the entire lifecycle and all the customer along the lifecycle in the project and ask those questions regarding the company what they think how mature they are. so to get independent information outside of the company.
  - d) Do you think maturity in terms of Lean Construction can be measured or recognized?
    - i think so yes the question is what are the right measurements
      - i think it is important when you look at the company and define the core value of the company, that the people who define those core values that those are part of creating the questions to measure against.
      - so that the people they define the value that those are also the people they define the measure tools to measure against.
  - e) In which areas would you think can the maturity and immaturity of Lean Construction be recognised? (for instance communication, information)
    - there is a huge amount of different areas.
    - the probably important ones to measure are
      - leadership
        - is one of the most important once
        - the leadership has to understand it and to believe it and than the best is to teach everybody.
        - is important to get it fast deployed throughout the company, the leaders have to believe in it and this is the key element
      - when i look into defining values on past projects what i always surface is one of the important values or true north indicators is collaboration coordination so in my point those three should be at least important points you should measuring against.
    - the whole training would be another one
      - how you change the company that is also a important measurement
      - how good is the training to support the change in the company, how well is that deployed throughout the company so in all departments and all levels and how is it accepted.
      - the level of training and the quality of training is also important measurements
      - how the people understand the training and how can they successfully apply what they have learned
      - further their training department or person wants to get a feedback how successfully is it applied.
  - f) What else do you think about this research? Any comments?
    - you should try to contact as much as you can big companies and then if you have set up your concept go to this companies and measure and help them to see where their are and in some cases open the company the eyes that they have to do this more deeply and fast. i see that in germany that they do not understand that they have to deploy it fast and deeply
    - it would help when you finish your thesis support companies and doing analysis of there organisation regarding maturity in lean construction.

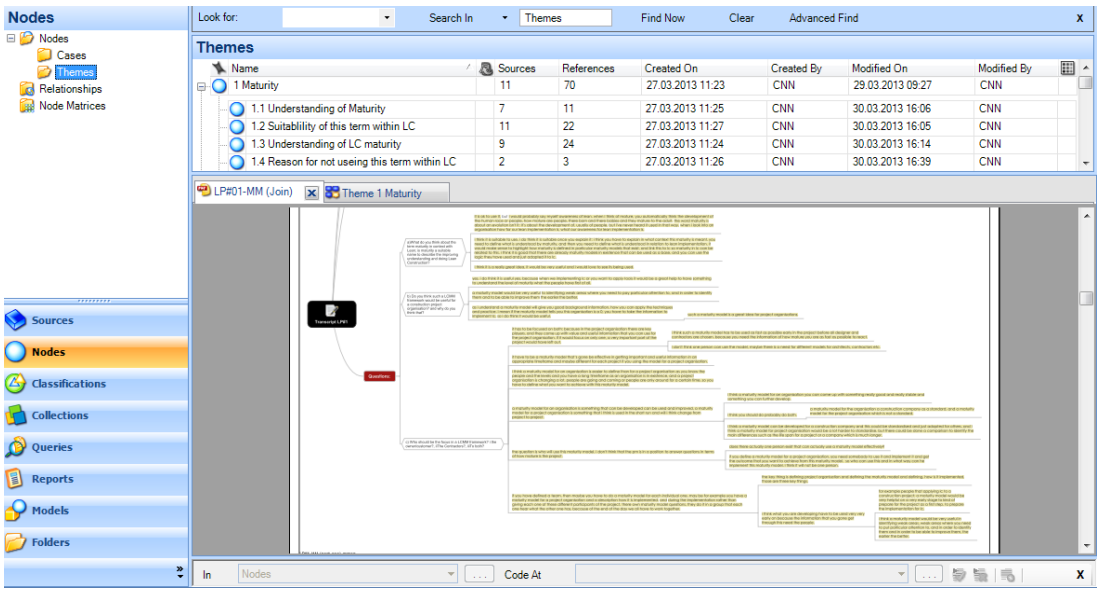
APPENDIX E: Sequence of the thematic analysis within the framework method©: individual interviews

Sequence of the thematic analysis using the Framework Method©

Indexing (coding) via NVivo: The conceptual thematic framework appears in NVivo as 'Themes' so that the identified passages of the transcripts can be indexed to the related sub-theme using drag and drop (see Screenshot below):

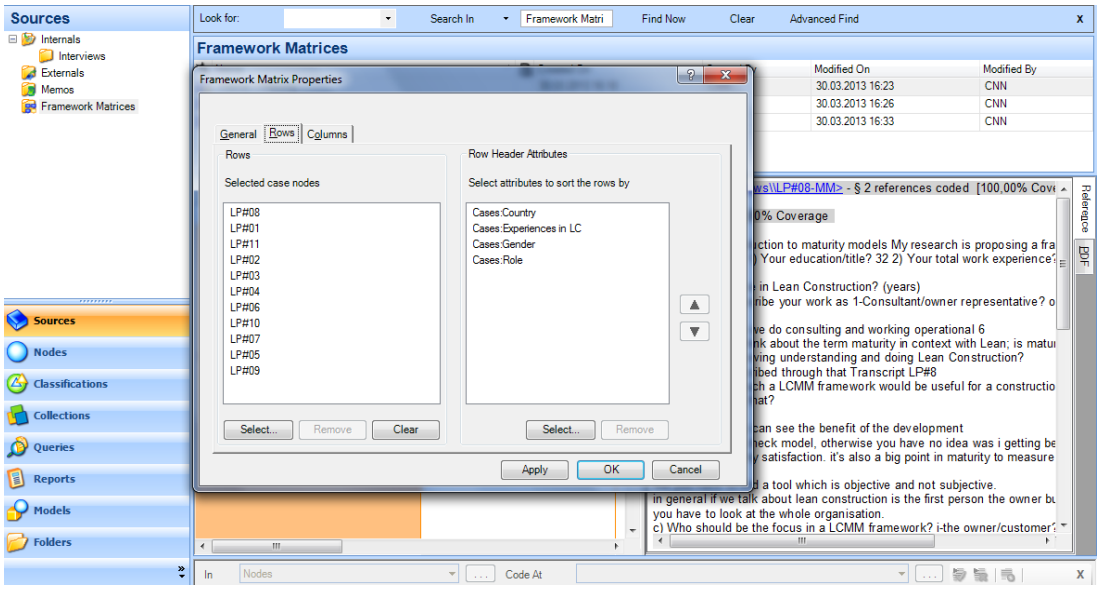


Applying the indexing throughout the whole transcript of an interview allows demonstrating the index or coding density as illustrated in the Screenshot below, through the yellow highlighted passages:

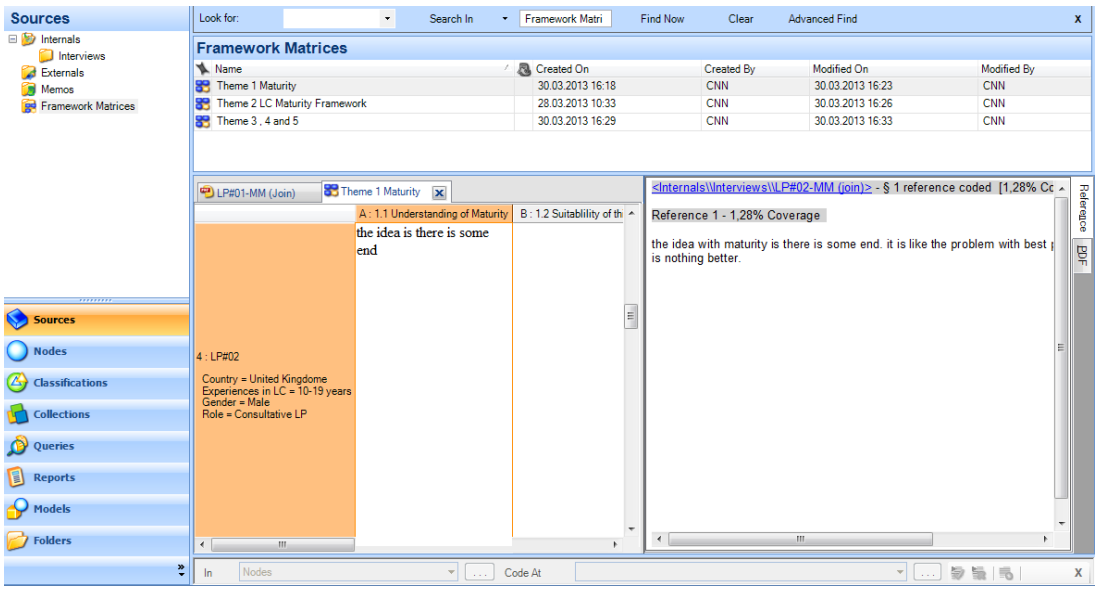


APPENDIX E

Following the indexing of all interview transcripts to the thematic framework, the framework matrixes have been created within NVivo. Hence the participants for the rows on the left side have been selected as well as the sub-themes for the first theme maturity as columns on the top of the matrix. This is illustrated in the Screenshot underneath.

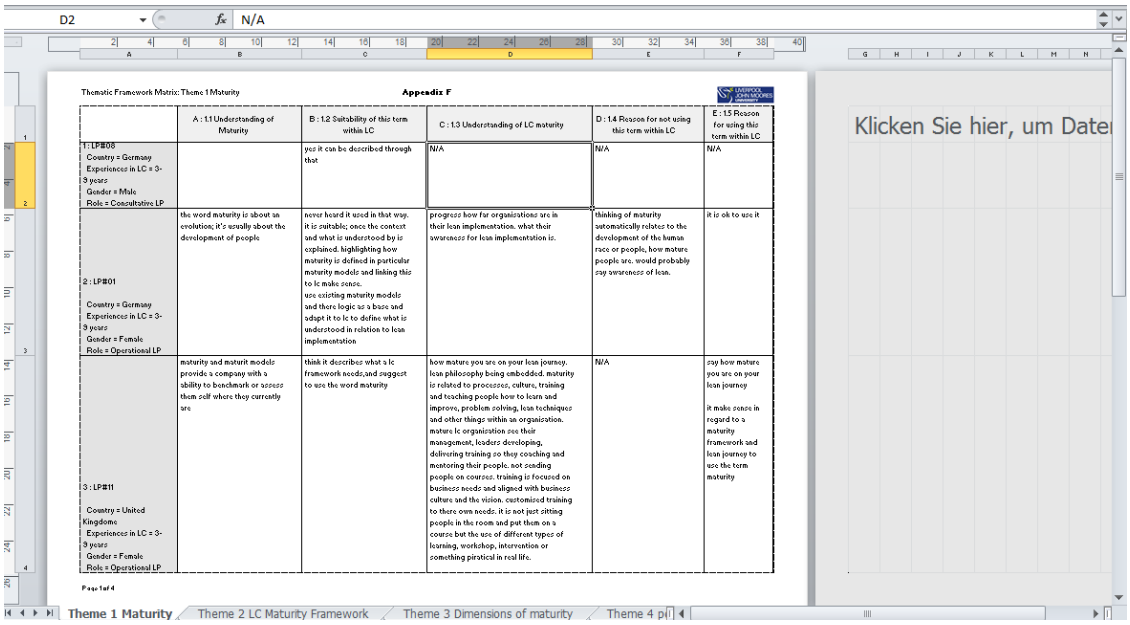


Is the matrix created, NVivo will show the indexed (coded) passages from each particular interviewee for each sub-theme (that appears as a single cell of the framework matrix) on the right hand side and the single cell on the left side. This allows then a straight forward process of writing down the indexed passages in a condensed form while keeping the context of the interviewees (see Screenshot below).



APPENDIX E

The completed framework matrixes for each theme were then exported from NVivo to Microsoft Excel into a spreadsheet (see screenshot below as illustration) and formatted to fit on a number of DIN A3 pages. An example of such a final thematic framework matrix can be found in the next Appendix F.



D2 N/A

Thematic Framework Matrix: Theme 1 Maturity **Appendix F**

	A : 1.1 Understanding of Maturity	B : 1.2 Suitability of this term within LC	C : 1.3 Understanding of LC maturity	D : 1.4 Reason for not using this term within LC	E : 1.5 Reason for using this term within LC
1 : LP#08 Country = Germany Experiences in LC = 3-5 years Gender = Male Role = Consultative LP		yes it can be described through that	N/A	N/A	N/A
2 : LP#01 Country = Germany Experiences in LC = 3-5 years Gender = Female Role = Operational LP	the word maturity is about an evolution; it's usually about the development of people	never heard it used in that way. it is suitable; once the context and what is understood by is explained. highlighting how maturity is defined in particular maturity models and linking this to lc make sense. use existing maturity models and there logic as a base and adapt it to lc to define what is understood in relation to lean implementation	progress how far organisations are in their lean implementation. what their awareness for lean implementation is.	thinking of maturity automatically relates to the development of the human race or people, how mature people are. would probably say awareness of lean.	it is ok to use it
3 : LP#11 Country = United Kingdome Experiences in LC = 3-5 years Gender = Female Role = Operational LP	maturity and maturit models provide a company with a ability to benchmark or assess them self where they currently are	think it describes what a lc framework needs;and suggest to use the word maturity	how mature you are on your lean journey. lean philosophy being embedded. maturity is related to processes, culture, training and teaching people how to learn and improve, problem solving, lean techniques and other things within an organisation. mature lc organisation see their management, leaders developing, delivering training so they coaching and mentoring their people. not sending people on courses. training is focused on business needs and aligned with business culture and the vision. customised training to there own needs. it is not just sitting people in the room and put them on a course but the use of different types of learning, workshop, intervention or something piratical in real life.	N/A	say how mature you are on your lean journey it make sense in regard to a maturity framework and lean journey to use the term maturity

Page 1 of 4

Theme 1 Maturity | Theme 2 LC Maturity Framework | Theme 3 Dimensions of maturity | Theme 4 pi

Klicken Sie hier, um Date

APPENDIX F: Example of the framework matrix of the individual interviews

	A : 1.1 Understanding of Maturity	B : 1.2 Suitability of this term within LC	C : 1.3 Understanding of LC maturity	D : 1.4 Reason for not using this term within LC	E : 1.5 Reason for using this term within LC
1 : LP#08 Country = Germany Experiences in LC = 3-9 years Gender = Male Role = Consultative LP	N/A	yes it can be described through that	N/A	N/A	N/A
2 : LP#01 Country = Germany Experiences in LC = 3-9 years Gender = Female Role = Operational LP	the word maturity is about an evolution; it's usually about the development of people	never heard it used in that way. it is suitable; once the context and what is understood by is explained. highlighting how maturity is defined in particular maturity models and linking this to lc make sense. use existing maturity models and there logic as a base and adapt it to lc to define what is understood in relation to lean implementation	progress how far organisations are in their lean implementation. what their awareness for lean implementation is.	thinking of maturity automatically relates to the development of the human race or people, how mature people are. would probably say awareness of lean.	it is ok to use it
3 : LP#11 Country = United Kingdome Experiences in LC = 3-9 years Gender = Female Role = Operational LP	maturity and maturit models provide a company with a ability to benchmark or assess them self where they currently are	think it describes what a lc framework needs,and suggest to use the word maturity	how mature you are on your lean journey. lean philosophy being embedded. maturity is related to processes, culture, training and teaching people how to learn and improve, problem solving, lean techniques and other things within an organisation. mature lc organisation see their management, leaders developing, delivering training so they coaching and mentoring their people. not sending people on courses. training is focused on business needs and aligned with business culture and the vision. customised training to there own needs. it is not just sitting people in the room and put them on a course but the use of different types of learning, workshop, intervention or something piratical in real life.	N/A	say how mature you are on your lean journey it make sense in regard to a maturity framework and lean journey to use the term maturity
4 : LP#02 Country = United Kingdome Experiences in LC = 10-19 years Gender = Male Role = Consultative LP	there is some end. it is like the problem with best practice, best implies there is nothing better.	it's problematic because we have no idea what a mature lc company will be like.	depends on all sorts of things; how long does it take to become mature as a human being or a peace of cheese. in a mature lean organisation we would see, a systematic continuous improvement	i think it is problematic because we have no idea what a mature lc company will be like and there is maybe a problem with maturity that it have a end. and lc is a journey without end, while we may have more an idea about what its like as time goes on. there might be a word that begins with "l" that you got a literation like llm. you could talk maybe about a lean immaturity model then you might be on to something.	maturity is maybe the best word to describe but it would make sense to do research in a thesaurus to be sure or finding another word for maturity

	A : 1.1 Understanding of Maturity	B : 1.2 Suitability of this term within LC	C : 1.3 Understanding of LC maturity	D : 1.4 Reason for not using this term within LC	E : 1.5 Reason for using this term within LC
5 : LP#03 Country = Spain Experiences in LC = 1-2 years Gender = Male Role = Operational LP	N/A	yes it is	enables to evaluate / assess working and performing on the long term continuous improvement path of lc	N/A	N/A
6 : LP#04 Country = Chile Experiences in LC = 3-9 years Gender = Female Role = Operational LP	N/A	yes like the word maturity, as it has to do how well the organisation is mastering lc. and people will understand it. further are usually english words used in chile for example.	knowing the lean concepts,to know or recognise waste. really understanding the lean concepts. using or understanding last planner is not mature in the sense of really knowing and applying lean concepts in a dally basis.	N/A	N/A
7 : LP#06 Country = USA Experiences in LC = 1-2 years Gender = Female Role = Consultative LP	maturity could be related to marshall arts as you never really done learning in it, even when you reach the highest rang you still learning and put things in place.	it is a good starting point	N/A	it's long term may not the right representation, because of always saying people are infantile which they would not like to be called. using maturity involves degradations along the way. lean is to her more about a thought process and that not get to an end, so how tie this to a journey level	N/A
8 : LP#10 Country = USA Experiences in LC = 3-9 years Gender = Male Role = Operational LP	N/A	yes absolutely and this is seen as a interesting topic	maturity in context of lc means how deeply the company immigrated the principles and the philosophy of lean in there operations in the entire company structure. so as further the company its deployed through out all levels of the company if its the bottom or the top management the further its deployed the further is the maturity of the company.	N/A	N/A
9 : LP#07 Country = USA Experiences in LC = 10-19 years Gender = Male Role = Consultative LP	He think the shingo price criteria are very good presentation of maturity. there are the basis for understanding an maturity of an organisation.	He use a maturity model within his company for the last planner system and a generalised maturity model for lean management yes it is useful, and at the same time he have experience to explain it on a regular basis. because people in the industry they don't have a sense of what a maturity model is but the people in the software industry they know it right away.	he like the way of think about it as the shingo says there are three different ways of looking they call it levels of transformation but another way is lean maturity. so you tool driven when using specific methods to create point solutions, you system driven when you structure the tools in your system context or you principle driven, lean in general is at best tool driven	N/A	N/A

	A : 1.1 Understanding of Maturity	B : 1.2 Suitability of this term within LC	C : 1.3 Understanding of LC maturity	D : 1.4 Reason for not using this term within LC	E : 1.5 Reason for using this term within LC
10 : LP#05 Country = USA Experiences in LC = 10-19 years Gender = Male Role = Operational LP	maturity for him are several levels, and behaviour, but also the thinking because thinking leeds to behaviour. the word maturity levels has to do and reminds of the thinking not of the process.	like maturity, because its much more related to behaviour and the thinking. like the word maturity level and it reminds him on the thinking not on the process.	maturity are several levels, and not just the behaviour, but also the thinking because thinking leeds to behaviour. so behaviour is an output of the way you see things, so lean being a philosophy that relies on the five element of lean thinking, the journey of lean. plus adequate thinking, plus constancy of purpose than people will chose the right processes and tools to achieve operational excellence. so the systemic and scientific thinking, what's hard to get into an organisation is the thinking. and he measure the maturity at the end. it is the thinking because you ask people: did you measure customer value? oh yeah i did... and than they show you the final user as customer, then i know there are thinking systemic. and for example if the customer value is not identified the maturity levels is 0=zero. he have a maturity tool that he developed and use to assess projects.	N/A	maturity is much more related to behaviour and the thinking and the word maturity level is related on the thinking not on the process.
11 : LP#09 Country = Peru Experiences in LC = 10-19 years Gender = Male Role = Consultative LP	maturity model sounds like the maturity of a person. so we will see in the measurement of the maturity of a person some objective things and off course you will have subjective things. there is no problem about using subjectiveness when you have the right people they looking at that. so you need people they really aligned on what to look at, and they have to share some knowledge about that.	yes he would suggest that	N/A	N/A	N/A

APPENDIX G: Instructions for transcribing

INSTRUCTIONS:
Transcribing focus group interviews

Aim: The two focus groups which have to be transcribed following the instructions below will be extensively analysed regarding the phenomenon 'Lean construction maturity'.

In order to guarantee a high quality of the transcripts it should be insured that the same person with the same instruction does transcribe both focus groups of this research project.

The transcribing involves two focus groups with the following details:

Focus group 1:

Filename: FGL20121019 and the (-debriefing 3.20 min)
Duration: 02:39:23
Moderator: Claus Nesensohn
Observer: XXXXX
Participants: PL#1 (…), PL#2 (…), PL#3 (…), PL#4 (…), PL#5 (…)

Focus group 2:

Filename: FGN20121026 and the (-debriefing 8.20 min)
Duration: 02:23:22
Moderator: Claus Nesensohn
Observer: XXXXX
Participants: PN#6 (…), PN#7 (…), PN#8 (…), PN#9 (…), PN#10 (…), PN#11 (…)

1. Identify always the moderator and it's the statements/questions/comments, and use consistently the style 'Normal-moderator' in the word template for those. Indicate a line before each statements/questions/comments of the moderator 'MODERATOR:' and use for this the style 'Heading 3,-Moderator'.

2. Identify always each participant in the focus group and write their names using the style 'Heading 2,-Participants' a line before continue with the responses of them. Use the standard style 'Normal'.

3. Identify always each of the three themes in the focus groups through writing the theme by using the style 'Heading 1,-Themes'. See example on next page.

Theme of the focus group

Moderator:

Text

Participant name:

Text

Further instructions regarding the transcript style should be followed without exception.

- The focus groups should be transcribed verbatim and word by word, without the often frequent repetitions such as 'hm's and the like, of an ordinary conversation.
- Pauses, emphases in intonation, and emotional expression like laughter, sighing and agreement have to be included in a practical manner. (only include such information if it was expressed clearly and underline the content)
- Pauses which emphasises the meaning have to be noted simply as ('a short pause') and ('a long pause')
- Underlining – <u>emphasis</u>
- Hyphen (-) at end of word-when a word is cut off abruptly in the middle
- Ellipsis (…) when a speaker trails off (gets interrupted or couldn't make his/her point)
- Round brackets – when the you are (transcriber) uncertain what was said, but you are able to make a reasonable guess – for example, (about)
- Square brackets – when you (transcriber) want to enclose comments. This could include that you can't make out what was said, (please include the time on the record file e.g. 00:11:21min)

If there are any questions or need for clarification please don't hesitate to contact me:

Mobile: 07774716333 – Claus Nesensohn

APPENDIX H: Example of the transcripts of the focus groups

Transcript focus group interview: FGN

Moderator:

As I said at the beginning, I would like to discuss three themes. Theme one is maturity in Lean construction, how does it look like. Then the second theme would be outputs and outcomes from being mature Lean construction. And the last theme would be improving maturity in Lean construction and I would have for all of these themes some questions. At the end of the session I will close it to make sure that we did not miss anything and to find out which of the comments are the important ones from your point of view. And then I would also like to make sure that we finish on time because I think you might have other commitments afterwards.
So to introduce myself, I am from Germany, my name is Claus Nesensohn, my home town is near Stuttgart, might some of you know it. I have a qualification as a Master of Engineering and Project Management for Construction, as well as Bachelor of Engineering in Construction Projects. And I am a State Certified Engineer in Civil Engineering and Carpenter. And I have worked two years as a project manager on the client side in Germany.
Before we start with our themes and discussion, it's important that you know why I am doing this and how we want to do this discussion. So I want to explain to you what I am doing in my research and how this focus group will contribute to this. Basically the purpose of my research is to investigate how Lean construction maturity looks, feels or sound like and how it could be measured and improved. And within this study I am trying to develop a framework for a Lean construction maturity model and in order to do this I have to … or I'd like to discover, experience, knowledge, opinions and attitudes from Lean construction practitioners out in practice. And therefore I choose to do this with a focus group and therefore I want to discover your highly valuable comments and experiences.
How this is going to work with the focus group, I like that the focus group is a group discussion amongst you, which means I will not directly contribute to the discussion. I am here to moderate the session, to make sure that we capture all of the three themes, so I might move us along a bit when the time goes on. And I have also prepared a couple of questions which hopefully stimulate a group discussion, as it should be not an individual conversation each one. So please feel free to respond to everyone, asking if I have to repeat a question or anything else. And the other thing is, as I want to analyse it afterwards from the tape, it would be really good if we avoid to speak simultaneously. It's very difficult to analyse it (laughs). And the other thing is we do have a video camera but it can't capture everything, it's just a back-up, so please try to voice everything and if you have an agreement, just say 'Yes, I agree', that's fine. That makes it much easier to analyse afterwards.
And also an important information is everything what people say today in this room will be absolutely confidential. At the end of the day in the thesis or in any reports, nobody will know who said what, so please don't hide any information, nobody will know it afterwards from who gave that information. Okay? Then let us start with an easy task; I'm sure this question can help everyone answer, if we just want to share our names, what are we doing in Lean construction and how long we are doing this. So PN#11, I would say we begin with you?

PARTICIPANT DESCRIBTION WAS HAS BEEN REMOVED FOR REASONS OF ANONYMITY

THEME 1: Maturity in Lean Construction

Moderator:

Okay, great. Let us go forward; the first theme, maturity, and I am interested in what …

PN#9:

Can you explain to us what you mean by 'maturity'?

Moderator:

Maturity is different for each person but I can give you what I think is Lean maturity.

PN#9:

Right.

Moderator:

Maturity would be in my case say the degree to how you understand Lean construction and how you effectively use it, is the simple one. But everyone has their own …

PN#9:

Okay.

Moderator:

This is similar to Lean itself, for everyone Lean is a little bit different and it's absolutely fine. So I'm interested in each person's view of it and each person's view is equally important for me. Okay, so the question for the maturity theme would be what in your eyes does Lean construction maturity look, feel or sound like? Can you describe to me what would typify an organisation that is mature in the use of Lean construction? You can describe it in theory or in practice; either way is fine for me. And I put the question on the screen too, so we can like focus on it as we will discuss it for half an hour. And I could write down on the flipchart whatever ideas we got.

PN#10:

I think it's where organisations understand their value stream. And then where waste sits and doing active things to prioritise and tackle it.

Moderator:

Do you all agree with that?

PN#6:

Yeah, value stream's really important and the understanding and articulation of what waste is and differentiation between waste and value, the sort of maturity of that. And an aggression to be almost when they're mature to actually keep going at the value and saying even of value, where's the waste? Because there's a gradual realisation that some of the value is actually not that useful as you get more mature.

Moderator:

Okay.

PN#6:

So assuming that in a very mature organisation you'd be aggressively going at that value as well and saying is it really … is it all real value? But in the early days it's all about waste for me.

Moderator:

Okay. So the value will change after you're getting mature, you're changing your understanding of …?

PN#6:

Challenging that, yeah, yeah.

Moderator:

Okay. So …

PN#6:

And in challenging that, you're doing for things like SMED, so you're trying to get more parallel working even in the value. So you are looking at the ultimate value rather than just a sequence of value in the chain.

Moderator:

Okay. So looking at the ultimate value when you are more mature?

PN#6:

Yeah, yeah.

Moderator:

Do we agree with that or have we other thoughts about it? Do you all agree with that, that the value is focused with more maturity gets more …?

PN#10:

It's a long way off I think for our industry. We've got enough waste in there to be busy with that one.

PN#6:

Yeah, for construction it's early days. I guess it's …

PN#10:

Probably where you come from.

PN#6:

Yeah.

PN#11:

The value changes all the time because it depends … it's a special movement from project to project and even within one project it can change and that is why it always requires revision and new challenges. So every organisation does it really, then it sounds like you know, one point in maturity.

Moderator:

Okay.

PN#9:

I think Americans put it in construction like these guys but we're there and mature and they've never said we're mature and I'm not too sure it's a good term to use 'mature' but there you go. What they understand … because people if they don't understand what the basic concepts of Lean are he would say Lean was just in time and whatever. And that was the same for … and it was the same for people to implement it, it was hugely difficult. The same with Lean, it's probably work in process and everything … you're looking at capping your work in process and then your waste tends to flow from that.

PN#6:

Yeah.

PN#9:

You're also looking at, and companies that are really into it now, it's looking at the seven ways; the seven ways. But the biggest waste is your human waste, your human capital waste and every waste flows from that. And I can get … you can get every initiative in the world but if you don't look at your leadership, look at bringing people forward and understanding what leadership is you know, it's something critical, reflection … reflective judgements and all these tools and all these … which are the cognitive tools, to develop things within your people and that's top-down, bottom-up. And to really focus and to understand the focus and the essence because I guess like for instance with The company I have worked for, they're saying BIM is a tool and it's part of Lean. It's not part of Lean, it's a tool. It's like a farmer going out and saying the combine is the harvester; well it's not, it does the job for me and what job do I want to do? It's like I want to look at waste and look at value and I want to simplify it. So I want to you know … if you say I'm capping work in progress which is … you know, simplify things, take out the uncertainty and develop your people, I think they are the biggest. And if you do that, then everything else will flow from it.

PN#10:

Yeah, you're sort of going rather from the tools to the philosophy.

PN#9:

Yeah.

PN#10:

And I think we accept that maturity is probably the start of the tools and then on its way up to what …

PN#6:

Yeah.

PN#10:

… you hope is people's day-to-day approach to how they tackle things.

PN#6:

Yeah and simplicity is the key word. Simplicity is a key part of maturity. It starts off quite complicated but when you mature it gets …

(various people agree)

PN#9:

Well it's different again, isn't it?

PN#6:

Yeah.

PN#9:

Because you say it's just in time, I mean just to go back to that, just in time, we pull from the end process; but it's to do with it because it's your people, isn't it? And that's where you have to start, it's about your people really and it's developing your people, which you probably … and it's this culture change and it's mindsets and …

(talking together)

PN#11:

So if it's all about people, then it is more than people understanding values and choosing tools according to necessities to allow to deliver this value. So they can be able to do this, they're not just following or picking up … or anything but they're choosing according to the needs of the current process or the current organisation or project.

(various people agree)

PN#11:

And they have this understanding, the organisation has this understanding where it's flexible, we're just choosing, it's not that just in time is a solution for everything.

PN#9:

No, yeah.

PN#11:

You're choosing one.

(various people agree)

PN#10:

I suppose the first bit of that is that you at a work level understand that you need to be measuring some output to know that actually you do improvement from that, it's the ownership of that.

(various people agree)

PN#10:

And when you talk about leadership, it's all the way from the bottom to the top leadership, yeah.

PN#9:

Yeah. Like Last Planner, if there's metrics wrong … they're really powerful metrics, aren't they?

PN#10:

Yeah, yeah.

PN#9:

But they're very simple to understand.

PN#10:

They're very engaging actually.

PN#9:

They are, yeah, they're a really powerful kind of … for discussion and for improvement.

PN#6:

There's something in there about having the KPIs, the simple KPIs that trigger a reaction and a reaction that is appropriate with the toolset. So you choose an appropriate toolset based on the trigger and the context, so there's some stuff in there around all those things coming together. And then to pick up because I don't think we captured the first one, which was you were saying about the value changes as well; it's being tuned in, so the KPI probably is giving you an indication of where the value is changing.

PN#10:

Oh absolutely.

PN#11:

Yeah, it should measure how effective we are in delivering the value.

PN#9:

I've got a bit of a problem with KPIs … I really have a problem with KPIs. I think within the industry the way … they're really good in the reports and all that, they're really good too but they've been just misused and I think it's such a terrible … you know, key performance indicators, they should be really simple but companies and contractors have used them as a smokescreen to cover what they're not doing too. I think KPIs should show what you are doing and not what you're not doing really, or what you're not doing to learn from that. But they've tended to become a smokescreen and I have a bit of a problem with the concept now. I know what they're trying to …

PN#10:

They're quite binary aren't they?

PN#9:

Yeah.

PN#10:

Either fail or pass.

PN#9:

Exactly.

PN#10:

And there needs to be some detail behind of understanding why you've failed or …

PN#9:

Yeah and you need to have just a few KPIs that are you know, in case there for … they are achieving but when they get too complex they become a smokescreen. It's this thing from simplicity, I think really in Lean you've got to look always to simplicity, it's the simple concept of what do we want to achieve and are we achieving it? If we're not you know, are we …?

PN#10:

You've got to have some metrics that are distant to know that happens. I think the trick is choosing a metric that can give you improvement and mostly they just measure the past.

PN#9:

Yeah.

PN#11:

Right but it has to be related to that also, right, because okay, you're working on the project, so you have identified what the values of this project are for all the stakeholders, so the KPIs have to be related to these values and they have to measure how you're delivering on. So once the values change, so the KPIs will change, right. For the next project they will have a different set of KPIs.

PN#9:

Right. I'd love somebody to just deconstruct KPIs.

PN#10:

And not always is Lean applied to a project, Lean can be applied to a service. And I think it's …

PN#11:

Absolutely, yes.

PN#10:

And you know, in major project, yes it's a project; in maintenance it's the service delivery.

PN#11:

Absolutely.

PN#10:

So that's not going to change, that's … the aspiration after that will be static over a period of time.

PN#11:

I think that in this case it has to be related to a process.

PN#10:

Yes.

PN#11:

So if you are choosing a process and then you have values for the process, you can use the values of all the participants of this process. So KPIs have to be again related to this balance.

PN#10:

But isn't the point of maturity that that you end up ultimately having teams that deliver and are looking for improvement and see that value chain right from the top of the organisation down?

PN#11:

Yes I think you right.

PN#9:

And I think but how do you create that culture of people wanting to participate in teams? I mean people will only … for instance people want to … at the moment in construction a lot of people don't want to be there because it's just bearing down on costs and it's just not a nice situation.

PN#10:

It's adversarial is what it is really, it's set up to be adversarial.

PN#9:

Exactly right. So what you want to do, you want to motivate, what you're looking to do … again, I'd go back to the people on the ground; you need to motivate teams and people within the teams to continually improve and they want to be able to feel that they're learning and that they are part of the … that their input is important. And that's where … you know, they are the main drivers and they have to create that kind of an atmosphere within teams, top-down and bottom-up. We're looking at Last Planner on the bottom-up, targeted value … design top-down, so we're bringing all … what we're looking at is the barriers to information and knowledge transfer across groups and across … between people. We need to look at the barriers, break these barriers down and get people involved and feel that people are involved in the process, they're doing something worthwhile. And I think that's the essence of Lean as well you know, that you're engaging within the …

PN#6:

You're right and if you take KPIs and … KPIs are a bit of a proxy for the things you'd have in a manufacturing plant which are vision indicators.

PN#9:

Yeah.

PN#6:

So you would have … you'd want to create … when you're really mature, the person who's doing the job has line of site what they're doing to the overall value at the end. So line of site a vision indication as well.

PN#7:

Sorry for being late.

Moderator:

No problem. Take a seat.

(talking together as new person joins the meeting)

Moderator:

We already started the discussion and we are at theme one, just have a look on the agenda, I'm sure you will be quickly into it.

PN#6:

So I think there's something in there around maturity is probably less … is where you've got vision indicators. So for me you're almost less numeric and less reliant on computers and all the rest of it, you are reliant … it's a bit like Kanban, it's a very visual process. So when we get mature, we will have that sort of instilled across our operation, in the offices and on-site somehow.

Moderator:

Okay.

PN#6:

But it might need to be enabled by IT say, because of the three-dimensional problem you've got on a construction site where you can't get that line of site through walls. But it needs to pick up that philosophy and vision indication because it's such a key part of it, the lack of reliance upon the numbers and a lagging indicator, having a real-time indication visually of what's going on.

Moderator:

And what about the … what is the visual indication for example on construction sites or on a construction project?

PN#6:

Well at the moment there isn't a lot but I just think … and we're trying to introduce something at the moment in my last life that I just left, where we could recreate the equivalent of a Kanban system on an iPad say, for people to see how what they're doing fits in with everything else around. Almost mimicking what you'd have on a manufacturing line. So visual indication is a key part of it because the people we're dealing with on-site, you can't get clever with digital information but visual information's great and it's a lot easier for them to digest and react to.

PN#9:

They currently do that in Brazil isn't it?

Moderator:

Do you agree with that?

PN#10:

Yeah, put visual management on construction sites and it may not quite be as clear as it will be in manufacturing but you know, I think it has brought some issues up from the concerns that happen to stop delivery and then it's caused concern …

Moderator:

Okay.

PN#10:

And I think that's worked on some sites and some maintenance depots now.

PN#9:

It'd have to be very simple like Kanban or like a pretty visual …

PN#6:

In this case it's recreating a sort of Kanban but it's the philosophy that's why is it that Kanban works? It's because it's very easy, very visual and people can tell information really quickly and they can react to that. And it's then translating that into …

PN#9:

Yeah.

PN#6:

And we're starting to create it in certain areas but it's that three-dimensional obstacle you've got inside a building if you like on a construction site that sort of locks you out. But it shouldn't be a barrier as technology improves, but it's that philosophy.

PN#10:

It's interesting that there is a project that I think it's Salford University's doing, which is trying to visualise using BIM as well, so it's collaborative planning, as in the Last Planner, into a visual approach.

(various people agree)

PN#10:

And there must be something in that you know, that actually gets all those …

PN#7:

There is a major BIM and Lean conference planned for I think it's Ulster towards the end of this year or early next year, where Lean and BIM are being … I can get you the details if you need them … are being integrated. I think the fundamental … I've read the notes you've got up there and I think the fundamental bit for me is … well I accept completely that the Highways Agency there in the UK is pretty damned unique to tell you the truth. They have pulled their supply chain and construction side along the path that they have taken. I think the problem for the Highways Agency, as it is for virtually all clients, is not so much the end product, not so much visual representation on site, not so much the use of whether you're going to use a Six Sigma based scoring methodology or whatever the problem is, what are the fundamental bases of maturity? What are they? How can you go, how does the Highways Agency … the Highways Agency has developed a product called HALMAT which luckily for me I was involved in … HALMAT was based on LEESAT underneath. And the problem is even HALMAT doesn't go far enough. For me, there are two fundamentals; one is you can have … there are only two options. You can have a Lean maturity self-assessment tool, which is HALMAT.

(various people agree)

PN#7:

Or you can have a practitioner-led maturity assessment, which is a skilled Lean person going and doing it(Agreed by PN#8, PN#9 and PN#6). Even on the basis of that, what are the ground rules that you would measure maturity with? What are they?

Moderator:

That's why I am going through the questions …

PN#10:

That's what he's trying to find out, yeah.

Moderator:

First, before we could measure it, I want to investigate how you would typify an organisation which is mature in Lean construction. So it could be visual, it could be feeling, it could be hearing, so therefore what do you think feels or sounds or looks like Lean construction maturity?

PN#7:

What … I mean I know PN#10 knows clearly this anyway, what HALMAT did was developed a methodology which was based on … and not just an end member of the supply chain or whoever it happened to be, being able to assess themselves, but that there was some documentary evidence to back that up. But that documentary evidence is things like for example, are you using a visual management system? Which is one of the basic questions about … but there's a whole list of documents. You'll need about ten sheets of paper on the wall to put them all up.

PN#10:

Well actually you've seen the HALMAT document and Lean …

Moderator:

Yeah.

PN#10:

We got it down to about ten I think areas.

Moderator:

Yeah.

PN#10:

And I think they're valid. I think you know, if you want … some of HALMAT is how you get to that point …

PN#7:

It is, yes.

PN#10:

Which is to do with engaging leadership and getting training in place but the other parts are do your systems talk to each other? Do you understand what value is? And do you do sort of preventative maintenance, etc?

PN#7:

What we've done in The UK multidisciplinary consultancy is we have developed a very, very different tool which is the practitioner-led assessment methodology. And the documentation is based on a number of sets. So you've got a set of documents that you would expect if an end client is available at the beginning of the path, and they should have these if they're at the beginning of the path. There's a set of documents which are if you're further down the path and …

PN#6:

What they're saying though, what are the criteria that typify maturity? So forget all the documents, what is it …?

PN#10:

Yeah, what is it when you walked into it that you'd think that's a Lean organisation?

PN#6:

And do you cover leadership for example?

PN#10:

Yes, the first one … we have the top three ones and we heavily weight that score for no reason. But this thing doesn't stay at the bottom if these things at the top don't happen.

PN#6:

Well what is it about a leader then that …?

PN#10:

Walk the talk, do it, show people that you care and actually do it yourself. So it's leadership as in …

PN#6:

Leadership walking.

PN#9:

And do you look at leadership or what parts of the organisation do you look at leadership in? Is it just top or bottom or …?

PN#10:

We ask whether it's in their business plan to do continuous … we call it like continuous improvement or Lean, do they have goals set to get money back for particular areas? Are they doing what they've said they're doing?

Moderator:

Do you agree with that, the leadership, that they go down and …?

PN#6:

I think without leadership actively driving it through, you can't subcontract it to a consultant.

PN#10:

No, no, it has to be owned.

PN#6:

And you have to understand it. I think leadership, they've got to walk and talk it and fundamentally they have to get it.

PN#10:

Yes.

PN#9:

But they have to talk, walk and understand it but a lot of them don't understand it.

PN#6:

It's that getting it that's really important. I mean I've sat there trying … from somewhere here trying to influence a target …

PN#10:

Yes.

PN#6:

And said 'Look, I can't do it unless you get it; we can't get the rest of the …' And that term 'getting it' is a really critical thing.

(talking together/agreeing)

PN#7:

One of the first things even at the very beginning, and it's actually … is has this particular company got a Lean strategic document which is signed off by the senior management, the board hopefully?

(various people agree)

PN#7:

If they've got that, then at least there is some knowledge within senior management and you can question that.

Moderator:

So that means knowledge from the senior management is important as a typification for Lean construction …?

PN#7:

It's critical, you can't do it without it.

PN#8:

It's a knowledge or it's a vision …

(talking together)

PN#6:

It's a published strategy … it's a published vision and intent.

(talking together)

PN#7:

Correct; sorry PN#8, absolutely correct.

PN#10:

What we want them to do ultimately is do Lean inherently as a strategy of deployment, not a stick-on carbuncle at the bottom.

PN#6:

Yeah.

PN#9:

Can I just ask a question there about Lean and vision; before they had a vision, did they have an understanding of … I mean at the end of the day, if you're going to describe Lean what does … it gets money in the bank quicker doesn't it? That's the end of it, you know.

PN#10:

And quality.

PN#9:

Quality … no but I'm talking about the process … so there's money in the bank … you're taking money out and the quality isn't there, so I'm talking about the whole lifecycle. Do they understand how that is going to deliver this to the organisation? Not in the short-term but in the long-term?

PN#7:

Do they need to?

PN#10:

Yes, absolutely.

(talking together)

PN#9:

Is it just another fancy thing …?

PN#7:

Well no, no, it may be, it may be but not so much a buzzword in the jungle but it may be a business-led goal because for example, take The UK multidisciplinary consultancy, that's who I work for, and any client, the Highways Agency says to The UK multidisciplinary consultancy Lean's the thing. So the The UK multidisciplinary consultancy board go 'Oh yeah, yeah, right, okay, well we'd better do that then'. So the The UK multidisciplinary consultancy board come up with their vision; do they mean it?

PN#10:

Initially I don't really mind whether they mean it but they do it and ultimately when we go round talking to them and we explain to them value they've got and the measure of benefits, then they get it. So does it matter how you start? All that matters is where you end up.

PN#7:

Yeah, I agree with you PN#10 but fundamentally what I'm saying is that in that initial step, the chance that the senior management of a company will grasp and understand …

PN#10:

They don't get it, no.

PN#7:

They may come out with the vision statement because of business demand in other words, because some client is pulling them down that path.

PN#10:

But it's a point in time and ultimately if you start doing some deployment you find some value and money coming back through the system and you've probably identified benefits. Then you'd be pretty daft not to do it because if your competitors are you will be lonely.

PN#11:

So you don't have to do it in the first thing, somebody can propose you to do it, so your client, your supplier, your kind of … a worker within your company, shows it beneficial but eventually leadership has to do it. It has to accept the strategy.

PN#10:

They have to own it ultimately.

PN#11:

Exactly. So when they don't, I don't think it's a sign of maturity really. I think that when they've bought it and they've said that well okay, we are doing it, then it might be.

PN#6:

Can I show a different way of looking at this? Because having worked in a few places, the thing that strikes me is that the reason I'm going to this new job say is because I don't need to be told to do it because I know that if I do this I can blitz the competition.

PN#9:

Yeah, they've done it in America, haven't they?

PN#6:

And it's just having done it and having seen the impact it has, I know I can differentiate. I mean I've sat in businesses for the last ten years that were looking for 1 or 2% marginal increases in performance as to justify their existence to their management team, so if you squeeze another 1% or make this extra profit. And I know there's tens of percent in there and that's why I'm going to go and do it. And I think a mature organisation, a really mature organisation doesn't wait for the clients, it just intuitively knows it can succeed by just doing this. And it will transform not just itself but the industry because it'll take the industry with it. But it shouldn't need to come from the client, it should come from them…

PN#10:

Yeah, but the reality is that most manufacturing companies want to be in a bunch.

PN#6:

True.

PN#10:

They don't want to be at the front, they don't want to be at the back, they want to … they don't actually care that much about …

PN#6:

They don't get it yet, they don't get it.

(talking together)

PN#7:

You're right PN#10 but I'd change the word, they don't actually … they care very much about profit.

PN#10:

They don't care about the vision of having more profit, they care about …

PN#7:

Or delivering value … yes, yes, or delivering end value to their clients.

(talking together)

PN#9:

Well it's not just contractors, it's the full construction industry.

PN#10:

Oh yes. No, no, when I say contractors, I mean consultance, contractors etc.

PN#9:

Yeah. But everybody's got … you know, it's designers, it's the whole … you know, they don't understand what needs to be done, so they don't know where they need to be going. Because the world is changing.

PN#10:

I don't think they see what's wrong with what they do now.

PN#9:

But the world is changing, it's never going to … I mean your budgets will never … gone are the days where you'd have pretty big budgets. You are where you are because you've got to be in that position because you need to get value now for the money you're spending and you need to get certainty on your quality and your whole-life cycle. So you need … there are certain things that …

PN#10:

And we have those expectations.

PN#7:

Yeah but PN#10 that's not strictly true. When the HA started this path, that was long before the major collapse started and all the rest of it. And believe it or not, at the time when we started on this path, eight months after we started the path …

PN#10:

Yes, then it hit.

PN#7:

No, the major physical stimulus hit.

PN#10:

Oh well …

PN#7:

That was the government poured an awful lot of money in.

Moderator:

I just want to ask, I didn't understand how this is really related to the question. We're now on some outputs and we have a theme on outputs, so if we have something what you're thinking on outputs and outcomes from the Lean construction organisation we can discuss this further in the second theme. But to focus more on how maturity might be in a project organisation.

PN#6:

So it's quite easy to have small pockets of excellence in this and I think that's what we see in construction. We're not seeing a whole groundswell but when you mature it becomes, the whole … the mass of the whole organisation goes. It's not about having one or two things, the whole thing works, the whole chain works and that's … if you can measure that and if you can see that happening and take the whole company forward, then you've got.

PN#10:

That's what I call policy deployment because it's knowing where your most value or criticality is and applying the tools in those places first and that is top-down isn't it?

PN#6:

It is.

PN#7:

I fundamentally disagree with that point, fundamentally.

Moderator:

Okay, what do you have instead?

PN#7:

In most clients and in most of the supply chain companies are not coherent, they have divisions and those divisions operate in very different ways. So if you take for example in the Highways Agency's terms, all the things that the Highways Agency has done has impacted its tier one supply chain. But if you go into its tier one supply chain, you will find that for example it's the Civils Division. If you go and talk to the Housing Division of some of these, they haven't even heard of what the Civils Division is doing.

Moderator:

Okay.

PN#7:

So to think of an end company or a client for that matter, as a single entity or a consultancy as a single entity, it's very naïve.

PN#11:

It depends on the size, it depends on the size of the company.

(various people agree)

PN#7:

Yes, but very, very small companies you know …

PN#6:

It's not going to have maturity though, the maturity of an organisation in these terms is the whole organisation.

PN#10:

Yeah, you're right.

PN#6:

Not one … it's very easy … it's not easy but it's easier to have one division doing it. But the whole system has to work, the whole system has to be Lean or it's not a success.

PN#7:

Yes, yes, I accept the point you've made but I fundamentally disagree with the fact that the method of measuring that is really complex.

In order not to unnecessarily increase the scope of these appendixes is here only an extract of one of the full transcripts(together more than 50000 words) shown!

APPENDIX I: List of significant statements from the focus group discussion

1 we're now getting more into a situation where design information is becoming even more key because our processes are getting more slicker in the construction phase….Well that's part of the general maturity of Lean as a concept and business performance improvement as a concept. going back 10/20/30 years, it was all about how to make things and build things quicker, faster, cheaper. Whereas the recognition that most of the cost and most of the fixing of the costs is done much further upstream … .generally it would be in the engineering or sales or purchasing, how to manage things to the Lean concepts.

2 I think it's still early days in terms of construction, picking up Lean principles and only now some of our task design houses, like you've mentioned the UK multidisciplinary consultancy and international engineering, architecture, and construction firms and they are actually taking up this on projects and include the Highways Authority as well. it's like a dog beginning to beg and sit up and take notice

3 I think that's going to come from the supply chain, it's going to come from the likes of UK's major main contractors, engineering companies and these sort of companies to influence.

4 one of the key things for me is can we reach a position on projects with technical queries which generally 300/400 on major £250million projects can be down to zero and I think that's a great target to try and achieve. And I think that's a key performance in trying to get to a maturity level as well.

5 I think we're rather immature. I mean I'm doing a sort of sustainability course to graduates and I check through all the … we're multidisciplinary, we've got architects, civil engineers and structural engineers. … because the RNBA, and I'm a member of the RNBA and have been for over 25 years, there's no mention of Lean as well.

6 the institution for the main three key disciplines are without Lean at all. And it's not coming from them, which I wish it was … .I would say there's a little bit of a protectionism in there because I think if you go to the Lean model, what will be proved is you don't need quantity surveyors, you don't really need the traditional architect's model. So the staid institutes that have protectionism and I know this is being a little bit provocative, aren't really required if you go to a full different solution (agreement PL#3)

7 I think you're exactly right that where you said that trying to do Lean just in construction is not the way to do it because it's all the influences beforehand, it's that free thinking, etc.

8 But part of the issue there is the word and the way in which … because nine times out of ten when people say 'Yes, I know all about Lean', they know all about 5S and changeover time reduction and the seven ways. They know about the physical waste elimination side of Lean and not the conceptual how to drive a business strategy.

9 There's pockets of excellence and then there's a big disjoint between pockets of excellence and where the rest of the industry players are. Because the situation you have on a regular basis is the fact that you know, people struggle with defining what the difference between cost and value is in the industry.

10 you can talk all the right terminology and use all the correct tools and techniques within the process but there's still the basic thing about culture and behaviour, understanding that needs a philosophy for the whole business not just for the construction phase out in the field (Agreed by PL#1, PL#2, PL#3 and PL#4).

11 when I first joined a UK training institute, my biggest frustration was coming from our type of industry prior to that was it was always going to fix the construction phase because that's where all the problems are. Well actually guys, most of those are symptoms of root causes that we've created throughout the length of this process.

12 And for me, the industry's got to wake up and not just stick to the tools and techniques that it knows and it understands, such as Last Planner and a little bit of 5C as we call it in our industry, mostly the things that fit currently are just a scratch of the surface of what the process does offer

13 And problem I have is you work with a client that starts that journey and it still takes a long while for them to realise well actually you know, three or four projects in, I need to speak to the client, I need to be working with the design team at that front end before we even get involved and engaged in the construction phase (Agreed PL#3). Which is a great win but it takes a long time to

14 But construction isn't much different you know, in terms of the concepts, in terms of the maturity, it's certainly not far behind the sector I've mainly come from which is aerospace, you know (Agreed by PL#3).

15 Yes, what I found a lot of the time when I go into a company. … you'll find that they've heard about Lean but it's always been put across to the industry as tools and techniques. … And they don't understand that the culture and behaviour is as important, if not more important, than the tools and techniques (Agreed by PL#1, PL#2, PL#3).

16 You have to create the culture and behaviour amongst the group, amongst the team, amongst your peers, otherwise you can't build on that and move forward (Agreed by PL#1, PL#2, PL#3). And that's one of the struggles that I always have you know,

17 Last Planner is a fantastic tool but if somebody just tries to drop that into place and use the tools and techniques element of it and not build the culture and behaviour alongside it, it's not worth doing. You won't get the impact that you require. And this is the thing that when you speak to a lot of clients about whether it be main contractors or the client themselves, they don't understand that at that level, that the culture and behaviour is key (Agreed by PL#3).

18 why we think about all the industries as different you know, we sort of categorise them as different industries. Because in effect, some of the things that I've looked over in the past is actually the tools and techniques of what you're doing in those industries is very much the same. So when we're looking at creating the speed of building a pharmaceutical facility, we went to look at how caravans were made. Why? Well they're just small facilities, aren't they? And what did we learn from there about tact time, etc, etc? So I think the maturity does come down to very much what you're saying is the open-mindedness to think about what you can learn from other areas (Agreed PL#5). … it doesn't matter what we're creating at the end of the day, every process has input, something that changes the nature, shape and form of those inputs to give desired outputs. And as long as you think about that alongside any industry sector or any process, that's what it is. If someone tells me every project's a one-off, well we do very similar processes, just in a different location with different constraints. So as long as we manage that.

19 I mean in terms of maturity, in my understanding, what we're talking about is what is that organisation's corporate understanding of Lean or business improvement? What is their level of recognition as to what it can do for that organisation? (Agreed by PL#3 PL#4 and PL#5) Through to a better understanding of how to recognise where to apply these techniques to drive business performance improvement.

20 And as we mature, we get to a situation where we're going even above understanding that everything is a process and everything has deliverables and customers and performance figures to you know, the organisation exists for a purpose. (Agreed by PL#3, PL#4 and PL#5). Its purpose is to spend Government funds efficiently to deliver a particular piece of infrastructure or it's to generate profits for the shareholders and sustainable growth. We can apply the exact same concepts at the top level of the company so that they influence the strategy and the culture within that organisation. And we're trying to mature to a situation where there isn't a differentiation between this is the day job, this is our process and this is what we do, we're employed to do, but then we also have some Lean initiatives. And often they're totally separate.

21 so we've started our strategic design of what Lean is there to do, which is only to do the day job but maybe a bit more efficiently than we did before, if we have that as a managed suite of corporate goals that we are constantly managing and improved level of performance and competitiveness and reducing the cost of the delivery of that level of performance, everything below it, whether it be the sales, marketing activity, engineering activity, manufacturing, irrespective of where it is, all of those contribute towards that cost equation. Part of that equation is the demand for capacity and then the realisation of our plan … everything like the staff training, recruitment, so all the personnel activities, the capital investment programmes, can all be part of that same managed framework that we're trying to get to a situation where it's optimised to the delivery of the corporate goals at the most efficient level of cost. And being able to understand and manage the optimisation of that framework of separate pieces of managed performance such that they give as easy as possible path to delivery of the corporate goals, I see it as part of the maturity of Lean.

22 It's getting everything aligned, so that everybody's activities are harnessed in the right direction to optimise the corporate role and such that every pound we spend whether it's on additional capacity, capital investments, new buildings, training of staff or business improvement activities of improving the performance of our existing processes, every pound and every hour we spend is giving us an optimised return on investment. We're leveraging the maximum possible improvement to those corporate goals.

23 I mean that's one of the things obviously from our industry's whole stream planning and strategic planning, one-page plan, whatever you want to call it, the industry doesn't do a lot of that. … I mean I find that if I work with a main contractor, you still talk regional offices, it's very much silo-thinking you know, you've convinced one regional office it's the right thing to do and we're doing it on some of their projects or the majority of their projects, yet then you've got to go and convince someone else in another region it's the right thing to do. And it's just so disjointed as a process.

24 But there is this misconception that if I'm doing Last Planner, I'm doing Lean in Lean construction. You're doing a very strong tool in Lean construction, at the construction phase….. it's the mentality of actually guys, this is a whole philosophy for the whole of the business

25 Now what you'll find is when we talk about maturity levels, you maybe do 12 months/18 months/two years' worth of collaborative planning, Last Planner type approaches on construction projects and then all of a sudden you'll start to filter into the other sides of the business because they'll have the data to say 'Look guys, that particular symptom you saw on site was caused because of this, this and this. Therefore in accordance, we need to address that in the system'. So clients that I've been working with now you know, all of a sudden I'm process mapping the activities back in the office or we're process mapping the relationship between the client, the design team, the construction team, working at that level.

26 it's very much been developed on that project and other Highways Agency projects down then. And the one I actually went to, the actual team said they were going to take this design and show the boardroom level how we actually achieved a great result. But I think the idea is don't say it's Lean, say it's Last Planner, say it's collaborative management; call it different ways, different processes of being used to show the value and efficiency at meeting current targets. … And that's shared within the department.

27 And the other one is The Olympics. And I met the Sustainability Manager, and I asked her about 'Can you give me some examples of buildings from The Olympics where Lean had been applied?' And she went away and came back and she told me 'I didn't realise how Lean some of the buildings were'. So it's like an invisible input … ..A bit like a magic trick, somebody convincing somebody this is the way forward and saying that's the way, it's the answer, let's move forward but don't call it Lean, don't call it all the heavyweight stuff, 5Ss and all the heavyweight stuff, let's be very careful on how we introduce it and show the benefits. Certainly once you've got some examples, even if they're down at the bottom there, they'll hit the boardroom. … So I think listening to the client, working collaboratively between the designers, the structural engineers, the architects and the M&E brought a very good solution; it worked very, very well.

28 They don't mind new techniques, new ways … it's change….It's a change in thinking …It always come back to the culture and behaviour, you know.

29 I think another piece comes down to the cost versus value….So somebody who understands what the value is that is being brought by the asset or what is being constructed…. So there's value creation but understanding the value.

30 I think the other thing, my point of view as well for a mature organisation in Lean construction is the in-house capability. Our industry works very much around certification; do you have a certificate for this? Well obviously you can do that work. Whereas Lean for me, to be delivered in whatever industry sector it has to be is about experience … As you said PL#2, what tools and techniques will work, where and when? How to utilise and how to implement, how to build a team, how to facilitate the process.

31 but until you've been out in the field and delivered it, and felt it and delivered it in different circumstances, you can't be a Lean practitioner or an expert.

32 But even in those supposedly mature sectors and the companies within those, that may invest in training everybody in Six Sigma or everybody in Lean tools and techniques, developing some people to be very powerful, effective practitioners for delivering a change event or a Kaizen event or using the tools and techniques … .It's very unusual, even in those which are more mature organisations, to actually find an infrastructure that's driving that application in a managed way.

33 Well if we considered most organisations, there's probably a million different things that need improved; yeah? … Is it sensible to choose one when only one of them is going to be the highest possible leverage to the success of the company? Having a system that tells you what most needs improved, as part of that maturity, because if we choose something we choose it based on which of the techniques we liked best, what we can see that we could change.

34 you've got to get in there, you've got to find the champions to try and change the thinking, that's the way forward and develop it.

35 obviously it's part of the process of an improvement champion to convince the team it's the right thing to do, as well as the skill sets as well. And the idea of that Improvement Champions programme is the animal left at the end of the day, it

doesn't matter what the subject matter is, it doesn't matter what departments, the processes they're looking at but they have the skill sets to do the right challenging processes that we need to do, whether it be diagnostic, whether it be improvement tools. And we're trying to build the confidence amongst that team of ten within the organisation to say 'Well okay guys, at the moment they're looking at implementation of BIM'

36 Well they do know what Lean is but what they think is Lean is a tiny piece of the equation.

37 The engineering example is a good example where an organisation that's maybe a little bit more mature will say 'Well yes, we've used all these tools and techniques in our production activity or our construction activity, we could apply those now in engineering or in purchasing'. But in terms of the maturity, we're still doing the exact same thing, which is deploying tools and techniques and with a blanket coverage that if we do enough of this it'll be good for us … .We can take the same logic as we use when we're using an individual tool and technique to the management of that function or that department or the organisation where rather than deploy tools and techniques in projects or through a suggestion scheme, we're integrating it more with performance management … we can make the value judgement as to which one matters most, which one most needs improvement, we can interrogate the data behind it to determine and prioritise the pieces of our performance that's weakest. We can determine what kinds of things we could do about it and prioritise them. And what we're doing in effect is saying rather than let's do an improvement project on this, we're saying this is what needs to be improved the most and which of the tools and techniques are suitable to help us?

38 To me, the mature organisations, so we've talked about creating space, so whether that be training or thinking or measuring or whatever. So there's a maturity about creating space to allow thinking time to look at things differently

39 A lot of the time some of the clients aren't educated about what Lean construction is themselves, so they're asking the wrong questions and wanting the wrong things from the process (Agreed PL#1). So we start the journey totally in the wrong way anyway. So I'm saying to people that I do believe I start to get maturity in the construction companies I work with and we also need to be educating the clients.

40 Rather than taking the brief which … so they've tried to step out of their comfort zone into ours and work and guess what the outcome is. Our skill I think is moving into their world and understand what the business outcome is. And so I suppose one of the maturity questions answering that is probably the right conversations, the right questions, the having the best way we move forward on some of the construction that we did was somebody who knew nothing about the industry … .It's about the design to go to the client and discuss their requirements and make him think more laterally … .the next project I'm saying well it would be really good if we could sit down with the client and when we talk of project charter, not just a piece of paper that says the outcomes … what does it actually mean? What are we expected to achieve in this project? What are you actually trying to target to get? And with them, to give them at the end of the day … and I know they do it in America, Canada, all the different countries, they have a lot more focus at the front-end rather than being in a situation where a lot of the time I have to introduce planned techniques or Last Planner when the project's already in trouble and three or four weeks before programme.

41 I think there's one thing that we've not talked about yet that is for me a sign of maturity. And that's when the motivation to be religiously on a Lean journey is intrinsic. We've talked about client pull and so on, that's extrinsic as far as I'm concerned. As soon as you take the pull away, people stop doing it. It's got to be embedded in the organisation. As a construction company, as a design company, as a client you don't need anyone to tell you to do it (Agreed by PL#3, PL#4 and PL#5). What you need to recognise is it's worth doing because of what it's going to do for your business. The bottom line is to do with how we relate as people.

42 So everyone that's an engineer understands what their goals are but that's part of a framework in which you've applied the exact same logic at the top level. So what is the aspirations of the company? What do they want to achieve? What do their customers expect of them? And that could be the shareholder requirements, so you're looking at the sales/profit margin, cash, as well as things like the environmental maturity, the customer expectations maybe, different approvals around health and safety or environment. If you're applying the same logic there where you're establishing the links between operational performance targets that deliver those commercial or other goals, it's … that then includes every department within the organisation, it includes every aspect of business. Whether that's the R&D activities to produce the next generation product that does have economic performance criteria way ahead of the last one, training activities, marketing strategies, the engineering is one part of that. You're doing the same with the sales, so to perhaps generate the pull.

43 Once a lot of people step into the construction world, they are probably only 20% in control because of the people in the supply chain in the various tiers are outside of control. So you're suddenly stepping into a world … so whereas you've said you'd do all of this work to control it and suddenly you face something else where you're out of control. So are the mature people realising that they take an umbrella and bring all that external supply chain into that thinking … .at Jaguar Landrover at the moment on the launch of the new Landrover and they have 5 o'clock meetings every night … We sit across the table between client and contract, you're one side and we're this side; don't make it all inclusive and try and do it together. So some of the maturity I think is about embracing that and bringing everybody into the team (All agreed).

44 I think in terms of leadership, what's really critical is making the design intent really clear and then providing leadership to align the team around the design intent. And that's not done through command and control, you can't do it.

45 Buildings are too complex these days to do it through command and control, you've got to use other means, hence the design intent plus alignment.

46 So I don't think we can say what is mature….We can say that some things are more mature than others but we have no idea of knowing where we're going to end up with Lean because I believe that an underlying pre-set position for Lean is that everything can be improved…So once you've got here, you're already thinking about going there, wherever that is

47 My understanding on that is we're looking for setting the ultimate top point on maturity … And you want to see an organisation where you've genuinely achieved a culture, where you've aligned the goals of all of the employees and motivated them with a passion to be constantly improving that performance, the performance against those goals … that requires a lot of things to be in place, Lean tools and techniques are only a tiny little bit of that. But if the corporate goals typically are sustainable and profitable growth, then if it's driving that direction, everything below it we can strategically manage to give that direction to the entire population and provide a context for applying their business improvement ethic.

48 the maturity as I suppose a senior leader is to have somebody come and challenge what the objectives are and be prepared to listen to that because that might be a better objective than the one you've set. Or the environment might have changed which means you need to adopt.

49 right because you've got the goals, you want to move forward; efficiency, value, cost efficiencies, etc, etc, you're going to be moving forward all the time. And you need to take these people with you, . And you need the champions as well, whether they're a champion in Lean or champion in sustainability, champion in energy efficiency, you've got this expertise to move forward. we've got to bring these into the right position. And if we can bring some of the techniques from Lean in to help, such as the Last Planner and all the rest of it, even visual management.

50 we're now seeing for the first time in our office visual management. And it's just a Post-It note on a whiteboard there with a list of dates at the top and people and what they're doing. for the first time I can see basic Lean tools being applied. Not from me telling them to go away and do it but it just materialised out of almost nothing at all. And it came from a problem where this group in our office said 'Right, we're being asked to do 40/50 activities, how can we manage it?' Well I'll tell you what, if we put it on the wall there, then everybody can see what they're doing and we can actually visually … So they do the same sort of thing, a Monday morning they have an hour meeting and then move it through the usual visual management requirements.

51 And the same with the Highways Authority and it's the same with other companies that you don't see it when you look at the overall high-level area, it's buried down below there but it's getting bigger and bigger.

52 I think it's where organisations understand their value stream. And then where waste sits and doing active things to prioritise and tackle it.

53 the understanding and articulation of what waste is and differentiation between waste and value, the sort of maturity of that.

54 And an aggression to be almost when they're mature to actually keep going at the value and saying even of value, where's the waste? Because there's a gradual realisation that some of the value is actually not that useful as you get more mature … .So assuming that in a very mature organisation you'd be aggressively going at that value as well and saying is it really … is it all real value? But in the early days it's all about waste for me. So looking at the ultimate value when you are more mature?

55 So the value will change after you're getting mature, you're changing your understanding of …?Challenging that, yeah, yeah. you're trying to get more parallel working even in the value. So you are looking at the ultimate value rather than just a sequence of value in the chain.

56 The value changes all the time because it depends … it's a special movement from project to project and even within one project it can change and that is why it always requires revision and new challenges. So every organisation does it really, then it sounds like you know, one point in maturity.

57 "You're also looking at, and companies that are really into it now, it's looking at the seven waste. But the biggest

waste is your human waste, your human capital waste and every waste flows from that. … And you can get every initiative in the world but if you don't look at your leadership, look at bringing people forward and understanding what leadership is you know, it's something critical, reflection … reflective judgements and all these tools and all

these … which are the cognitive tools, to develop things within your people and that's top-down, bottom-up. And to really focus and to understand the focus and the essence because I guess like for instance with the company I work for, they're saying BIM is a tool and it's part of Lean.

It's not part of Lean, it's a tool. and saying the combine is the harvester; well it's not, it does the job for me and what job do I want to do? It's like a farmer going o"

58 waste is your human waste, your human capital waste and every waste flows from that. … And you can get every initiative in the world but if you don't look at your leadership, look at bringing people forward and understanding what leadership is you know, it's something critical, reflection … reflective judgements and all these tools and all

59 these … which are the cognitive tools, to develop things within your people and that's top-down, bottom-up. And to really focus and to understand the focus and the essence because I guess like for instance with the company I work for, they're saying BIM is a tool and it's part of Lean.

60 It's not part of Lean, it's a tool. and saying the combine is the harvester; well it's not, it does the job for me and what job do I want to do? It's like a farmer going o

61 Yeah and simplicity is the key word. Simplicity is a key part of maturity. It starts off quite complicated but when you mature it gets …

62 So if it's all about people, then it is more than people understanding values and choosing tools according to necessities to allow to deliver this value. So they can be able to do this, they're not just following or picking up … or anything but they're choosing according to the needs of the current process or the current organisation or project.

63 And they have this understanding, the organisation has this understanding where it's flexible, we're just choosing, it's not that just in time is a solution for everything….You're choosing one.

64 I suppose the first bit of that is that you at a work level understand that you need to be measuring some output to know that actually you do improvement from that, it's the ownership of that.

65 And when you talk about leadership, it's all the way from the bottom to the top leadership, yeah.

66 There's something in there about having the KPIs, the simple KPIs that trigger a reaction and a reaction that is appropriate with the toolset. So you choose an appropriate toolset based on the trigger and the context, so there's some stuff in there around all those things coming together. And then to pick up because I don't think we captured the first one, which was you were saying about the value changes as well; it's being tuned in, so the KPI probably is giving you an indication of where the value is changing.

67 Yeah, it should measure how effective we are in delivering the value. … And there needs to be some detail behind of understanding why you've failed or …

68 you need to have just a few KPIs that are you know, in case there for … they are achieving but when they get too complex they become a smokescreen. It's this thing from simplicity, I think really in Lean you've got to look always to simplicity, it's the simple concept of what do we want to achieve and are we achieving it? If we're not you know, are we …?

69 But isn't the point of maturity that you end up ultimately having teams that deliver and are looking for improvement and see that value chain right from the top of the organisation down?

70 So you would have … you'd want to create … when you're really mature, the person who's doing the job has line of site what they're doing to the overall value at the end. So line of site a vision indication as well.

71 maturity is probably less … is where you've got vision indicators. So for me you're almost less numeric and less reliant on computers and all the rest of it, you are reliant … it's a bit like Kanban, it's a very visual process. So when we get mature, we will have that sort of instilled across our operation, in the offices and on-site somehow.

72 it needs to pick up that philosophy and vision indication because it's such a key part of it, the lack of reliance upon the numbers and a lagging indicator, having a real-time indication visually of what's going on.

73 what is the visual indication for example on construction sites or on a construction project? … Well at the moment there isn't a lot but I just think … and we're trying to introduce something at the moment in my last life that I just left, where we could recreate the equivalent of a Kanban system on an iPad say, for people to see how what they're doing fits in with everything else around. Almost mimicking what you'd have on a manufacturing line. So visual indication is a key part of it because the people we're dealing with on-site, you can't get clever with digital information but visual information's great and it's a lot easier for them to digest and react to … .In this case it's recreating a sort of Kanban but it's the philosophy that's why is it that Kanban works? It's because it's very easy, very visual and people can tell information really quickly and they can react to that. And it's then translating that into …

74 They currently do that in Brazil isn't it? … Yeah, put visual management on construction sites and it may not quite be as clear as it will be in manufacturing but you know, I think it has brought some issues up from the concerns that happen to stop delivery and then it's caused concern

75 For me, there are two fundamentals; one is you can have … there are only two options. You can have a Lean maturity self-assessment tool, which is HALMAT….Or you can have a practitioner-led maturity assessment, which is a skilled Lean person going and doing it(Agreed by PN#8, PN#9 and PN#6). Even on the basis of that, what are the ground rules that you would measure maturity with?

76 HALMAT is how you get to that point …Which is to do with engaging leadership and getting training in place but the other parts are do your systems talk to each other? Do you understand what value is? And do you do sort of preventative maintenance, etc?

77 What we've done in the UK multidisciplinary consultancy is we have developed a very, very different tool which is the practitioner-led assessment methodology. And the documentation is based on a number of sets. So you've got a set of documents that you would expect if an end client is available at the beginning of the path, and they should have these if they're at the beginning of the path. There's a set of documents which are if you're further down the path and …

78 we have the top three ones and we heavily weight that score for no reason. But this thing doesn't stay at the bottom if these things at the top don't happen … We ask whether it's in their business plan to do continuous … we call it like continuous improvement or Lean, do they have goals set to get money back for particular areas? Are they doing what they've said they're doing?

79 And you have to understand it. I think leadership, they've got to walk and talk it and fundamentally they have to get it….but a lot of them don't understand it. … It's that getting it that's really important. I mean I've sat there trying … from somewhere here trying to influence a target …

80 And said 'Look, I can't do it unless you get it; we can't get the rest of the …' And that term 'getting it' is a really critical thing.

81 One of the first things even at the very beginning, and it's actually … is has this particular company got a Lean strategic document which is signed off by the senior management, the board hopefully? … If they've got that, then at least there is some knowledge within senior management and you can question that. It's critical, you can't do it without it. It's a knowledge or it's a vision …It's a published strategy … it's a published vision and intent.

82 What we want them to do ultimately is do Lean inherently as a strategy of deployment, not a stick-on carbuncle at the bottom. … They may come out with the vision statement … They have to own it ultimately … Exactly. So when they don't, I don't think it's a sign of maturity really. I think that when they've bought it and they've said that well okay, we are doing it, then it might be.

83 Can I show a different way of looking at this? Because having worked in a few places, the thing that strikes me is that the reason I'm going to this new job say is because I don't need to be told to do it because I know that if I do this I can blitz the competition.

84 I think a mature organisation, a really mature organisation doesn't wait for the clients, it just intuitively knows it can succeed by just doing this. And it will transform not just itself but the industry because it'll take the industry with it. But it shouldn't need to come from the client, it should come from them…

85 They don't care about the vision of having more profit, they care about …delivering value … yes, yes, or delivering end value to their clients.

86 So it's quite easy to have small pockets of excellence in this and I think that's what we see in construction. We're not seeing a whole groundswell but when you mature it becomes, the whole … the mass of the whole organisation goes. It's not about having one or two things, the whole thing works, the whole chain works and that's if you can measure that and if you can see that happening and take the whole company forward, then you've got some maturity.

87 That's what I call policy deployment because it's knowing where your most value or criticality is and applying the tools in those places first and that is top-down isn't it?

88 it's not easy but it's easier to have one division doing it. But the whole system has to work, the whole system has to be Lean or it's not a success.

89 Organisations are led mainly by humans I mean we'll go back to the similar point … some individuals in the organisations will be impacted much faster than others. And my experience, having been in different companies, shows that if … or if the Lean construction sponsor or the one who spreads the word quits the organisation, then the organisation goes back to the old ways. So I could have a problem in saying that the organisation is mature before or unless that it can be run with any kind of people and that the maturity of the organisation is not related only on the maturity on … usually it's one single man who pulls all the crew.

90 I think if you're not going to change your leadership then that's …

91 I don't think of any company in the construction industry who is actually mature … one of the largest professional construction services in the US ok may be a general contractors in the US ranked in the top 50 as well but they are isolated in California….And the largest construction and engineering company in the US they have an inordinately efficient methodology built into their systems internally which is a continuous efficiency improvement methodology which drives change and drives improvement for example in their internal design process, it drives change and improvement in their financial control processes, it drives change and improvement in their internal procurement processes. If you looked at the internals of that organisation, it would look as though they were a very, very Lean focused organisation. And they use the word Lean, they … some of their command and control, as you would call them, processes are inordinately efficient and I mean inordinately so. But they're not driven by clients' value, so …

92 Correct. So unless you went out and looked at what they were actually delivering externally, you could get a false picture. We've got examples of that in this country. There is an organisation which funnily enough the Highways Agency has used on one occasion to the best of my knowledge for a Lean intervention. And they had an internal Lean team which was quite substantial, driving Lean improvements in their business because of what they provided. That Lean team then went externally and started to sell its services externally, I think … I think they're the largest Lean provider or consultancy provider as an external consultant in the UK, Lean just as consultancy. But if you actually went and looked, one of their major clients is British Rail or Railtrack, sorry … They do the logistics for Network Rail. But if you looked at how they dealt with Network Rail, oops. If you went round their offices, you would see massive amounts of visual management. You know who I'm talking about. Massive amount of visual management. You would see massive amounts of Lean. They teach Lean, they sell their services.

93 Well for a start you're not getting the contract out every five minutes to go through … you know, there's a maturity in understanding, in managing change and … that's seamless almost. So yeah and non-confrontational … and we're a long way off that I know but that's the way it should feel and that's the way it would feel in other industries when it's working well.

94 maturity is actually a one-size-fits-all. If you develop it correctly, it will apply whether it's a five-man outfit or a 50,000-man outfit. It's irrelevant of the size of the entity. It is … Lean will apply regardless of size.

95 It's just harder in a bigger organisation. ..… bigger organisations end up with divisions and different structures and different demands. But the maturity model that is developed has to be a one-size-fits-all, so that if you develop the correct one … Joe Bloggs and his ten employees who build 40 houses a year, should be able to pick that up and use

96 Lean is a philosophy, it's a way of thought, you can't just pick it up and use it. And this is where you know, like Toyota, we can just take it on board anywhere in the world and to step back it's within the culture of the company. And culture is really what drives your thought process.

97 I was very careful in the wording that I used; I said the maturity model. And that is different to … I accept completely what you said; you can't just pick up Lean and just go 'Go out and do it', I accept that. The maturity model itself however, is not teaching somebody how to believe. The maturity model itself is measuring or has the capacity to measure are you performing to a Lean standard.

98 And I think it's more than that. … It's not are you performing to a Lean standard, it's are you and your knock-on supply chain … are you helping them …I think you become … in traditional project organisations, the heroes are the ones that fixed problems and the thing with a mature Lean team is that they are fanatical about perfection. And I mean fanatical in an extreme way. They're living it and it's all about lead times, it's about removing waste, planning and they're totally living it. And they apply it in the workplace but they're probably applying it in their normal lives as well outside. So they just become all-encompassed.

99 So it becomes all-pervading, so people I think are applying it … it's a bit like safety you know, you can apply safety when you get to work but you can also apply it in the wider context, it's a complete behaviour change (All agreed).

100 Can I say I know it's not easy and it's not good English and all the rest of it but 'getting it' for me at a senior level and in 'getting it' down through the organisation, as a term, is really … because it's alright having the intent but you mentioned about you've got to understand it but it's … you've got to more than just understand it, you've got to get that embedded in your DNA and then start to get fanatical about it.

101 And it's the vision of where it gets you to that you probably have to get first … It's what your outcome is going to reward you with.

102 You know we were having the discussion about senior management and you talk to senior management that they know all things and see all things. But another thing that Lean does, it points out really bad leaders and bad senior management.

103 I think there's a huge amount of things and you see it in organisations that do it well is that red is that because that means that actually you know you've got a problem, you know that the team know that there's a problem and you know someone who's doing something about it. That is a major organisational change because usually … … red gets massaged into amber and back to green … .That's a really key point. …Yeah, absolutely, bad information early … bad news early is …I think that you have to have a culture change to accept that in your own organisation that seeing red is not a failure, seeing red …

104 But Lean maturity could also investigate the equation of change. But will explain why a company is getting it and getting it fast whilst another one is slower at getting it. And the equation of change is the first times the vision, times the … something else, should be stronger than the resistance to change. And all the components you have to have a vision, you have to have the how. And the third thing is the … The burning platform, the actual needs and the constraints from the market. And all that must be greater than the intransient resistance of the team, of anyone and I have experienced it in my former company….it's that communication about the 'what's in it for me as an individual?' because I think sometimes … it's like most change management, if you do not communicate effectively and you do not tell people what's in for them, then why would they change? I don't think that's Lean, I think that's any.

105 And also it's inclusion of people, people in organisational management, key management in an organisation, values of those people into the change. So if you … it makes it easier to buy it if your value is included, so you have the impact on it. So when you ask … when the manager asks the question 'Why do I have to do this?', they just show and say 'Because you agree with that, because your value is there as well'.

106 Both terms go into change and it sounds like … there is also some nodding agreement that the resistance of change if it is very less in an organisation or a project organisation, Is this a sign for a higher maturity? … .The change will be unsustainable.. … And if it's very high or very high resistance against change and not include the people into the change process, then I'm a very immature …

107 For me, while I agree with each of those individual points, it's just subsumed within the fundamental point, the application of change management. And that is the overarching point that is critical. Most organisations, including the Highways Agency and most government departments, pay lip service to change management.

108 And change is … in a mature organisation, change is a way of life and everyone can deal with it. So because you've got continuous improvement, I mean at the end of every day, every meeting, every gathering if you like, everyone should be when it really is working, saying what could we do better? What did we do right in the last hour, what did we do right in the last day? What do we need to do better? And that should just be … and then there should be a reaction to that, not just yeah, okay, I'm going to put that on my pad and then forget about it, it's yeah, I'm going to do something with that. So we say everyone can deal with it and everyone's empowered then to go and make it happen, not expect someone else to take it away and fix it for them. … So change is fix in the processes of the organisation?

109 And the point is that change management encompasses all of these things. And that fundamental point is if you can't find a senior management level change management policy, if you want to call it that, the chance of getting any of this to work is zero.

110 There's an honesty and integrity which you probably can't measure but you should feel like there is an integrity there and there is a transparency within. So you're allowed to accept what's happening, the current status. And again, it needs to be in real time. I know that's probably stating the obvious and it's transparent but you need to be able to react in real time and not have to wait if you want the ultimate in maturity.

111 Well you don't just accept failure, you accept that failure can be very positive.

112 One thing that I guess, at least from my understanding, could be or would be a huge asset is to make a parallel between the level of maturity of the particular organisation against a mature organisation. And the level of how much they are still using the cost model …Because to me, Lean and the cost model … and we discussed about this, they are completely opposite. And the cost model is focusing on cost and only cost and I will generate my revenue out of dealing with my costs but Lean is much beyond that.

113 the maturity I think is … it's so complex to try and assess how an organisation from top to bottom has implemented it. … .the potential for luddites within organisations is so high that … especially in construction because there's so many of them, that even though you've got a department or a company which is Lean and keen on Lean and they'll see the management's all for it, you've got divisions which are really all for it but in that division you've got one particular set of people who … and they'll sit there forever, who are total and complete luddites. They don't believe it, they'll never accept it, they won't use it. And how you overcome those things but much more importantly how you detect them is probably the hardest bit of all.

114 So if you were a Highways Agency and you were going to measure a main contractor ; the Civil Division have got a policy, they've got their senior management all committed to it, they've got quite a few Lean practitioners that they've brought in. They've got a lot of their senior project directors are committed to it, etc, etc. But there's a group sitting over here who they're part of the Civils Division and if they get involved in one of the eight year projects, they are totally and completely against utilising anything to do with Lean.

115 this might sound a bit over-the-top but in a mature organisation, the organisation would kill that team….In a mature organisation, the business will take those people and it will kill them. And it doesn't have to … because at the moment, in an immature organisation, that team, that group, would basically mess the whole company up just because they can.

116 And the attention goes into trying to persuade them. And in a Lean organisation it's not like that, it will kill them. It doesn't need to persuade them and it doesn't need to encourage them, it just kills them and then it regrows a piece that will do that job. So you know, if they're a mature organisation it doesn't put up with that. And I've been in teams that have suddenly got this and they have gone and they've gone and kicked you know, the head in for the person or the group that is trying to stop you. And I haven't needed to go and say 'Go and sort them out' or 'We need to fix them', they've just gone behind the scenes and sorted it. And those people either disappear or they change but the team itself has sorted that out because it's got that momentum behind it and they realise that they're not succeeding because of that group. So the traditional view is to go and persuade and argue and make the case and do this and it gets dragged into that. And you get a third that will, a third that'll sit on the fence and a third that will fight and the old way is to try and persuade that last third. So grow the big third over here, the positive third, the middle third follow. Half that group will go and you'll still get 10-15% that will try.

117 And I think that maturity comes when instead of just living with that, you get rid of it…..Well actually I've seen that people actually leave themselves …Yeah because the culture isn't that …Yeah, they just can't stay with this organisation….They can't cope. And that is truly mature I think when that happens automatically because you really have … and that's when you're embedded because when that leader goes, this team now, they will sort it out …

118 But people will detect it. I mean I've been through this scenario a few times and you get to a point where the team actually gets a life of its own. Because they … I mean as a manager, you don't know what everyone's doing and I'm damned sure the guys that are sat next to the people that are passively resisting, okay and staying on the radar, the rest of the team know and they will fix the problem before you ever notice it, in a mature group . And not saying … I said I was going to go over the top to make the point but they will either join or they will jack and they will come along.

119 Yeah. He played lip service to the implementation of Lean but once his team got out on site and his whole team followed him. So detecting that, the ability to be able to detect it and cope with it in an organisation is what designates an organisation's maturity.

120 One big one for me and I'm going to jump in straightaway with this is lessons learnt and actually effectively using the lessons learnt. We have this mentality in the industry that we build one-offs. Yes you do guys but there's lots of lessons we can learn from that one-off because as I said before, the way I simplify it is we do very similar processes in different locations with different constraints. It'd be rare for a process to be used once in any sector … ..So you'll be told that we did a project review at the end of the project and okay guys, you probably did it financially, where there's blame there's a claim, etc but what lessons should we be repeating in our project or should we be saying 'Right okay guys, that didn't go as well as it could have done, what are we going to do different?' The processes should develop as a result..So continuous improvement is an outcome of lessons learnt. if an industry is on the journey for maturity and they tell me they collect lessons learnt we don't utilise them if you know what I mean, we're not using them well enough.

121 I think the outcome is probably, … people start doing what they learnt in the previous ones but nobody's telling them … they haven't actually done it as a formal lessons learnt, it just becomes … that's just the way we do it round here … That's right and they keep changing it.

122 And the real success is when we're not calling it Lean, we're not calling it Last Planner, we're just doing it whatever, whatever and whatever. So that's an outcome, it's embedded (Agreed by PL#2, PL#3)….Embedding change without realising it.

123 So if you're doing a project on the M62, you've embedded a system to encourage Lean and continuous improvement, that local team are learning things in their way of working and their own experience and skill but unless it's formally fed back into and captured within the process instructions, the training materials, when the next project's done and it's at the bottom of the M1, it's an entirely different lower tier of subcontractors doing the work. And we need to pull that information back, make the changes, improve the quality and the efficiency and reliability of the processes so that the next ones using it get the training.

124 And I think when we're mature, we're going to recognise that with every pair of hands comes a free brain and we're going to use that brain. And this is going to become a knowledge industry rather than just a managed industry.

125 Yes but we also need to be finding ways to use the brains of the guys on the tools. So that we're getting much earlier warning of when things are going wrong, even though there's only one way to put these blocks together, actually putting those blocks together that way doesn't work because it doesn't enable us to achieve what we want to achieve.

126 I mean there are some aspects, when we're in the ground, embedded engineering is of only limited use because the ground conditions remain unknown until we know them. And no matter how much ground investigation we've done, we can't do 100% or it's ridiculously expensive to do 100% … ..But we can't get 100% picture of the ground conditions. And if we're doing a refurbishment, we don't know what's behind the panels that we haven't yet removed.

127 I think it's an outcome, is that 100% of contingency is spent on additional scope rather than unknown unknowns. We have contingency in there because we don't know what we don't know until we know but then let's spend it on …We'll give it back to corporations so they can improve the profitability and whatever else..100% of contingency is spent on something that the client wants.

128 I mean the one thing I would pick up on on your point as well, PL#1, I wouldn't want to accept that contingency all the time, if you know what I mean, I'd want to be challenging the contingency all the time….I accept that it's to challenge the contingency amount; all I'm saying is I don't think you can eliminate it totally.

129 So outcomes like from buildings, the output would be design of a building and the construction, the outcome is how efficient has the building been? Is it too hot, too cold, is it leaky, can you get upstairs, can you use the lifts, etc, etc; those are the outcomes for me. And unless I know about these outcomes, how can you go away and build another office block when the first one is not working? Or is it working so well, then we do the same design? … Has it improved the prospects of me getting the next contract to build a building …?

130 Our industry is very short-term mentality. As a subcontractor, I want to win this project, I want to be working on that project, so we become hunters in the sales process. If I'm working with a major contractor in the UK, yeah I've hunted it and I'm now farming it. Not to oversell my services but to take them on that Lean journey and at the end of the day I want to have a company and an organisation that we can use in this industry to demonstrate that's the journey you should be on guys.

131 I think one symptom of the short-termism is the amount of litigation we enter into …So one outcome I would see would be no litigations.

132 One thing that will help reduce contingency is ensuring that the only changes are customer-instructed. A lot of changes come from rework and other internally-generated, internal to the construction process generated change. We ought to be able to get rid of that and it is really important that the construction team are able to respond to changes in customer requirements.

133 Again though we can be challenging the amount of customer changes and in a lot of industries the volume of customer changes can be managed to be a much, much lesser amount with better collaborative planning.

134 So I think it's the changes … that's the only constant in this world isn't it, change?

135 So you need to have the systems in place to allow for that change rather than say … I've sat in meetings where some of my team have said to the client 'Sorry, you can't change it now, it's frozen' and the reaction from the client is 'What?' Rather than 'Well we're the client, surely we can change'.

136 It's an interesting piece here that I think we're getting so many more outcomes than outputs. And just thinking about that because if you do Lean, it becomes embedded and it is … on your analogy, Researcher, it is more outcomes than outputs because they're sustainable, because Lean gives you that constant improvement. So I don't think it's a surprise that we're getting more outcomes than … because outputs are just you build a building site for cheaper, faster …

137 Yeah, that came to me PL#4, I was just thinking quality, cost, delivery, health and safety, environmental impact; they're my outputs. And that can summarise them all. And you can go into however much detail on each subject matter you wanted to but….But the outputs that you were about to write down are also outputs from traditional construction.

138 lots of traditionally organised companies do lessons learnt and they end up in a filing cabinet or drawer or computer system and that's where they stay. But they do lessons learnt, they recognise the phrase and they'll give it a tick. This is one of the big, big … you know, it's how you phrase the different levels of lessons learnt. ..And probably a lot of senior managers will delude themselves that the lessons they collect are used. But if you're going to ask people further down the organisations, no chance.

139 Your output for a particular building or project would be a specific suite of performance criteria, but it would be specific to that one activity. So you'll have the quality performance, the delivery performance, the cost performance, achieved on that building. You'd want the output to be a known fact that the next building would be of a higher level of performance using the same criteria.

140 I start every project where I want to be 100% right first time in construction; yeah? And I know it's very hard to achieve where the industry is at the moment but that's the mindset I give my teams, 100% right first time for quality.

141 When we talk about delivery, I want to at least achieve programme because a lot of the time the clients aren't working and will turn round and say 'Do you know what, PL#5, if we hit this programme timeline rather than be two weeks overrun, then that's a start point' but my objective is always that I want to improve on that.

142 When we talk about cost, how many times do we see it in construction projects where we've thrown additional money at it in the last eight to ten weeks of a project to get over the finishing line?

143 Exhilaration … Exactly. So when I said the quality, cost, health and safety and environmental impact, that for me is the ultimate goal of achieving 100% right first time, delivering the programme as programmed, not as per the rewritten and reprogramme; what was the original programme timeline that we said? And all of that detail goes into that process.

144 When we talk about lessons learnt, I totally agree the organisations that I do see it in construction will capture it but as I said earlier in the conversation, the question is do they use it?

145 Demonstrate to us that you've utilised lessons learnt through every stage of the lifespan of this project to say I've identified that as a possible issue and I've gone and looked at the lessons learnt and what we've done to mitigate that in the past is this. If we haven't got it on the system already, I'm going to make sure it's on the system for the rest of my colleagues to utilise going forward. And that to me is a real sign of maturity. … If we're doing that, then I would say to somebody yes, you are a more mature organisation than others

146 there's got to be feedback into the organisation….That's where I think A3s are really, really important in our industry because they have a physical form, they can be in a file, they can be on site.

147 I would like to see is companies having regular A3 conferences where they treat an A3, maybe they ramp it up to A2 or A1 and there are poster sessions and the authors of the A3s are there to answer questions from people across the business and across related businesses, so it's not just … it's the supply chain that are integrating with this, so that that's accessible to the community.

148 Our improvement champions do exactly that, they create the A3s for their subject matter and in person they're doing it at the moment because it's the first journey that they've gone in this process. They're available on their intranet system but they're also out in the office on a big visual management board, as you say because we're trying to sow the seeds of people saying 'Oh what's this about? I'm interested in this' and understanding a bit more. And that's what you're looking to do through the A3, as well as capturing all the knowledge that you've gained through the process.

149 Not just A3 … I mean visual management I think is the headline there.

150 I think for motivation and communication and sharing the good word, the A3 is useful. But to ensure that we've embedded the learning in other processes, it's using equipment, it's going to use a certain standard operation.

151 If we've got standard operations in place, then it's going to use the skill of the individuals and the materials or the condition the materials have received or stored or used. If we're not changing one of those, for the next time we do that repeat job, well you're much less likely to actually see a change in output performance.

152 The detailed field level language, the Sheppard Way, Perfect Delivery, comes out of … is much more like a level language and I don't have a problem with that … Yes, no. And the thing that I think that has is it's a good anchoring system to anchor the process to that. You know, if Lean's not leading the process, then anchor it to Perfect Delivery … .Whereas Perfect Delivery was a different philosophy approach but Lean seems a major tool within there. So it's a good thing to anchor it to. Because one of the things that we are quite good at in our industry is a lot of initiatives all at once and not really strategically pulling it together.

153 And often what we find in technology is people take the modern tools, whether it's BIM or whatever it is, and go into a phone box to use it rather than working in a different way with that technology. Where I'm going with this is thinking Lean allows you to say oh that's a new technology, how do I do things different to make best use of that technology rather than how do I fit that technology into my traditional approach?

154 Thinking that you're allowing the technology to change how you deliver not necessarily just do the same thing over and over again. As soon as you change the technology, the social relations around that technology will change

155 And this is the thing you know, people talk about off-site manufacturing would be great for construction you know but if we don't plan it well into the process of construction, we've lost the benefit….One of the things I would say relates to that and that is that there will be smooth transitions from manufacturing to site assembly. That for me would be an example of maturity … .So we don't have stuff arriving at site, stacked on wagons in the wrong order. We have it stacked on wagons, so that it's lifted straight off the back of the wagon, straight into …where the off-site manufacturing facility have loaded the wagon in the right sequence but then we haven't planned it well enough on site …

156 risk is managed collaboratively. And planning is done at the lowest possible level, rather than planning is done at a high level and risk is pushed as low as possible.

157 And we are developing unique tools to address specific problems rather than having tools searching for problems … To solve specific … to address specific problems. So we're doing what Ono and Shingo and everyone else did in the early days, they didn't have tools that they could pull off the shelf and a lot of problems to solve; they had problems and they developed tools. We should be doing the same.

158 yeah because the debate then is do you build a flexible facility or an adaptable facility? And I'd always say you go for an adaptable facility because a flexible facility means it's all things to all men, so it's never exactly right. Whereas an adaptable facility hopefully you can adapt it so it's always right and I think that's along the lines you're talking about there.

159 The other thing I would like to do or would expect to see happening is not only will there be standard work for the operatives, there will be leader standard work, that leaders will have standard ways of interacting with projects, project teams and so on, so that they are collecting information in a standard way to feed into corporate management … ,And so not overloading local management but having a fairly quick interaction with local management to collect the information they need for making strategic decisions at a corporate level and leaving the site team to get on with managing the job, which is what they're paid to do. … .I think that comes to the point of you know, clear definition of roles and responsibilities across the team, not only in the Site Management Team but also in the supply chain.

160 It's creating … one of the things I was going to put on there is the environment for innovation, for soft managed

161 One of the things I did want to say which I think summarises a lot of what we've talked about anyway is proactive rather than reactive.

162 I think a non-Lean project which is organised on the traditional paradigm of command and control, adversarial, bilateral contracts and critical path method, top-down push programming, will find it very difficult to deliver most of these. … Whereas relationally contracted multi-party agreements are based around collaboration and short-term planning systems will have a very good chance of delivering these.

163 Faster, cheaper, safer.

164 Well I suppose my mind is thinking more of the output from that project is that it is part of cheaper, safer, better quality. Then the outcome is that the organisation learns to do this in more places, you learn how to do something … It's transferred to the rest of the organisation as a way to do business.

165 And I suppose happy client is an outcome….All clients happy … And if you think about a project there are many clients as well … And stakeholders as well.

166 Ultimately at the end it's repeat business as well as an outcome.

167 Enhanced reputation I suppose too.

168 Well if you meet or exceed the client's expectations and they've got further work, then you can win it. But through doing a more efficient job, you might be able to help a client to actually do more with the money they've got and stimulate extra work as well. So there's a repeat but there's also new work of a different sort because you're going to do it cheaper, quicker, that they didn't think they could do. So they get the confidence in you that you can deliver on that.

169 One output I have witnessed on some of my sets that I was writing on with some of the Lean construction tools where that was that the project managers or … everyone from the labour to the project manager were experiencing less stress….And for me it's an output almost immediate, almost immediate … .Because of less stress.

170 Absolutely, absolutely, less stress face to less availability….Less formal, contractual discussions.

171 Less adversarial behaviour. And then as a consequence, a true constructive atmosphere was created to find alternative ways of constructing or designing. We worked with the architect to simplify his design, whilst keeping the value for the client.

172 People having more fun as well….Absolutely, absolutely, we were having to nice lunches, we were France then …

173 My partner worked on a project where they were less stressed, he was talking about that they acquired a project manager when sailing for ten days before the project, the project end date, so there was no issues, no nothing, everybody …

174 In fact I brought 12 of my people from the architects to the client sailing around Corsica two weeks. Everyone was looking at it as 'Are you crazy?', I said 'No, we will have to learn how to behave together and on the same boat you can't escape basically'. So we have boats where we learn how to behave together and then the project extremely well and we saved 40% of the time, of the lead time, 40%.

175 Additional value.

176 I think the other thing is that you've got … if you reduce lead times and you've got a better relationship, you can be more agile in adapting to changing requirements, flexible to the environment.

177 adaptability to changes.

178 Adaptability? … Yeah, to changing customer and environmental requirements … Agile is a good term to use.

179 I think there must be something about safety because although you can't prove it, I think that well-planned projects that are not continuously changing their programmes where people go and do things out of sequence and out of knowledge of themselves, must mean that you have it safer. You can't do the metrics but you could probably do subsets …we had the discussion … and that would have measured Lean contracts with the Lean contracts that they are safer and have less accidents and really can't understand why. … and it is going back to less stress. If people here are less stressed, they can concentrate on the job … It's reliability … .Yeah and knowing where you are and feeling less stressed because when you're stressed you can have accidents or you tend to not really see the dangers that are in front of you

180 responding to it will be progress or like one step closer to vision, that would be our outcome then.

181 what we're getting is a thinking team. So one of things I've found in construction is people do things because they've always done them the same way. So it's not … they'll say they've got ten years' experience but they've got one year's experience ten times over. But in this, they will be … it's part of the learning about your thinking. So you're going from doing things by rotes because you did them last time, to really thinking about what you're doing and how you're doing it and how … so there's that. And that thinking … through the thinking you become more aware of things like safety because you're just not … you're not going to a toolbox … you become a bit of a robot if you're not careful … the output in terms of staff is thinking staff, as well as … yeah … .They're using their brains not just their …Yeah, because if you've got an input then you are part of the decision-making then and …Part of the decision-making process, yeah.

182 So it's really, really an output is total systems thinking, that's what the …So it's total systems thinking. … An output of a mature organisation is that's how they behave, they behave that way. So it's not about oh let's build this ten storey office block, it's just another ten storey office block. Total systems thinking says let's build this ten storey office block; is there any way we can improve on what is already … we've already known? Is there any way we can improve on what we did before? Can we make it easier to look after it and maintain it? Can we make its lifespan better? Can we make all sorts of things … you know?

183 When we understood that, we understood the real value. So there's an understanding of the critical customer goals … so it's the goals but then what is it, what does the customer really want? It's a bit like … and this is where this company are quite good at getting their requirements management done and the true understanding of what is the real requirement from the construction system and the built environment. Understanding what the ultimate aim is, so you're not just building a building, what you're going to use the building for, how does the client see it being used and understanding that across the team inherently means that you fix the things that really matter to them.

184 And you're tapping into … the architects and the designers who have the grand ideas and you know, all that sort of stuff, they don't really understand how it's built. But if you can tap into that systems thinking and then you can release the inherent knowledge in the workers, that they can contribute to the design at that detail level and feedback during the course of the build … .It's target value design and integrated project delivery, it's two concepts that have come together….Target value design is you can identify value and apply that value to your contract … Target value then is a process that you apply to achieve the desired outcome, the desire value and desired cost. So …It's an output. It has to be an output, it has to happen before the event takes place … .It a process that you use to achieve something.

185 I would put down identified the value and the processes to make it cheaper.

186 So you know, you get a confidence that you can do stuff and that you will achieve it and certainty that you will deliver. It's more of an emotional thing rather than …Confidence and predictability.

187 Yeah, I accept that PN#10 but I think it goes a little bit beyond that. It also goes beyond that the review process has to include, it has to include in it, something which is a bit like off-the-shelf thinking. So is there something that we could have done differently with this one? So it's not just about review of how you did what you did …Is that not continuous improvement though? … It's an outcome in that you can increase the likelihood of investment through that confidence and that's a really key …

188 I think if you can get them to analyse what they could become and see what that gap is and do an improvement plan that fills it in over a period of time.

189 We get our workforce focused, they're doing what they should be doing …Yeah, predictability in construction is one of the hardest things of all.

190 Honestly I can't see any difference. I've worked in aerospace, telecoms, rail and construction and there's no difference. …But I think you'd have more uncertainty in civils….But I don't think that means it doesn't work. I think it works to a different level. And you won't get to 100%, you won't get to 99%, you could get to 80% which is good.

191 Understanding that the variation in construction exists and is realistically unpredictable in certain areas

192 I think in the early stages of your maturity, right, it's useful to have, like we've got there, a set of checklists. Later on you actually start to realise there's a lot more depth to it and then it's quite difficult to articulate it and you need to respond to changes in thinking. Because you know, the maturity of thinking is moving all the time.

193 I think you need to set extreme targets. So I think … if you tried to do this … and you've got to say something completely outlandish. I'll give you an example, okay; on the railway, the last job I had, we had to cut the time to do a job from 54 hours to eight hours and everyone said it was impossible. And they've just done it. And you've got to be … you've got to really set outlandish challenges and then look at how you're going to get there. But if you go for small challenges, you'd never move and you undersell the power of Lean. And I think you're right, it's setting the aspiration isn't it? … It's got to be a leadership team that set that really to drive that change.

194 I'm not particularly in favour of setting very extreme targets. I think extreme can apply to vision; you can have an extreme vision. But then the targets if you want to keep your team motivation must be achievable. This means you … we know that for people … to help keep people motivated, you have to small steps and then that's Lean somewhere and this somewhere is … there is a vision.

195 Improving … the words that we use here as our community of experts of … or at least people who know something about the organisation, are very unknown in the rest of the industry. And we have to make a huge effort in making those words accessible to the audience … .And it's been my experience that the use of word like 5s, LPS like Kaizen and we all know that and not speaking chinese to you but I speaking chinese for someone who is outside this community.

196 And if we are speaking about maturity and maturity I guess is also about getting the other buy, you are using the buy towards getting … the use of the word buying, if someone has to buy this Lean construction we must make this the terms, the words, the expressions accessible and understandable to the others. … They're a professional language, right, so the most important thing is too that everybody in one organisation talks the same language. So whatever language it is …

197 I think that's going to come from the supply chain, it's going to come from the likes of UK's major main contractors, engineering companies and these sort of companies to influence.

198 One of the great things for me is to use the case studies. So try and use examples that people can relate to, to sort of market it through case studies, so let people visually see that they're not taking a risk, it's not necessarily something new that's been done successfully before.

199 I think if you apply a Lean champion somewhere within that Lean construction, then you've got a better chance of actually applying tools and techniques that could change that and make it more on target. So perhaps a Lean champion may be a way forward. Well you can him whatever you want (laughs) but if he knows the tools and techniques, he can be seen to be not call it Lean but improvement expert or improvement champion, take Lean out, they're all improvement systems and methodologies.

200 If we want to optimise the Lean maturity of a particular project, the kind of things that you'd want to see is a clear definition of the commercial functional and operational objectives for that project. And the definition of a management framework, so that you can align the management objectives and motivations to the successful achievement of that project. All of which is about trying to get a context for applying new business improvement effort.

201 I think the one thing for is as well to understand that it's not going to be a quick win you know, there is work to be done on culture and behaviour, as well as implementing tools and techniques. And early engagement of Lean principles in the project rather than the typical scenario of you know, I'm eight weeks into the programme already, we're on site, we're now falling behind by a week and a half/two weeks and come and do Last Planner for us.

202 let's start the journey in the correct manner, which is picking up on your point you know, a clear definition of what the project requirements are, let's build the team. And when I say build the team, not go and build a raft on a lake somewhere, actually build a team ethic across the team on what we're trying to deliver.

203 I think Demig's answer was a really good one. And it doesn't matter when you start, so long as you begin today

204 I think if you're improving maturity, you must start with some maturity but you might have to say can we check that PL#5's methodology/philosophy is actually the way we want to go. So that may be already in-built if it's already mature but it depends on how mature it is. So let's check that that's embodied, so they've got some concept of this but they may need to be educated further. So 10-15% maybe in there they understood but you might want to get that up to 80-90% and start the journey then when it's much easier. So you've got the collaboration and …So you're influencing, you're educating and you're putting it at a higher level, so it's better established for the next project from learning on the first project. And then once you've done the second project, you go through education again and then it gets bigger … so it's like a mushroom, it just grows and grows and grows, until eventually I hope it'll be a high level to say right, yes, this is the Sheppard Way because it's all embedded in the company.

205 "So I think it depends, where the maturity is in the Lean construct to start with if you're going to improve it.

It might be at the bottom, it might be somewhere near the top; I don't know. It depends how much you need to … how far you need to go."

206 The other one was allowing everybody to knowledge share. I think it's great when a subcontractor turns round to another subcontractor and says 'Oh yes, I did this on a previous project'. And okay, there was teething problems but in the long

run it really worked out well. And okay, we can improve on that and I think it's great to hear that from the horse's mouth rather than a consultant coming or a senior management team, tell the team about it.

207 Yeah, I think we're in danger of conflating two completely separate issues here. One is the maturity of a project and the other is the maturity of … a company

208 I think that what's important is in both cases to move from a focus on the individual and a project to a focus on the system. And move from a focus on results to a focus on learning. You probably need to do the first or get started with the first before you get started with the second.

209 But it seems to me that a mature Lean organisation is going to be good at learning and good at thinking systemically about everything that it does. And I think it's very, very difficult to do what Lean Build suggests which is to move straight from thinking about results and thinking about … and blaming people for those results when they're wrong, to being in a position where you're focusing on learning and focusing on the system and how the system is or isn't supporting learning.

210 So at a project level, I think it's really important to start with short-term planning because that's going to tease out reasons for not doing what the programme says should be done. And as you start to understand that, then you can start putting systems in place which enable you to do what you want to do.

211 I think with companies I'd start with what I know as a study action team, getting diagonal slices of managers from the organisation talking, reading together and then discussing in a systematic way what their learning is from the book. And it just almost doesn't matter. Lots of companies I know and I've done it with construction companies that I've worked with, have read The Toyota Way, Toyota Kata, Toyota Way You Feel book, books like that which have nothing ostensibly to do with construction but it's getting senior managers, senior and middle managers together thinking about what the implications of this Lean stuff might be if we started to get a grip on it in our organisation. And I think a study action team is an incredibly powerful way to begin to do that … .within a company I would expect there then to be a degree of alignment emerge between the managers involved in that process. And that alignment creates energy because people have a way of thinking about how they're going to proceed and have some agreement about how they want to proceed within the business … .if you've got the chief exec or chief operating officer or whoever it is as part of one of those teams, then you've got the energy at the very top. And I think as Denning said way back in 1950/51, it's really important to get top management on board.

212 One of the things I try and achieve is light the touch paper at both ends. So I'm trying to convince the senior management team and give the grassroots guys or ladies enough so that they can start to learn

213 If people at grassroots level are thinking about the seven wastes as a basic principle and identifying look, hold on, why are we doing this there? Why is that causing us a problem there? And also the senior management team have the overall strategy being built in the process; at some point it's got to meet successfully. That's the best way for me I honestly believe.

214 We've come full circle though haven't we, it's not about tools and techniques, it's about culture and behaviours of people.

215 I think we used the term before, do it to them and it doesn't work. Do it with them and it works. You know, I go onto sites and there's construction managers or project managers, etc, with 20/30 years' experience, they've got some good things they're doing already

216 I think the one top end thing that's an essential for making Lean sustainability successful is a strategic framework to provide a context. To link in right the way through from the commercial aspirations through to the objectives in measurable terms for every team within the organisation whatever they're doing.

217 I would come back to some of the things we've just been talking about there on creating the environment to allow the behaviours to flourish of the type of things we've talked about. So whatever that be, how your contract might be set up, how your supply chain is set up, how the senior management works, the whole thing about creating that environment to allow a lot of what we've talked about to flourish. I think that's almost the same but subtly different

218 That would be one of the natural things that you would definitely be addressing if you're trying to deliver your commercial objectives. You need the right culture to make it happen.

219 I keep coming back to collaborative working actually….

220 I'll always come back to culture and behaviour is a big driver because … a lot of people will read Toyota Way or they'll go onto a website and look at principles and tools and techniques and I do think sometimes people walk away with the impression that actually this isn't for us in construction because it's too much manufacturing terminology. If somebody asked me for a book to read, I always say 'Read The Goal'. If you read The Goal, it tells a story in a way that I think will fit with most people. You know, you get a better understand of what it's trying to achieve. If somebody asked me for a book to read, I always say 'Read The Goal'. If you read The Goal, it tells a story in a way that I think will fit with most people. You know, you get a better understand of what it's trying to achieve.

221 And the one final thing I would say is people have got to realise it's a journey. You know, it sounds very cliché but it is a journey that you're starting and we can use all the terminology of single steps and all that but to me it is a journey and it's understanding there's different points of that journey that we will achieve. … By bringing in a consultant may raise your awareness, by starting to utilise Lean techniques within your processes and your projects will take you further along that journey. The goal I always have with working with my teams is I want to create an internal capability within your organisation because that's what you need.

222 it needs to be intrinsic within your business. It's got to be what happens within your organisation

223 Just one word, leadership.

224 A common goal from people who are trying to deliver this within the industry.

225 I think … having a guru and then what I probably didn't push enough is that it's quite easy for the organisation to think the guru's a complete waste of time because they're just putting money in and they're not getting anything out. And usually that guru lives in ideal world language and then there's an arrangement around them that protects them, that says you can't kill that person. Because usually an organisation will see it as a cost save fairly early on after …

226 The thing is that I've seen when you keep that person it's quite … sometimes you do that yourself, is it worth keeping this person on after a while, but they need to stay pure, they need to keep the language. And then you need an organisation around it that translates that and eventually the rest of the organisation will come to their level. And that's quite a … it can be quite a difficult thing to maintain the business case to keep that person within an organisation.

227 And it's best to have them inside rather than as a consultant, they need to … Yes, they need to understand the organisation.

228 For me it's engagement of leadership and to get them to understand the potential and that they're doing it for them.

229 For me it's verification methodologies.

230 Leadership, so need an understanding top-down, bottom-up

231 Leadership from the top, we need to engage and need to understand, need to have the vision that you create the leaders and understanding what the leaders are….Because again, the people that will implement are the leaders who create.

232 Value driven….Yeah, so we were talking about the the largest construction and engineering company in the US case of working on the organisation internally, how efficient is it, how effective is it and how does it deliver the benefits to their clients.

233 I think it's about leadership championing the change or the increase in maturity that the leadership needs to internalise it. It's not just a mouthpiece, it's actually really understanding it. So they can say with a passion they've got that fanaticism.

234 To never be happy with the status quo….Keep challenging, keep challenging as we have been doing. If we are all happy then is it the end of the day? I like that someone is not happy, someone is unhappy and what's that challenge?

235 You know, they're using the same excuses as existing construction that you know, most of our jobs are 80% the design cycle and then a very short manufacturing, we have very, very low batch sizes or one-offs you know, maybe you've got the high technology argument as well but a million and one reasons why Lean isn't for aerospace and defence. It's fine for the guys making millions off in electronics or automotive and you know, it doesn't wash really, it's not true. It's a misconception.

236 Around that just got me thinking when you talked about acceleration and A3s and so there's a whole terminology thing which is an outcome that we're actually talking a language that we all understand and that goes across industry

237 I think it's even more important to have standard language, so that as people move from one project to another, if we've got standard terminology then people have a standard understanding of what it is. It's like having standard operating procedures really or standard work or whatever you want to call it. And I think having a multitude of terms for the same thing can cause confusion.

238 we had a wonderful example of one of the biggest main Contractors in the US, where a recent graduate working on his first project was stopped by the President of Turner for the whole of the US and asked what he was doing. And so he explained and this was a project that was being run on Lean grounds and the President had planned 20 minutes to be on that sitre. Two hours later he was still there talking to this young engineer. And he left and suddenly Lean was on the agenda for Turner nationally. People had been pushing up for about seven or eight years and getting nowhere. But that young engineer with his enthusiasm, from what he'd seen on the project, converted the President.

239 The workers like it because they're able to earn their money faster and more easily because things are better planned, the bosses like it because they can see all sorts of business benefits but it means that middle manager roles have to change (All agree).

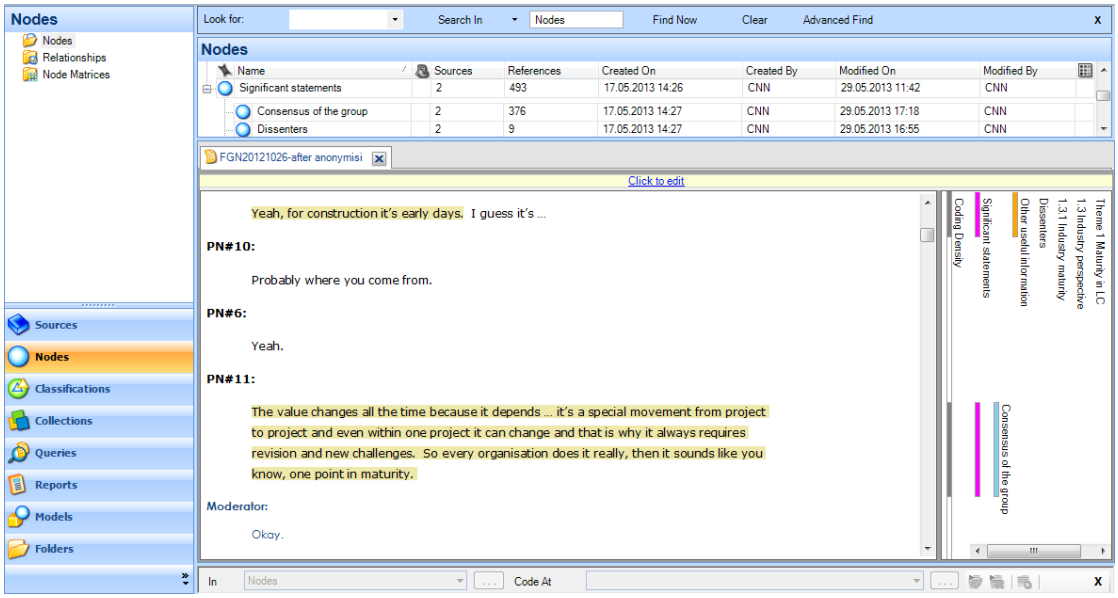
Significant statement of dissenters

240 PL#1 I don't agree 100% with that. I think we need grit in the oyster in order to produce the pearls. We need people who are thinking differently in the organisations, which are not aligned, who are thinking the awkward thoughts and challenging leadership so that we continue to develop. And that requires disalignment as well alignment.

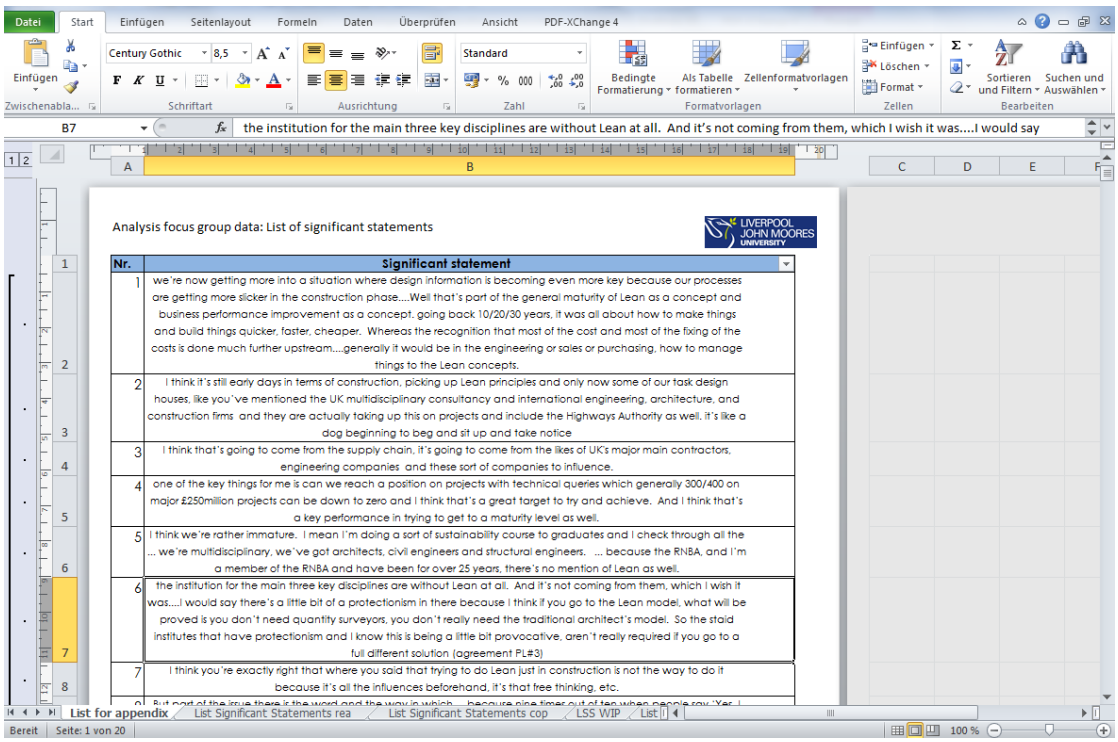
241 PN#9, I've got a bit of a problem with KPIs … I really have a problem with KPIs. I think within the industry the way … they're really good in the reports and all that, they're really good too but they've been just misused and I think it's such a terrible … you know, key performance indicators, they should be really simple but companies and contractors have used them as a smokescreen to cover what they're not doing too. I think KPIs should show what you are doing and not what you're not doing really, or what you're not doing to learn from that. But they've tended to become a smokescreen and I have a bit of a problem with the concept now.

APPENDIX J: Sequence of the analysis approach: focus groups

The significant statements were identified and indexed using NVivo: The significant statements appears in NVivo within the field 'Themes' so that the significant sentences or passages it terms of the phenomenon 'LC maturity' that have been identified in the focus group transcripts can be indexed to a node 'Significant statement' using drag and drop (see Screenshot below). The highlighted text shows that this passage was identified as a significant statement:



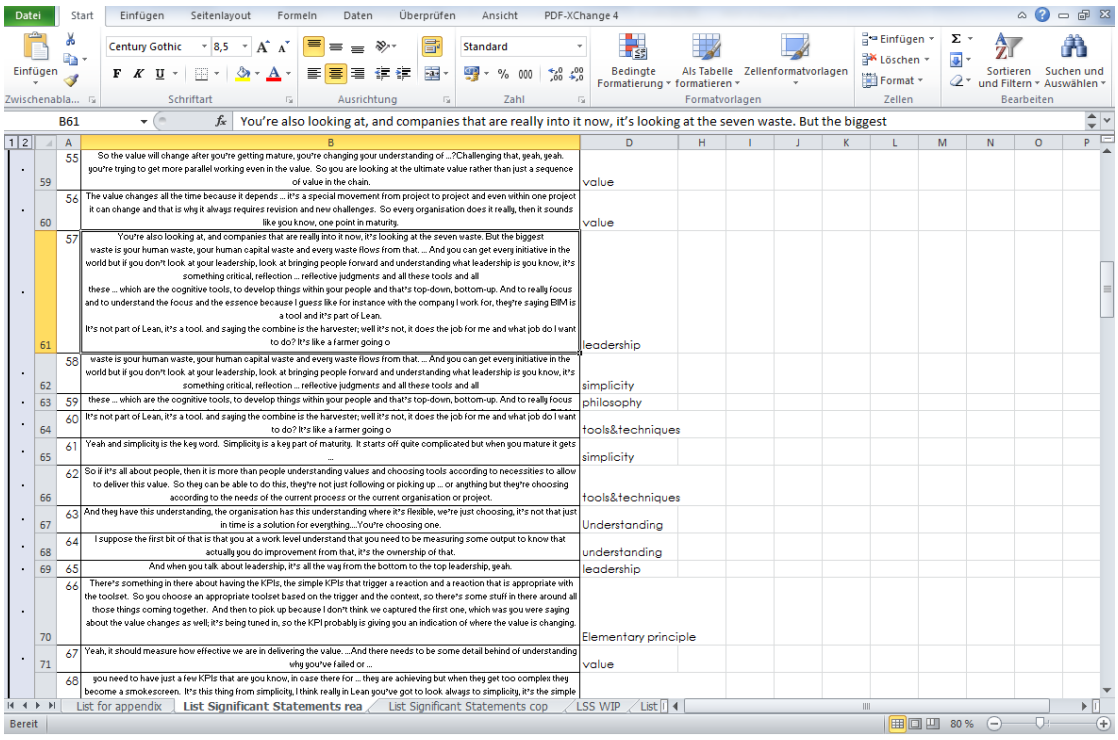
The identified and indexed significant statements were then exported through the interface of MS-Word to MS-Excel to create a non-repetative list of significant statements. The screenshot below illustrates this list in MS-Excel.



Analysis focus group data: List of significant statements

Nr.	Significant statement
1	we're now getting more into a situation where design information is becoming even more key because our processes are getting more slicker in the construction phase....Well that's part of the general maturity of Lean as a concept and business performance improvement as a concept. going back 10/20/30 years, it was all about how to make things and build things quicker, faster, cheaper. Whereas the recognition that most of the cost and most of the fixing of the costs is done much further upstream....generally it would be in the engineering or sales or purchasing, how to manage things to the Lean concepts.
2	I think it's still early days in terms of construction, picking up Lean principles and only now some of our task design houses, like you've mentioned the UK multidisciplinary consultancy and international engineering, architecture, and construction firms and they are actually taking up this on projects and include the Highways Authority as well. it's like a dog beginning to beg and sit up and take notice
3	I think that's going to come from the supply chain. it's going to come from the likes of UK's major main contractors, engineering companies and these sort of companies to influence.
4	one of the key things for me is can we reach a position on projects with technical queries which generally 300/400 on major £250million projects can be down to zero and I think that's a great target to try and achieve. And I think that's a key performance in trying to get to a maturity level as well.
5	I think we're rather immature. I mean I'm doing a sort of sustainability course to graduates and I check through all the ... we're multidisciplinary, we've got architects, civil engineers and structural engineers. ... because the RNBA, and I'm a member of the RNBA and have been for over 25 years, there's no mention of Lean as well.
6	the institution for the main three key disciplines are without Lean at all. And it's not coming from them, which I wish it was....I would say there's a little bit of a protectionism in there because I think if you go to the Lean model, what will be proved is you don't need quantity surveyors, you don't really need the traditional architect's model. So the staid institutes that have protectionism and I know this is being a little bit provocative, aren't really required if you go to a full different solution (agreement PL#3)
7	I think you're exactly right that where you said that trying to do Lean just in construction is not the way to do it because it's all the influences beforehand, it's that free thinking, etc.

To group the significant statements in themes 'meaning units', the researcher captured the main meaning of each statement in a keyword next to the statement to allow a systematic building of themes (meaning clusters). This is shown in the screenshot below:



59	So the value will change after you're getting mature, you're changing your understanding of ...?Challenging that, yeah, yeah. you're trying to get more parallel working even in the value. So you are looking at the ultimate value rather than just a sequence of value in the chain.	value
60	The value changes all the time because it depends ... it's a special movement from project to project and even within one project it can change and that is why it always requires revision and new challenges. So every organisation does it really, then it sounds like you know, one point in maturity.	value
61	You're also looking at, and companies that are really into it now, it's looking at the seven waste. But the biggest waste is your human waste, your human capital waste and every waste flows from that. ... And you can get every initiative in the world but if you don't look at your leadership, look at bringing people forward and understanding what leadership is you know, it's something critical, reflection ... reflective judgments and all these tools and all these ... which are the cognitive tools, to develop things within your people and that's top-down, bottom-up. And to really focus and to understand the focus and the essence because I guess like for instance with the company I work for, they're saying BIM is a tool and it's part of Lean. It's not part of Lean, it's a tool. and saying the combine is the harvester; well it's not, it does the job for me and what job do I want to do? It's like a farmer going o	leadership
62	waste is your human waste, your human capital waste and every waste flows from that. ... And you can get every initiative in the world but if you don't look at your leadership, look at bringing people forward and understanding what leadership is you know, it's something critical, reflection ... reflective judgments and all these tools and all	simplicity
63	these ... which are the cognitive tools, to develop things within your people and that's top-down, bottom-up. And to really focus	philosophy
64	It's not part of Lean, it's a tool. and saying the combine is the harvester; well it's not, it does the job for me and what job do I want to do? It's like a farmer going o	tools&techniques
65	Yeah and simplicity is the key word. Simplicity is a key part of maturity. It starts off quite complicated but when you mature it gets	simplicity
66	So if it's all about people, then it is more than people understanding values and choosing tools according to necessities to allow to deliver this value. So they can be able to do this, they're not just following or picking up ... or anything but they're choosing according to the needs of the current process or the current organisation or project.	tools&techniques
67	And they have this understanding, the organisation has this understanding where it's flexible, we're just choosing, it's not that just in time is a solution for everything....You're choosing one.	Understanding
68	I suppose the first bit of that is that you at a work level understand that you need to be measuring some output to know that actually you do improvement from that, it's the ownership of that.	understanding
69	And when you talk about leadership, it's all the way from the bottom to the top leadership, yeah.	leadership
70	There's something in there about having the KPIs, the simple KPIs that trigger a reaction and a reaction that is appropriate with the toolset. So you choose an appropriate toolset based on the trigger and the context, so there's some stuff in there around all those things coming together. And then to pick up because I don't think we captured the first one, which was you were saying about the value changes as well, it's being tuned in, so the KPI probably is giving you an indication of where the value is changing.	Elementary principle
71	Yeah, it should measure how effective we are in delivering the value. ...And there needs to be some detail behind of understanding why you've failed or ...	value
	you need to have just a few KPIs that are you know, in case there for ... they are achieving but when they get too complex they become a smokescreen. It's this thing from simplicity, I think really in Lean you've got to look always to simplicity, it's the simple	

The developed hierarchy of themes with similar meaning was than imported into NVivo as 'Nodes' together with the non-repetitive and non-overlapping list of significant statements to

group the statements with similar meaning together in that hierarchy of themes (see screenshot below):