A Lean Six Sigma Maturity Model for Higher Education Institutions (HEIs)

March 2021

A thesis by Stephen Graham Anthony for Doctor of Philosophy

Supervisor: Professor Jiju Antony

Department of Business Management

School of Social Sciences

Heriot Watt University, Edinburgh, EH14 4AS

Abstract

Lean Six Sigma (LSS) is a continuous improvement methodology that aims to reduce the costs of poor quality, improve the bottom-line results and create value for both customers and shareholders. LSS has been deployed in organisations in a variety of sectors and cultures for more than two decades. However, its implementation in higher educational institutions around the world has only just begun to emerge. Furthermore, there is a lack of any empirical evidence to support any successful deployment of LSS in higher educational institutions when addressing the key challenges faced by these institutions today.

Therefore, the purpose of this research is to investigate the current status of Lean Six Sigma (LSS) in UK higher educational institutions and subsequently develop a Lean Six Sigma Maturity Model which can be used to assess their current level of LSS maturity and help these institutions develop action plans and strategic objectives to successfully build maturity in LSS.

The study is based on a Taguchi styled systematic literature review of papers that were published on LSS in higher education in high ranking journals in the field of LSS, academic leadership and other specialist journals, from 2000 to 2020. A descriptive survey via a questionnaire was conducted in the second phase of the data collection process and semi-structured interviews were conducted in the third phase. Based on the literature review and the findings of the empirical research, a Lean Six Sigma Maturity Model for higher educational institutions was developed and tested on a mix of UK and International higher educational institutions, along with a sample of Master Black Belts from industry. The results of the empirical study show a lack of maturity in LSS, that UK institutions are in the early stages of implementation, and that these institutions have only recently started to recognise the importance of LSS to their organisation. Therefore a maturity model for this new emerging sector is vital for its success in developing its approach to deploying LSS and will become the basis for future work and publication by the author.

Research Thesis Submission

Name*:*	Stephen Anthony		
School:	School of Social Sciences		
Version: *(i.e. First, Resubmission, Final)*	First	Degree Sought:	Doctor of Philosophy

<u>Declaration</u>

In accordance with the appropriate regulations I hereby submit my thesis and I declare that:

1. The thesis embodies the results of my own work and has been composed by myself
2. Where appropriate, I have made acknowledgement of the work of others
3. The thesis is the correct version for submission and is the same version as any electronic versions submitted*.
4. My thesis for the award referred to, deposited in the Heriot-Watt University Library, should be made available for loan or photocopying and be available via the Institutional Repository, subject to such conditions as the Librarian may require
5. I understand that as a student of the University I am required to abide by the Regulations of the University and to conform to its discipline.
6. I confirm that the thesis has been verified against plagiarism via an approved plagiarism detection application e.g. Turnitin.

<u>Submission</u>

Submitted By *(name in capitals):*	STEPHEN GRAHAM ANTHONY
Signature of Individual Submitting:	
Date Submitted:	20th OCTOBER 2020

<u>For Completion in the Student Service Centre (SSC)</u>

Limited Access	Requested	Yes		No		Approved	Yes		No
E-thesis Submitted (mandatory for final theses)									
Received in the SSC by *(name in capitals):*						Date:			

Table of Contents

List of Tables

List of Figures

List of Publications

To support this thesis the author has published articles in three respected international journals, contributed four chapters to two recent books on higher education institutions, and delivered five conference papers sharing the author's research and findings. A full list of publications can be found in table 1 below:

Type of publication:	**Relevant Thesis Chapter**	**Publication Details:**
International Journal Article	Chapter 1	Anthony, S.G. and Antony, J. (2017), "Academic leadership – special or simple", International Journal of Productivity and Performance Management, Vol. 66 No. 5, pp. 630-637.
	Chapter 3	Anthony, S. and Antony, J. (2016), "Academic leadership and Lean Six Sigma: A novel approach to systematic literature review using design of experiments", International Journal of Quality & Reliability Management, Vol. 33 No. 7, pp. 1002-1018
	Chapters 6 and 7	Anthony, S. and Antony, J. (2020), "A Lean Six Sigma Maturity Model for Higher Education Institutions" Lean Six Sigma in Higher Education, Emerald Publishing Limited, pp. 141-159
Book chapters		Book 1: Lean Six Sigma for Higher Education: Theory and Practice **,** World Scientific Publishers 2019
	Chapter 1	- Academic Leadership – Simple or Special
	Chapter 5	- Current state of UK Lean Six Sigma implementation
		Book 2: Lean Six Sigma in Higher Education: a practical guide, World Scientific Publishers 2019
	Chapter 1	- Academic Institutions – Their culture and Characteristics
	Chapters 6 and 7	- A Lean Six Sigma maturity model for academic institutions
Conference Papers	Chapter 3	- A systematic literature review using Taguchi methods - Third International Conference on Lean Six Sigma for Higher Education – June 2015
	Chapter 1	- Academic Leadership – Special or Simple - Sixth International Conference on Lean Six Sigma – June 2016
	Chapter 5	- The application of LSS in academic sector – initial findings - 4th International Conference on Lean Six Sigma for Higher Education – May 2017
	Chapter 6	

	Chapter 7	- Using case study to build theory - Seventh International Conference on Lean Six Sigma - May, 2018. - A Lean Six Sigma maturity model for academic institutions – testing theory - Fifth International Conference on Lean Six Sigma for Higher Education - June 2019

Table 1: Full list of author's publications during the period of this thesis

Introduction

In a globalised world, all countries are trying to educate their people to enable their nation to prosper, by using 'world class universities.' Many of these universities have recognised that today's globalisation is creating a series of trends which academic leaders must address. These trends include, but not exclusively, the belief that education no longer has any borders; technology is advancing in ways unforeseen by many institutions; there is more choice which has led the student to become a "customer" or "consumer" of learning, resulting in institutions competing not just locally for talent but internationally; social welfare has weakened and institutions need to raise more funds privately than ever before; and finally, universities are becoming more (not less) de-centralised, with more decisions being made at the local level. This current paradigm universities find themselves in is not actually new. History teaches us that the very early institutions needed to change to stay relevant, perhaps some universities have just forgotten they need to change. Those that are embracing change though are doing it through a variety of approaches and some are embracing tools and techniques developed in the world of manufacturing to change their culture and their physical institution.

The author has always been interested in how manufacturing and process improvement tools/techniques and methodologies have changed and morphed over the decades. Usually these tools/techniques have improved because technology has allowed engineers to do more, or new industries within manufacturing have embraced operational excellence methodologies such as Lean and Six Sigma and this has brought new challenges to the way process improvement is delivered in these traditional hierarchical, situational leadership driven sectors. Occasionally, though, a completely new sector embarks on this journey, and the learning is not centred within a new tool or approach, but within a new context of the change. The way continuous improvement is deployed in a hospital, in emergency services such as police, within a software house, in a town council has the potential to be very different when compared to a steel works, a car plant or paper mill. The author's research is centred on this specific interesting context: how does a Higher Educational Institution (HEI), with all its challenges, culture and unique world views successfully deploy Lean Six Sigma to deliver change? In addition, and perhaps more importantly, how does that institution grow and mature in its approach to continually change and improve using Lean Six Sigma methods?

The author has worked for over 20 years deploying Six Sigma and building cultures of continuous improvement in a variety of sectors and is motivated to bring the benefits of Six Sigma, Lean and other continuous improvement approaches to the HEI. This motivation has led the author to research the current situation within the UK HEI sector and develop a method of measuring the maturity of a HEI Lean Six Sigma journey.

Throughout this thesis the author will refer to universities and academic institutions by their formal title – Higher Education Institutions (HEI.) higher educational institutions (HEI) are defined in UK law, under the Further and Higher Education Act 1992, as i) a university, or ii) an institution conducted by a higher education corporation, or iii) an institution designated as eligible to receive support from funds administered by the Higher Education Funding Council for England. HEI are mostly universities and have three functions – Education, Research and Contributing to Society, (World Conference on Higher Education, 1998.)

The research presented in this thesis is broken down into 8 chapters, with figure 1 below demonstrating how the research was structured and evolved:

Chapter 1 introduces the reader to the context and history of higher educational institutions, the characteristics and challenges faced by these institutions in the modern changing world, and the importance leadership has played in changing higher educational institutions to meet these challenges. The chapter concludes with a new definition of academic leadership to be used in the remainder of the thesis.

Chapter 2 introduces the reader to the concept that change can be managed, and that leaders delivering change develop their knowledge, skills, behaviours and competencies over time. This observation is often defined as a level of "maturity" within the chosen field. This chapter illustrates several examples of maturity models, including how they are constructed, defined and developed. The chapter concludes by highlighting the elements the reader requires if they are to develop their own maturity model.

Chapter 3 introduces the reader to the approach taken by the author to gain the knowledge required in Lean Six Sigma to support the development of factors and levels as outlined in the previous chapter. The novel approach taken in conducting a systematic literature review using a Six Sigma methodology was published by the author in 2016. This approach was used instead of a more traditional approach to systematic literature reviews to allow the author to demonstrate how Lean Six Sigma techniques can be used outside of the typical HEI administrative based improvement project.

Chapter 4: The pursuit of knowledge requires the author to understand their own view of the world, their strengths, their weaknesses, their assumptions and their internal and external conflicts when it comes to conducting research. Before the author moves into the area of gathering new data to combine with their systematic literature reviews it is important to try and understand how this data could be influenced by the author's own paradigm and bias. Thus chapter 4 is a review of current research philosophy and methods to enable the reader to understand the author's thinking and any bias which may exist.

Chapter 5 takes the research and literature reviews in earlier chapters to identify 10 questions to approach all the UK higher educational institutions. The aim is to identify those academic institutions deploying continuous improvement, specifically Lean Six Sigma, in some manner to drive change and improvements in their respective institutions. Due to the limited responses and lack of evidence of it being widely adopted in the UK these questions were shared with a wider international audience to try and identify potentially cross boundary studies and case study material for future chapters.

Chapter 6 describes the history, background, research and the development of the author's ideas into a conceptual maturity model that university leaders could use to map and benchmark their Lean Six Sigma journey. The model is built using a mixture of case study evidence and literature review.

Chapter 7 introduces a final refined Lean Six Sigma maturity model. The original draft model was tested over a 12 month period in a variety of methods, including interviews, workshops and benchmarking case studies. The final model here is presented in two forms: the first a single page traditional capability maturity model, and the second a broken down maturity model, across several pages, in the form of a benchmarking questionnaire or diagnostic tool.

Chapter 8 is an opportunity for the author to express his views on his Lean Six Sigma maturity model and the way in which academic institutions in the UK are managing change. These views and opinions are based not on subjective analysis but on 8 years of research and studying the HEI sector. In this time the author has talked to many academics, managers and leaders about how change really works in the UK and these informal discussions combined with his detailed research has enabled him to form the views in this chapter. The author identifies 9 areas where higher educational institutions lack maturity with respect to LSS deployment.

Chapter 9 draws together the authors' final conclusions by chapter and identifies 4 limitations of his research, and potentially future directions of research the author could undertake.

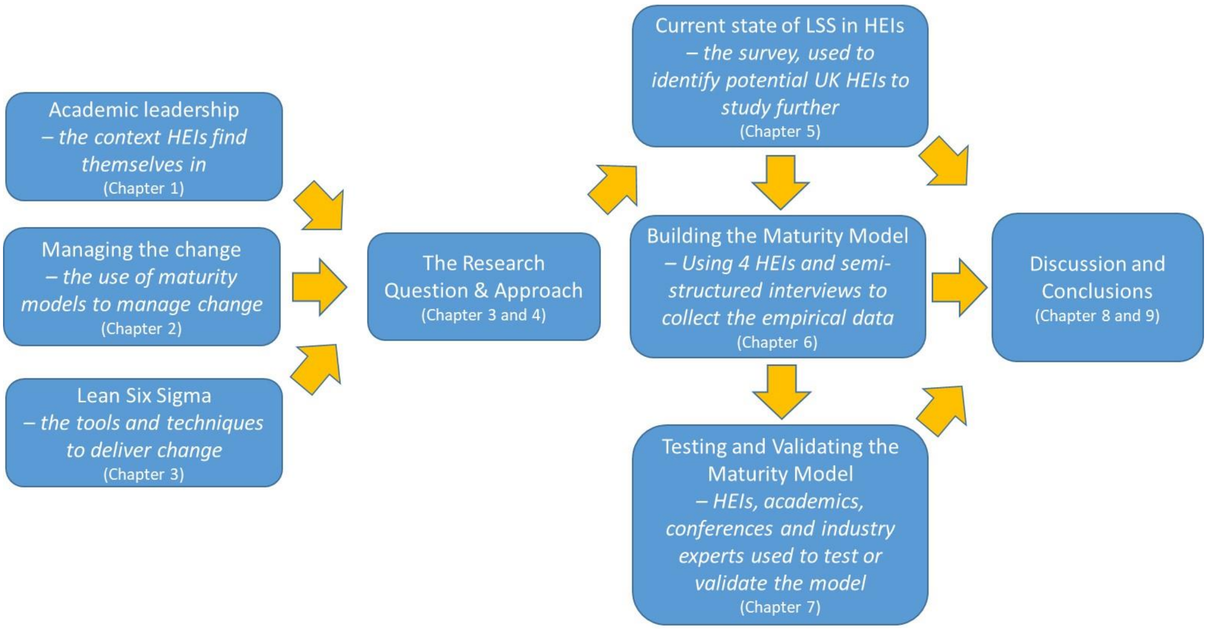


Figure 1: The structure of the authors' research

To support this work the author has already successfully published in three respected journals, produce six conference papers and contributed to four chapters of two books on the subject of Lean Six Sigma in higher education.

This thesis starts at the beginning of the 11th Century and the creation of the institutions we know as universities today…

Chapter 1: Higher Education Institutions – the need to change

1.1 What is a Higher Education Institution?

Western Universities, like cathedrals and parliaments, were unique creations in Europe during the Middle Ages. As the Papacy extended its reach across Europe, it became clear that the inward-looking monasteries and cathedral schools could not provide the training needed for the growing number of priests, missionaries and administrators within the church. These old schools and monasteries were not teaching the "new" ideas of philosophy, mathematics, medicine, and law. These new ideas were needed in the changing world the Papacy found itself in during the 11th century AD (Haskins 1923.) As the church encouraged these old inward looking institutions to become more outwards-looking and more "modern" in their approaches, new institutions, called universities, were born. Because these new institutions grew slowly and incrementally from around the 11th century, it has become almost impossible to identify exact birthdates of our oldest institutions, although this has never stopped one claiming an exact date. For example the University of Bologna is regarded as being the oldest university in continuous operation in the world. This Italian university is able to traces its originals back to 1088, although it didn't get its formal charter till 1158 (Janin 2008.)

As these institutions began to attract more like-minded individuals and grow, they needed to organise themselves to become more efficient and effective. Administration and infrastructure became the new competencies needed and thus specialisation and faculties were created. Slowly, physical infrastructure began to be created, individuals were housed together to form small communities, quadrangles or "campuses", and by the 13th century AD the "modern" university was born.

The 13th century "ivy league", "red brick" university leaders of that time would have been found in France and England, but student numbers were small, often driven down by famine, war and disease, and many still tied to the church in some form (Haskins 1923.) The new colonies founded in North America had to wait till the 1600s when a John Harvard opened his first college, and with help of other colonialists created the modern day North American higher education system. John Harvard opened his university doors only 15 years after landing in Plymouth but he still built it using medieval ideas around infrastructure, style and Christian values (Clark 1987.)

During this period of expansion, universities grew rapidly in size and number, all driven by a strong reason to exist and strong characters. These strong characters, whether they be settlers or Tudor kings, all had needs which could only be met through the new university machine. Of all the European academic institutions established by 1520, 70 still exist, centred mainly in France, Germany and the UK (Kerr 2001.) Besides faith, all were bound by a common language – initially Latin, which interestingly later became German and then, driven in part by the Tudor Kings and Queens, eventually English (Altbach 2010.)

By the 16 century AD, universities were recruiting teachers and researchers from around the western world and were starting to work beyond their own borders, becoming global institutions. The original founding values of these institutions began to flex and change to meet the needs of a "global" 16th century view of modern society. Even those countries not colonised by the western powers, such as Japan, Thailand and China, adopted initially the same western approaches to building centres of learning, having discovered the approach by sharing "academics" across borders (Altbach 2010.) This globalisation in universities could not be avoided and shows that it is not a new phenomenon. History reveals that when universities shut themselves off from economic and societal trends they become moribund and irrelevant. European universities, for example, ignored both the Renaissance and the Industrial Revolution and some ceased to be relevant. Indeed, the French Revolution swept away the notion of universities entirely due to their aristocratic view of the world, while von Humboldt had to reinvent the German university model in 1809 in order to save the institutions from becoming obsolete (Ben-David & Zloczower 1962). It is interesting to note that throughout history universities, originally set up to meet very specific demands, have needed to change as society around them changes. Institutions and systems do possess great latitude in how they deal with change and for example globalisation. Those who argue that there is just one model for higher education in the 21st century are clearly wrong. There never has been one model for building a successful university and probably never will be due to the varied nature of society (Altback 2010.)

The emergence of a global education exhibits itself in the form of a variety of multinational higher education initiatives - ranging from "twinning" programmes linking academic institutions or programmes in one country with counterparts in another, to universities in one country setting up branch campuses in another. As we have seen, the multi nationalisation of higher education has historic roots. During the colonial period, universities from Europe frequently set up branch institutions or sponsored new schools in the colonies. Examples include the British in Africa and Asia, Dutch institutions in what is now Indonesia, and French initiatives in Africa and Asia. Roman Catholic universities set up new institutions in Latin America and the Philippines; religious orders such as the Jesuits undertook multinational higher education initiatives. In the 19th century, American Protestant missionaries set up universities based on the USA model in Lebanon, Egypt and Turkey, among other places. The most interesting fact is that all of these new institutions and initiates were built on the medieval model of research, teaching and administration dating back to the 11th century AD, (Altback 2010.)

In over a thousand years universities have not really changed the way they are created, built, developed and globalise. However, the reasons for their existence are always different and unique to the university, and the time and society it finds itself in. Some were set up to provide engineers, some were set up to provide doctors, but all can trace their roots back to the time when philosophy, mathematics, medicine, law and faith ruled the day. This strong sense of history, worth, and almost entitlement to exist feeds into the culture and characteristics of HEI and drives much of the paradigm that is HEI in Western Europe today.

1.2 The changing model and characteristics of HEIs

In recent decades, a number of structural changes in society frequently described in terms such as *globalization* (although arguably not that new), the *information age*, and the rise of the *knowledge-based economy* are significantly transforming the way we acquire, disseminate, and transform knowledge (Posselt et al 2019, Daniel 2015, Goransson and Brundenius 2011.) These structural changes have resulted in knowledge production becoming closer and more directly linked to a country’s economic competitiveness. It could be argued that today’s knowledge and competencies play a more critical role than ever before in national economic growth and welfare creation of a given country or region (Sheikh 2017, Goransson and Brundenius 2011.) Thus institutions are being forced to change their paradigm regarding their role in society and the value they bring to their country (Sheikh 2017, Goransson and Brundenius 2011, Coccari and Javalgi 1995.) It has become a norm to refer to today's economy as a knowledge-based economy. Knowledge is increasingly becoming "the" resource, rather than "a" resource for wealth generation. It is widely recognized that knowledge is the critical asset for an individual as well as an organization to succeed in the increasingly competitive environment (Hersh and Merrow 2015, Cheng et al 2009.) Universities are there to serve as the platform to enable academics to speak of their knowledge, ideas and insights (Martin and Marion, 2005.) One of the common functions of a university is not to just create or share knowledge but also to serve as the knowledge repositories (Bhatt, 2001; Rowley, 2000). A trait going back to the Middle Ages, it has always been the practice in higher educational institutions to store all relevant documents contributed by in-house resources in the knowledge repository, library or the database (Cheng et al 2009.) Today, knowledge is considered as a strategic resource. It is inevitable that we create, store, share and transfer information and knowledge in a continuous flow and for the advancement of society. For more than a decade, academic institutions have struggled with how to manage the collective, digital intellectual output they produce. Clearly, due to technological advancement, it is easy to create and access digital material. Paradoxically, however, while there is potential for instantaneous access, all too often many materials are not usually made accessible to many users and they remain marooned in the institution's collection of disparate databases, computers and libraries (Daniel 2015, Jain 2011.)

The need for a university to be relevant in its current era is clear, however the responsiveness of universities, and of the university system, varies considerably among institutions and countries. Universities in many regions of Europe can currently be described as being in a state of crisis, which is caused by their inability to respond to the changing conditions they find themselves in. Thus, many historic universities in Europe currently suffer from some of the same maladies as their counterparts in developing countries: an acute lack of funding, problems with maintaining quality of research and education, and with providing knowledge and education that meet the changing needs of their surrounding society and economy (Sheikh 2017, Hersh and Merrow 2015, Goransson and Brundenius 2011.) Historically, universities have been shaped by, drawn their agenda from, and been responsible to the communities that founded them. Thus each generation has established a “social contract” between the university and the society it serves. If the institution is no longer serving the community and is not prepared to change, why should it exist? Back in 1999 Duderstadt was writing about the need for universities to change to meet the challenges of the coming 21st century. He identified 5 forces exerting pressure on USA institutions who have not changed their thinking for over 300 years.

The 5 forces were:

The age of knowledge. Western societies are evolving rapidly into a post-industrial, knowledge-based societies, with different needs, desires and expectations.

Demographic change. The U.S. population is becoming increasingly diverse with respect to race, ethnicity, and nationality. Women, minorities, and immigrants now account for roughly 85 percent of the growth in the labour force.

The globalization of the world. Whether through travel and communication, through the arts and culture, or through the internationalization of commerce, capital, and labour, the West is becoming increasingly linked with the global community – something universities have been at the heart of for hundreds of years without realising.

The post-Cold War world. For almost half a century, the driving force behind many of the major public investments in national infrastructure has been concern for national security, and protecting country boundaries; defence research funding drove many of the aims and objectives of university departments.

Market forces. Most people generally think of higher education as public enterprise, shaped by public policy and actions to serve a civic purpose. Yet market forces also act on colleges and universities. Society seeks services such as education and research. Academic institutions must compete for students, faculty, and resources if it is to survive and be relevant.

Selingo et al 2017 brought this list up to date by describing the shifting nature of academic institutions in the West after their financial collapse in early 2008 and creating five new models for building or changing universities:

The *“Sharing University.”* This model calls for campuses to link student and administrative services to realise efficiencies of scale and/or capitalize on the expertise of institutions. For example in the UK the University of South Wales Group links former Glamorgan and Newport Universities with local colleges in Cardiff and Merthyr Tydfil, along with the Royal Welsh College of Music. In Georgia, USA, the University System of Georgia has started the OneUSG initiative to develop and put in place streamlined policies, procedures, and technologies to benefit the 28 institutions within the system. Repetitive activities would be either automated or outsourced to a single institution within the system, enabling the other campuses to focus resources on more strategic activities. Critical to this approach is to go beyond customary back-office operations. By sharing activities such as career services, international recruitment, academic advising, legal affairs, and information security, university systems can decrease spending on administration to allow for reinvestment in the academic core.

The *“Entrepreneurial University.”* In this model, a university system differentiates its offerings at the institution level while coordinating at the system level to align educational investments with student and country economic needs. Individual institutions would specialize in areas such as undergraduate education, vo-cational training, or research, while degree programs and curricula would be centrally influenced through the definition of clear goals by the country and system. An example from the USA is the Western Governors University (WGU.) The WGU is a non-profit university established in 1997 by the governors of 19 US states to expand access to quality higher education to adult students with some college education or no degree. While this strategy stresses the idea of separate identities for each institution within a system, it also encourages cooperation: Given that specialisation may result in less competition, campuses could share faculty, departments, and academic and administrative resources as needed.

The “*Experiential University.”* The Experiential University integrates work experiences deeply into the curriculum, with students toggling between long stretches in the classroom and the work world related to their area of study. Most universities in the UK offer some form of work based learning and in the USA Co-ops, as they are known, are offered by a handful of institutions, including the University of Cincinnati and Georgia Tech. Under the co-op model, working is part and parcel of the undergraduate experience, making up anywhere from one-third to almost half of the time a student spends in school. This back-and-forth movement between theory and practice trains students’ brains differently from a traditional classroom-only curriculum, and gives employers a chance to evaluate students for potential fit before committing to hiring them for a full-time position. Because the work experiences in this model would be closely tied to the country’s economic development priorities—and its emerging job market—it would likely enjoy strong support in the legislature as well as from state economic development officials, who could use the system as another incentive to recruit new businesses to the country.

The *“Subscription University.”* This model reimagines college education as a platform for continual learning that provides students with multiple opportunities to develop both soft and critical technical skills, not just between the ages of 18 and 22, but whenever necessary. Within the UK, The Open University has been developing adult learning since 1971.

The *“Partnership University.”* This model extends the annual budgeting cycle across a window of several years, making it easier for institutions to plan and make strategic investments. It would guarantee a certain level of funding from the state over multiple years (absent extraordinary circumstances) in exchange for agreements from colleges for tuition limits, cost savings, increased collaboration and consolidation, and private fundraising. An example from the USA from early 2000 saw Maryland’s Effectiveness and Efficiency Initiative instituted a partnership model. In its first ten years, the initiative saved US$356 million at the 11-campus system, which froze tuition for three of those years. In return, lawmakers were generous with the system, giving it more money for cost increases attributed to rising enrolment. Integral to this partnership would be businesses and other employers, which would provide insights on curriculum, financial assistance for equipment, and other essential resources, as well as a steady stream of students to counter balance fluctuations in state appropriations.

It is interesting to note that these models have been created by the same system that is under discussion, i.e. academic institutions. However when one looks at current “universities” being created by society to fill their need in the 21st century it becomes difficult to map them against these 5 academic models. Today, students can study at the university of Motorola, Facebook, or Google in the USA, the Dyson Institute in the UK and the Matsushita Institute of Government and Management in Japan – all set up because the established university structure in their countries is not providing them with the engineers, scientists, managers and civil servants they need, not just for today but also for the future.

1.3 The future of academia

There is some evidence that HEI are embracing new technologies, for example the internet based learning management systems (LMS). These systems are designed to help HEI design and teach courses over the internet and are being heavily invested in by some universities especially in the USA and UK (Naveh et al 2010.) Although some will argue this is a response to the commercial competition brought to the table by large IT firms such as Google and Facebook, at least these institutions are trying to meet the needs of the modern student, business and government.

In addition to embracing new technology, HEI are becoming more commercially minded, especially through the creation of university “spinouts”. The rising number of universities involved in commercialisation activities such as licensing and spinning out has been well reported and documented in several surveys (Djokovic and Souitaris 2008.) In the UK a sharp rise of spinout creation between 1996 and 2001 has been reported, from an average of 95 per year in the four years up to the end of 2000 to the 175 created in 2001. The number of patents and licenses in the last decade has almost tripled as these new firms exploit commercially their “parents’” knowledge, technology and research results, developed within the university and historically rarely shared.

After new technologies and commercialisation, the final area where HEI are changing is in the way they measure performance. While corporations and public bureaucracies have attracted sociology-based organisational studies since their early modern development, higher education and research institutions as organisations remained for many years a rather unexplored topic (Paradeise and Thoenig 2013.) Academia is today a key issue on public agendas, on top of financial concerns, its performances are questioned with respect to their consequences for economic growth and social equality. The “quality” of a university’s output has arguably never mattered more than today.

It is a truism that universities form one of the oldest established institutions in the western world - far older, for example, than the public limited company or indeed the modern bureaucracy of the nation-state – and despite changes in form, function and fashion, the very latest universities retain some links, however tenuous, with their Medieval forebears. Equally, while bodies bearing the title university vary dramatically in terms of their structure, function and form, the very fact that they choose to label themselves as universities rather than any one of a number of other alternatives, for example; “colleges”, “institutions”, or “centres of learning”, suggests at least a desire to capture and share in that thousand year old tradition (Pollock and Cornford 2004.) On the one hand, then, it is tempting to see the university as something different or set apart from other organisations – as a unique institution in the modern world. On the other hand, it is also clear there are many similarities between universities and other organisations. As Geoffrey Lockwood put it, back in 1985, ‘universities as organisations face many problems common to most modern organisations’, including, for instance, the problems of co-ordinating resources, controlling costs, of stimulating and facilitating enterprise among staff, and so on. Thus, it might be argued, that since universities have problems common to a wide range of organisations, then the standard tools of contemporary organisational analysis, institutional management and modern management techniques such as Lean or Six Sigma can be similarly applied in all aspects of university life (Pollock and Cornford 2004.)

Table 2 below summarises the main characteristics of HEI when compared to other types of organisations, for example manufacturing or profit driven public sector organisations, and potentially helps the reader in understanding the challenges faced by leaders and change agents within HEIs when trying to deploy organisational change and implementing Lean Six Sigma and meet the challenges of the 21st century.

Reference	Characteristics for a typical profit driven organisation	Characteristics for a higher education organisation
Moore (2000) – discussing the difference in strategic objectives between profitable and non-profitable public sector organisations	- Enhance shareholder wealth is the main strategic driver - Revenues earned by sale of products and services - Measure of performance is financial bottom line - Find and exploit distinctive competence of firm by positioning it in product or service markets - Strategic triangle aligns financial performance, with organisation survival with social value	- Achieve social mission is the main strategic driver - Charitable contributions or tax appropriations / government funding - Measures of performance linked to efficiency and effectiveness of achieving the mission Finding better ways to achieve the mission - Strategic triangle does not link social value with financial performance or survival
Bosch et al (2011) – discussing the difference in corporate visual identity and marketing practices between profit, not for profit, manufacturing and service organisation	- Higher scores for corporate visual identity for both management characteristics and management instruments - Actively improve their corporate visual identity - Less open and dynamic towards sharing corporate visual identity data - Strong understanding of business strategy and how it links to corporate visual identity	- Poor scores for management characteristics and management instruments to develop and manage corporate visual identity - Spend little improving and changing their corporate visual identity - More open and dynamic to sharing data with public bodies and institutions - Poor understanding of the links between successfully delivering the mission and strategy and corporate visual identity
Soni et al (2000) – discussing the challenges faced when implementation quality initiatives	- Top management commitment drives success - Customer focus, driven by a need to meet and exceed customer satisfaction	- Complex organisations with a strong sense of traditional and culture - Vagueness in their educational mission statement

within the academic sector compared against Talib (2012) discussing the characteristics needed when implementing quality initiatives within the manufacturing and service sectors	- Strong human resource management, with broad training and development strategies - Full employee involvement, - A focus on process management and benchmarking against outside "best practice"	- Anarchy within the organisational governance - The structure is split into administrative and academic silos - Concept of academic freedom and the refusal to tolerate interference from outside sources Changes identify stakeholders and "clients" of the organisations
Duarte and Martins (2013) reviewing the different maturity models used within education to drive improvement in information management and data		HEI are complex with multiple power decision centres combined with a wide range of interests - Classed as Professional Bureaucracies group, not centralised, with two parallel often contradictory hierarchies. - One of complex work, directed upwards, democratically informal in workflows and communication, developed by professionals within their own silos - The other a standardised systematic logistical support, directed downwards, more like a Machine Bureaucracies, with work flows directed and controlled in a formal manner

Table 2: Differences between HEI and other types of organisational structures

These differences in characteristics between HEI and profit driven organisations mean that any leader or change agent trying to transfer one management approach or philosophy, such a continuous improvement or Lean Six Sigma from the mainstream into HEI will need to adapt their approach. In addition they will need to recognise that within HEI itself, two contradicting paradigms exist between the informal professional bureaucracies of the academic staff and the formal machine bureaucracies of the administrative functions (Duarte and Martins 2013.)

Whichever approach, model, or culture universities strive to adopt, at the heart of any university is its reason for existence, and its need to maintain its social contract with society. As society changes, a university needs to change with it, and its ability to successfully manage its own change is something within its own power – the role of today's academic leaders has never been more important, and the role of academic leadership never more crucial.

1.4 Academic Leadership

In a globalised world, all countries are trying to educate their people to enable their nation to prosper, by using 'world class universities': the term used by the USA and UK to help distinguish between the great and the good. These universities have recognised that today's globalisation is creating a series of trends that academic leaders must address. These trends include the belief that education no longer has any borders: students can take classes anywhere in the world; technology is advancing in ways unforeseen by many institutions, including how their students and staff wish to interact with the institution through it; there is more choice which has led the student to become a "customer" or "consumer" of learning, resulting in institutions competing not just locally for talent but internationally; social welfare has weakened, and institutions need to raise more funds privately than ever before; and finally, universities are becoming more (not less) de-centralised, with more decisions being made at the local level. These trends require the Dean or Chair of the university to think about "organisation mission, unit productivity, and individual performance," (Mehmood et al 2012, Shahmandi et al 2011,) and begin to start to define a more relevant leadership term for these institutions that reflects these trends: Academic Leadership.

Academic leadership, a relatively new field in leadership, currently does not have an established respected journal of its own and articles and research appear in a variety of sources, for example: The Leadership Quarterly, The Organisation Development Journal, Management Decision, Industrial and Commercial Training, International Journal for Educational Management, and Advanced Management Journal. Here in the UK, the Leadership Foundation for Higher Education self-publishes a series of research reports on Academic Leadership and literature reviews on the subject. Similar institutions exist in places like

Australia and the Far East. Much of the research outside of these organisations and journals is published through government or non-academic bodies. The author has reviewed the current academic leadership literature from the last ten years across a variety of management and leadership journals and mapped the findings against the more established view of leadership from authors such as Drucker (2004), Kotter (1990) and Collins (2001). It is worth noting that currently there are no high quality journals dedicated solely to academic leadership with articles published in a variety of educational research journals and a wider than normal review was required to support this work.

The end of this chapter includes the authors' view on Academic Leadership and a definition to be used in future chapters and literature reviews.

1.5 Academic Leadership Literature Review: The Special or Simple Context

There is no denying that academic institutions are facing many challenges in today's globalised educational world, with public funding cuts, commercially driven credit based curriculums, accountability, quality assurance, the student as customer, and performance based management, (Laing and Laing 2011, Kurniawan and Puspitaningtyas 2013.) In addition, traditional management language such as "excellent academic performance", "organise effectively", "efficiently", "sustainably", and "accountability" have sneaked into the vocabulary of academic leaders, (Kurniawan and Puspitaningtyas 2013.)

Universities are expected to be efficient and cost effective, and flexible in their offerings, while being responsive to the student expectations (Joyce and O'Boyle 2013.) These tensions have resulted in resentment from academic staff who see their autonomy being reduced as more commercial methods are deployed in academia; for example the recent trend for mass online education by several US institutions. The emergence of the concept of the "knowledge economy" and its perceived importance in economic growth has increasingly challenged the university sector to provide a skilled workforce that can service such requirements (Joyce and O'Boyle 2013.) Leading universities present unique challenges, because of the organisations' complexity, their multiple goals, and traditional values. Academic leaders are often chosen from the pool of academics, based on their academic capacity; whereas in industry often the managers appointed not on their technical expertise but on their managerial capacity. (Kurniawan and Puspitaningtyas 2013.) Are institutions, therefore, limiting the talent available and re-enforcing behaviours they are trying to change? Add to this the challenges identified by Jones (2013) when he describes academic work as becoming increasingly fragmented. The horizontal fragmentation of the academic profession into disciplinary tribes has been accompanied by the increasing role played by student affairs, and educational development bodies outside the academic institutions completing complementary or competing academic work. This is coupled with the vertical fragmentation within universities, with the increased use of contract lecturers, researchers and outsiders such as management consultants as lecturers.

According to Ramsden et al (2007), in higher education, variation in forms of leadership is experienced by lecturers and heads of departments, with an evident persistent dichotomy between authoritarian, self-interested control on one side and a collaborative but firm management on the other. Surveys of academic staff across the developed world have illustrated the potential for leadership of the Dean or Chair to improve the quality of university activity. This is no different to the claims made in industrial leadership about the variety of styles and that good leadership equates to good results. But what is good academic leadership?

Academic Leadership research has centred on senior academic staff who have a formal leadership role (Laing and Laing 2011.) This approach is consistent with traditional views of leadership, and emphasises a top down approach by a single individual. Laing and Laing (2011) argue that the unique nature of universities mean a “distributed” form of leadership is required, characterised by a democratic, shared, collaborative style of leadership. Two models exist: one where a small group of individuals share a common approach; and one where a network of diverse individuals’ form, where their expertise and quality is called upon as required by the network. It is clear that, whichever model prevails, the autonomy driven by academic institutions will lend itself to a more distributed model and definition of leadership. These trends and context outlined above require the Dean or Chair to think about “organisation mission, unit productivity, and individual performance” (Shahmandi et al 2011), and start to help define the characteristics required by an academic leader.

1.6 What are the characteristics of an effective academic leader – Special or Simple?

An academic leader needs to be someone with a broad vision of their field, and who has the power to bring the change in their field. They need to have the ability and capacity to release and engage human potential in the pursuit of a common cause. They must sustain change and this energy must come from within the academic unit, driven by the vision of its leaders (Mehood et al 2012.)

However, sustaining change and releasing human potential is challenging in academic institutions. Academic units and institutions are particularly challenged in achieving unity around a focused mission because of the independent mind-set that pervades academic culture: academic leadership is therefore a personal, face-to-face concept. Thus the strategic planning process becomes an opportunity to mobilize and bring together stakeholders in pursuit of a mission. Supporting this, Mehood et al (2012) and Kurniawan and Puspitaningtyas (2013) believe that the primary role of academic leaders is to create a vision of the future that can be understood by the individual, support the "idea of spontaneity" and allow the freedom to experiment within their organisation. Thus sustaining change and releasing the human potential.

This is similar to traditional views of leadership where the desire to take risks creates competitive advantage. One way an HEI can take risks is to give power to key stakeholders within schools through the building of strong communication networks. Through these networks an academic leader can give priority to academic excellence, both in research and teaching, and this can be then measured both internally and external to drive continuous improvement. In this way academic leaders can create a culture of learning through collaboration, deploy continuous improvement through change and further release the human potential within their institutions, A key function of academic leadership is to use these networks to create a pleasant teaching and research environment for faculty and thus provide students with a quality of education they deserve, (Kurniawan and Puspitaningtyas 2013, Shahmandi et al 2011.)

Academic leaders need to think big, beyond their institution, literally to promulgate a world-wide view of their institution, (Shahmandi et al 2013). Specifically they need to: work as an equal, have a long term orientation, facilitate change, create learning systems, motivate employees to excel, lead and participate in teams, direct the foreign employment cycle, understand their own values and assumptions, accurately profile the culture of others, and demonstrate knowledge and respect for other countries and cultures. Thus academic leaders who lack the knowledge skills and behaviours required to lead global institutions will have a negative impact on the quality of leadership across their institution, (Kurniawan and Puspitaningtyas 2013, Shahmandi et al 2013, Shahmandi et al 2011.)

At the heart of academic leadership, and probably the key uniqueness of academic leadership, are specific academic values and identities that need creating, developing and deploying within a particular line in scholarship rather than directing and controlling at a micro and macro level academic work, (Joyce and O'Boyle 2013.) Bryman (2009) identified different leadership behaviours depending on the level within the university. Specifically Bryman identified two levels: the first list relates to effective leaders at departmental/college level, the second relating to more senior institutional leaders.

Within the department/college level, academic leaders require a clear sense of direction and should prepare and manage their department to meet that direction. They need to be considerate, treat staff with integrity and foster supportive environments for staff to engage in research and teaching. Change should not just be imposed, and staff need to be allowed to participate in key decisions, with leaders encouraging open communication. The departmental leader needs to act as a role model; creating a positive work atmosphere, providing feedback on performance, and adjusting workloads to stimulate scholarship and research.

Within the instructional level of leadership, academic leaders need to proactively pursue the university mission, with an emphasis on a visionary approach that guides and provides focus for what the leader seeks to achieve. They need to be seen to be internally focused, to be drawing inspiration from the universities participants while balancing the need to be externally focused, networking with a variety of constituencies and re-enforcing within those constituencies the direction the university is taking. It is clear they will need personal integrity and act in a way which entails consultation with others and not sealing the leaders off from the university at large. They need to be entrepreneurial and a risk taker, not underpinning pre-existing organisation culture but being flexible in the approach to leadership. They need to design structures to support change and to influence the organisational culture and values to support the change. The key word here outlined by Bryman (2009) is change and the way he has linked academic leadership to the management of change – a very traditional view of leadership.

1.7 The overlap between Academic Leadership and "Traditional" Leadership literature

Within the literature reviewed above, there appears initially to be a significant overlap between the language used by academic leadership journals and traditional articles on leadership. Figure 1 below demonstrates this overlap but also the unique characteristics of both fields. To construct figure 1, ten "popular" leadership references were chosen from the Harvard Business press and compared to ten recent research papers from a variety of journals covering academic leadership. Analysing the language used in all 20 references it becomes possible to create a list of unique competencies, knowledge, skills and behaviours required by academic leaders, and those which they share with their traditional leadership colleagues:

Figure 2: The overlap between traditional leadership and academic leadership

Sources supporting this diagram:

Leadership:

Goleman (1996), Drucker (2004). Kotter (1990), Heifetz & Laurie (1997), Goffee & Jones (2006), Bennis & Thomas (2002) Collins (2001), Rooke & Torbet (2005), George et al (2007) Anacona et al (2007)

Academic Leadership:

Bolden et al (2012), Jones et al (2011), Mcfarlane (2011), Ngui et al (2010), Gibbs et al (2009), Goodhall (2009), Breakwell & Tyherleigh (2008), Bryman (2007), Spendlove (2007)

It is interesting to note what is outside the central circle. For example, traditional leadership avoids the management requirements of dealing with complexity, where academic research avoids the term emotional intelligence. Many of the unique characteristics under academic leadership reflect the uniqueness faced by academic institutions in dealing with this fragmented, networked based, islands of excellence structures. This appears to support the view that perhaps academic leadership in itself is not that different to traditional leadership, but the context it finds itself in is unique.

1.8 Current threads of academic leadership – Motivation and Effectiveness

It is clear that leadership in academia is not as widely researched as other areas of leadership. Siddique et al (2011) believes that, due to the characteristics of academia relating to networks and decentralised power bases, much of the research has focused on motivation and effectiveness - a rather narrow view of leadership.

Motivation in academia is not solely linked to salary, promotion or financial rewards (due to salary being linked to experience and salary sliding scales,) but when faculty staff have the opportunity to learn new skills, show helpfulness, feel a sense of being appreciated, and most importantly, have professional autonomy, (Daumiller et al 2020, Siddique et al 2011). Siddique et al (2011) acknowledges if faculty staff have the freedom to make decisions and are given autonomy, then they feel more satisfied with their jobs and put more effort into accomplishing their goals. Thus the role of leadership in academia is to prevent and eliminate dis-satisfiers, whether internal or external, which will adversely affect the faculty member’s autonomy. The reason for “satisfying” these “egos” is simply an economic one. Motivated faculty members can earn international recognition, a good image world-wide, and with this reputation - or ‘brand’ - institutions can attract the brightest students from all over the world, they can attract large amounts of funding for research and create a strong influencing culture in their field. This, in turn, maintains the pressure for autonomy, creating an almost perfect self-perpetuating process (Daumiller et al 2020, Watt and Richardson 2020, Hanaysha and Majid 2018, Siddique et al 2011.)

Motivation and specifically effectiveness (according to Hanaysha and Majid 2018 and earlier Siddique et al 2011) has also had little academic research. Few researchers believe that outcomes, results, or accomplishments of organisational goals can be a criterion to measure organisational effectiveness in the academic sector. An alternative to the “Goal” driven approach is the “Resource Grab”. Organisational effectiveness is measured by how an institution interacts with its surroundings and effectively utilises the resources available, and “grabs” resources from others, if required. A link is assumed that this acquisition of talent and resource is a major contributor to achieving its goals. Recent forms of measuring effectiveness treats the student as a customer, and that universities should be tracking the development and education of its students. Ultimately the best measure, derived by Siddique et al (2011) regarding effectiveness, is that both student and teacher satisfaction are measured – but again this feels old fashioned and narrow (Daumiller et al 2020, Watt and Richardson 2020, Hanaysha and Majid 2018, Siddique et al 2011.)

Akhter and Sharif (2012) conducted research into student expectations of their teachers and academic leaders as a way of measuring effectiveness and identified, from a sample of 280 students across seven departments, the following important qualities in academic staff across all levels within the hierarchy:

- Communication
- Competency
- Honest and trustworthy
- Humanism
- Intelligence
- Judgement
- Motivation

- Supportive
- Visionary

It is interesting to note that words such as “humanism”, “intelligence” and “judgement” are unlikely to appear in a similar survey of staff within a traditional leadership survey and this again underpins the differences and the context academic leaders find themselves in.

Ramsden et al (2007) developed a structural model which they believed re-enforced the concept that good academic leadership leads to good teaching which leads to good student satisfaction metrics. Siddique et al (2011) concludes that an academic leader should lead in three areas: Research, Education and Administration, and that academic leadership should utilise Motivation and Effectiveness measurements to achieve their aims. The requirement to meet specific needs of the academic sector has led academics to research into a theory of a distributed model of leadership that tries to balance the needs and wishes of the internal stakeholders with those pressures placed on the institution from external factors. It appears that those leaders who excel in this field have been able to balance these sometimes conflicting and opposing forces, and harness them to create something special and exceptional. Finally Daumiller et al 2020 define motivation in HEI as *“the overall process that gives rise to faculty members initiating, sustaining and regulating goal directed behaviours”.*

Within all the research highlighted above, managing change is still part of the picture and helps explain why some universities are looking to industry for solutions to their cost, delivery and quality problems. If those who have yet to venture outside were to look externally at organisations delivering change, they would see for the last 30 years industry has wrestled with similar cost, delivery and quality challenges, although in a different context, and has developed strategies such as Lean, Six Sigma and more recently Lean Six Sigma to meet these challenges and deliver exceptional value to consumers.

1.9 Conclusion: Academic Leadership defined – the author's perspective

It is evident that academia has unique challenges when it comes to leadership and the institutions' history drives its current behaviour and culture. Academic Leadership is a wide term, currently poorly defined, reflecting both institutional and departmental leadership qualities. Academic leaders can come from, and be translated into, leaders with positional power, leaders with expertise power, leaders with networking power and leaders with personality power, but this is no different from any other industry.

Moving forward the author defines an academic leader as someone in a position to identify the need to change, to allocate resources to change, to actively manage and facilitate the change, to monitor and motivate during the change, and finally deliver change within higher education, both at the institutional level and the departmental/college level.

An example could be a Dean of a school, when realising that they are under pressure to improve performance, cut costs, and attract more research opportunities, deciding to utilise Lean Six Sigma tools and techniques to fundamentally change the department both culturally and physically.

This definition relates closest to Kotter's (2002) and Collin's (2001) definition of Leadership – managing change not managing complexity, and level 5 leadership respectively. The similarities of academic leadership and traditional leadership are such that it is the author's view that universities can recruit exceptional "outsiders" to run institutions and that, at its heart, academic leadership is no different from traditional leadership. However, there is something unique in academia. It is this context, the academic environment, the culture, the paradigm, and the way they have evolved over time that is unique and special and this uniqueness is what makes academia both challenging but also immensely rewarding for leaders.

Thus the role of academic leaders is to manage change, but how does one deliver change? Chapter 2 explores the approaches often taken by leaders to deliver change through the introduction of organisational maturity models.

Chapter 2: Delivering change through the use of frameworks and maturity models

2.1 The history of maturity models and frameworks in business thinking

Since the Software Engineering Institute launched its Capability Maturity Matrix over 20 years ago, hundreds of maturity models have appeared and been proposed by researchers and practitioners across a variety of industries and applications, (Sun et al 2009.) At the centre of all of these models is the desire to think of the world as a process, with a purpose, inputs and outputs and methods of measuring the outputs and inputs against the desired purpose, (Sun et al 2009.) In the world of process improvement an array of maturity models have been proposed, with recent literature reporting an increasing academic interest in maturity models and the way they are designed, developed and utilised, (Poppelbulb and Roglinger 2011.) Maturity models are based on the assumption of predictable patterns of evolution. These patterns within maturity models usually include a sequence of stages or steps that form a logical path from an initial starting state to a defined maturity, (Poppelbulb and Roglinger 2011.) This is why maturity models are also often called stages of growth, stage models, or stage theories, (Poppelbulb and Roglinger 2011.) Maturity models are different from change management models. Maturity models are based on evolution, whereas change is often revolution. Early examples of maturity models include the “economic growth model” (Kuznets 1965,) the “process of IT development” (Nolan 1973) and the “quality management model” (Crosby 1980.)

Maturity models are not without their limitations or critics. Table 3 below summarises the concerns expressed by six research papers over a 30 year period with respect to the development and use of maturity models.

Reference:	**Potential Limitations of Maturity Models:**
Herbsleb, and Goldenson, (1996)	• Adopting a CMM approach can cause added bureaucracy • Maturity models tend to be incomplete or worse flawed in design • Change is not necessary measured objectively, depending on the characteristic under study • Often there is a lack of rigorous testing and representativeness, since only successfully companies publish case studies

Visconti and Cook (1998)	• Broad maturity levels provide limited value, as it provides incomplete information about which key practices are satisfied and which are not • There is no framework for developing maturity models which has been rigorously tested.
Rosemann and De Bruin (2005)	• Often the maturity model has only one dimension of measuring maturity • There is a significant lack of application for models describe in literature • There is difficulty in using objective measures to measure certain problems • Readiness for change can be too complex to measure objectively • Often models are missing rigour in model development and lack empirical testing
Mettler (2009)	• Although gaps are identified in models they rarely explaining how to bridge the gap • Often they contain overemphasis on process and disregard peoples capabilities – extensive model bureaucracy can actually reduce individual innovation and creativity • Often maturity models have poor theoretical basis, using only “good practice” or “success factors” derived from favourable project results • There is a lack of testing and empirical evidence
Tarhan et al 2016	• Despite the high number and variety of models available to leaders in other domains the use of business process maturity models has still not gained widespread acceptance in practice or in research. • There is only a handful of studies in the literature examining the adoption of these models and their achieved benefits • Recent surveys report a decline in the attention shown by industry to certain maturity models, such as the scarcity of empirical. This lack of empirical evidence the validity and usefulness of the model is limiting the prescriptive properties of the models, impeding their application. • There is a lack of a clear distinction between the maturity model itself and the assessment model that is applied to evaluate the level of maturity against the model
Felchet al (2019)	• The CMM model appears to be the only standard model noticed within academic research • Large numbers of models exist that do not meet the needs of their intended audiences • Difficult for leaders to select the most appropriate model from the selection available since little empirical evidence exists to help the decision maker

Table 3: Limitations of maturity models

2.2 The use of maturity models

Maturity models are often applied to the “as is” state to assess an organisation’s current position and also to develop a plan for how to move forward through the model, (Tarhan et al 2016, Mettler (2009), Rummler and Brache 1990.) The aim and desire being for most maturity models is to diagnose and eliminate deficient capabilities. Rummler and Brache (1990) referred to such tools as engines for continuous improving systems, and road maps for organisations.

Thus, the notion of maturity has been proposed as a way to evaluate the state of being, with maturity typically defined as: “complete perfect” or “ready” and the “fullness of perfection of growth or development”, (De Bruin and Rosemann 2005.) Maturity therefore is a useful form of measurement to evaluate a product or process’s capability, **(**Tarhan et al 2016, De Bruin and Rosemann 2005, Visconti and Cook 1998.) De Bruin and Rosemann (2005) gave examples of what maturity could be described as, for the extremes of both low maturity and high maturity:

Low maturity in a capability maturity matrix process is:

- Uncoordinated isolated projects, low business process management (BPM) skills, limited personal involvement, reactive, manual, internally focused, naïve and static

High maturity in a capability maturity matrix process as:

- Coordinated BPM activity, high BPM expertise, organisational wide coverage, proactive, meaningful automation, extended organisation, efficient resourcing, comprehensive understanding, innovative

The desire to diagnose and eliminate deficient capabilities became a driver for the creation and deployment of maturity models, (Tarhan et al 2016, Rummler and Brache 1990.).

As for their application in practice, maturity models are expected to disclose current and desirable maturity levels, and to include respective improvement measures. The intention is to diagnose and eliminate deficient capabilities and be a tool for continuous improvement, (Tarhan et al 2016, Poppelbulb and

Roglinger 2011, Rosemann and De Bruin 2005.) Typically to help in this application, a maturity model can be categorised, although not exclusively, into three types: (Poppelbulb and Roglinger 2011):

Type 1: Descriptive: Use for “as is” assessment where the current capabilities for the entity under study are investigated and assessed with respect to given criteria. Used as a diagnostic tool, the findings are often shared with relevant stake holders and used to drive change and develop maturity. Maturity models following a descriptive purpose of use need to propose assessment criteria for each maturity level and available level of granularity, which must be repeatable. The assessment methodology needs to feature a procedure model that guides model users through maturity assessments by elaborating on the assessment steps, their interplay, and particularly on how to elicit the criteria’s values. Results from an assessment need to be correct, accurate, and repeatable if they are to be used in a type 3 comparative manner – see type 3 below.

Type 2: Prescriptive: A maturity model is describe as Prescriptive if its purpose is to indicate how to identify desirable maturity levels and provide guidance on improvement measures – often described as a road map or future state map. Maturity models following a prescriptive purpose of use need to include improvement measures for each maturity level and available level of granularity in the sense of what good looks like, or best practices. This target driven approach helps the reader in understanding what good looks like and in addition discloses potential for improvement.

Type 3: Comparative: Any model, descriptive or prescriptive, which allows for internal or external benchmarking is known as a comparative maturity model. Given sufficient large data sets maturity levels of different entities can be study and compared. For example creating “best in class”. These comparative models then become the generators of future descriptive and prescriptive design principles and are used as management tools to drive improvement behaviour in organisations.

Examples demonstrating the three types of model are the BPM Maturity Model (BPMMM), proposed by Rosemann et al. (2006), the Business Process Maturity Model (BPMM), presented by the Open Management Group (Weber et al. 2008,) and Hammer's (2007) Process and Enterprise Maturity Model (PEMM.) Table 4 below highlights how these models meet the 3 types of maturity model design criteria and are regarded by the author as excellent examples due to their ability to operate in more than one category or type of maturity model:

BPM Maturity Model (BPMMM)	**OMG Business Process Maturity Model (BPMM)**	**Process and Enterprise Maturity Model (PEMM)**
Descriptive - contains an "as-is assessment" Prescriptive - encourages the development of a roadmap for improvement Comparative – allows for benchmarking against industry standards and other organizations	Descriptive – allows for the evaluating the capability of processes and suppliers, Prescriptive - Guides business process improvement programs, and assesses risk for developing and deploying enterprise applications Comparative – allows for benchmarking	Descriptive - contains an assessment of process maturity and enterprise readiness for process-based transformation Prescriptive - determination of where and how to improve

Table 4: Three examples of Descriptive, Prescriptive and Comparable CMMs

Poppelbulb and Roglinger (2011) suggest there are 4 basic areas which need to be considered in every capability maturity matrix design, along with specific considerations depending on whether you are trying to develop a descriptive and / or prescriptive model – see table 5 below:

Group	**Design**	**Principles**
BASIC	1.1	Basic information: a) Application domain and prerequisites for applicability b) Purpose of use

		c) Target group d) Class of entities under investigation e) Differentiation from related maturity models f) Design process and extent of empirical validation
	1.2	Definition of central constructs related to maturity and maturation: a) Maturity and dimensions of maturity b) Maturity levels and maturation paths c) Available levels of granularity of maturation d) Underpinning theoretical foundations with respect to evolution and change
	1.3	Definition of central constructs related to the application domain
	1.4	Target group-oriented documentation
DESCRIPTIVE	2.1 2.2	Intersubjective verifiable criteria for each maturity level and level of granularity Target group-oriented assessment methodology: a) Procedure model b) Advice on the assessment of criteria c) Advice on the adaptation and configuration of criteria d) Expert knowledge from previous application
PRESCRIPTIVE	3.1 3.2	Improvement measures for each maturity level and level of granularity Decision calculus for selecting improvement measures: a) Explication of relevant objectives b) Explication of relevant factors of influence c) Distinction between an external reporting and an internal improvement perspective
	3.3	Target group-oriented decision methodology a) Procedure model b) Advice on the assessment of variables c) Advice on the concretization and adaption of the improvement measures d) Advice on the adaptation and configuration of the decision calculus e) Expert knowledge from previous application Table 1. A framework of general design principles for maturity models

Table 5: Design considerations when constructing a capability maturity model

Maturity models have been applied to a variety of applications, below are some examples of where and how they have been designed, developed and deployed. The three main types of maturity models chosen below reflect the interests of the author and his area of research: leadership - specifically academic leadership; process improvement and Lean Six Sigma – the main approach used in this research to manage change. The maturity models are then summarised and tabulated at the end of this chapter with their advantages and disadvantages along with a link to the author's own final five characteristics of capability maturity model design (which are described later in this chapter.)

2.3 Leadership Maturity Models

Maturity models can not only be applied to leadership but also the process of creating concepts such as leadership, (Graeff 1997.) The original writers of situation leadership (Hersey and Blanchard 1977) in the 1980s developed from a 1-dimensional view of leadership to a multiple dimensional view, combined with levels of maturity, looking at both "ability" and "willingness" of leaders. In 1985 they completely re-wrote their model, and renamed their dimensions from "ability" and "willingness," to "commitment" and "competence". In 1988 Hersey and Blanchard's 5th edition of their book replaced the term maturity to readiness and expanded some of the terms within their model; the idea being that not just concepts but the design of such concepts can mature and change over the decades just like product, processes, or organisations, (Graeff 1997.)

Earthy, in 1997, used the capability maturity matrix approach to develop a model to understand culture and human centeredness in organisations, with the aim of creating better leaders within those organisations. Utilising levels, rather than dimensions, Earthy categorised human centeredness as X, A, B, C, D and E, where X is not recognised, A is low maturity or little human recognition, and E mature or human systems are institutionalised. Moving through the levels, from say A to B, is a major cultural change, similar to a craft based traditional engineering outlook to a systems based approach, (Earthy 1997).

Arguably one of the most quoted leadership and change management maturity models of the last twenty years is that of Jim Collins' level 5 leadership (Collins 2001.) Over a five year period Collins study successful CEOs in international businesses and developed a relationship between performance and leadership style. His research went on to order these relationships into what Collins describe as a leadership maturity model, (Collins 2001.) The aim of this was to allow leaders the ability to benchmark themselves and their leadership styles against his leadership maturity model and to consider the knowledge skills and behaviours they would need to become truly exceptional level 5 leaders.

Collins leadership maturity model is built over 5 levels:

Level 5 Executive: Builds enduring greatness through a paradoxical combination of personal humility plus professional will. One example is Berkshire Hathaway's Warren Buffet. He gives autonomy and praise to those surrounding him. He recently put in place a succession plan. And in 2008, although Berkshire stock lost 32% of its value, it still beat the S&P 500. Instead of spinning this as a victory, Buffett shouldered responsibility, saying, "I made some errors of omission, sucking my thumb when new facts came in that should have caused me to re-examine my thinking and promptly take action." A second level 5 example could be taken from steel refiner Nucor, CEO Dan DiMicco has a firm grasp on reality, facing the brutal facts of an economic downturn instead of being a mindless cheerleader for his industry. The downturn, however, hasn't changed DiMicco's view that the most important people are the employees who do the day-to-day work, not the executives in the front office. Executives are the first to take a pay cut during a downturn, and because of the company's "pain-sharing" plan, the company claims that not a single employee has ever been laid off because of not having enough work.

Level 4 Effective Leader: Catalyses commitment to and vigorous pursuit of a clear and compelling vision; stimulates the group to high performance standards. An example of a level 4 leader could be found at Strayer, their CEO Robert Silberman oversaw the company's rapid expansion 2001, and the stock jumped 650% during his first nine years at the helm. However, Silberman's doesn't make the level 5 status due to blaming a 20% drop in customer enrolment on bad press;something a level 5 leader would not do. A second example of level 4 leadership could be Netflix CEO Reed Hastings. Netflix is one of the most successful stock holdings, appreciating in value more than 40% annually since going public. Hastings has arguably executed fabulously, expanding into ever more homes while forcing one-time market leader Blockbuster into bankruptcy. However, Netflix is in a very critical stage for growth and it needs to balance plans for international expansion against bandwidth issues and rising prices for content; and there are concerns that without Hastings the company will struggle to navigate these challenges. A final example could be the late Steve Jobs of Apple. His recent departure has Apple's future literally depending on whether Jobs has produced enduring greatness. Collins himself inadvertently made the case for

Jobs' Level 4 status while trying to praise him. In a 2009 interview, Collins stated, "Steve Jobs is an industrial Beethoven. I think that ... the iPhone is the Seventh Symphony." Taking the comparison a step further, the musical genius of Beethoven wasn't something that could be easily replaced or replicated. The same could be said of Jobs (Collins 2009.)

The remaining three levels of Collins model reflect badly on modern day leaders, in essence categorising them as mere upgraded managers, potentially competent at managing the status quo but poorly equipped to deliver change, hence no examples are included.

Level 3 Competent Manager: Organizes people and resources toward the effective and efficient pursuit of predetermined objectives. Typically these are individuals who have been promoted “beyond” their leadership ability, often based on experience and years’ service to the company.

Level 2 Contributing Team Member: Contributes to the achievement of group objectives; works effectively with others in a group setting. Sometimes referred to negatively as “management by committee”, these leaders will often hide behind the wider senior leadership group and fail to make decisions at key points in the strategic cycle.

Level 1 Highly Capable Individual: Makes productive contributions through talent, knowledge, skills, and good work habits. The lowest level of leadership maturity the highly capable individual works hard but lacks the knowledge, skills, behaviours and competencies to move their business forward.

Prosci (2007) developed what he called a change management maturity model, built around evolution not revolution dimensions. Prosci model is more akin to Collins’ (1991) 5 levels of leadership rather than a traditional change management approach. Prosci 5 levels of change management maturity are:

Level 1: Awareness of the need for change

Level 2: Desire to support the change

Level 3: Knowledge of how to change

Level 4: Ability to demonstrate skills and behaviours needed

Level 5: Re-enforcement to make the change stick.

However this was not felt sufficiently detailed enough for supporting the change management in large capital projects, specifically in the construction industry, and a new maturity model was developed, (Sun et al 2009.) This new change management maturity model included the mapping on a traditional capability maturity model's key process areas, or dimensions, against maturity levels. This new model, with its added level of complexity, had the aim of assessing companies on their organisational learning progress measured through the maturity model, (Sun et al 2009.) Figure 3 below demonstrates a simplified view of Sun et al (2009) change management maturity model for leaders in the construction sector:

Maturity Levels Key Process Levels/dimensions:	Ad-hoc change	Maturity Levels	Informal change	Systematic change	Integrated change	Continuous improvement in change
Project Management Process	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Risk management	etc					
Communication						
Management Information						
Collaboration						
Leadership						

Figure 3: Example change management maturity model

By combining the levels of maturity with the key dimensions or processes of change management Sun et al (2009) generated 36 potential "scenarios" to map organisations against. To create these 36 scenarios, sometimes called descriptors, which can now be used to measure maturity in a multi-dimensional manner, surveys and interviews were used with relevant stakeholders.

Chen et al in 2010 describe a leadership maturity model using Supply and Demand or “Push vs Pull” concepts. Chen created “dimensions”, or key headings in his model, including dimensions he named as Human Capital, Structural Power and Organisational Support. Each of these dimensions feed into either supply Side Leadership (pushing concepts, decisions and change onto the organisation by the leadership team) or Demand Side Leadership (pulling concepts, responding to the need for new concepts, decision and change placed on the leadership team.)

Maturity models are not just restricted to abstract concepts such as leadership. The need for a methodical approach to process improvement has been successfully addressed within the software industry over the last twenty years to support change management in a variety of industries from manufacturing to construction, (Sun et al 2009.) Often built on the founding design principles of the original capability maturity model from the Software Engineering Institute, these maturity models are usually created to give a path of improvements or recommendations for organisations to increase their process and project capability (Sun et al 2009.)

2.4 Process Improvement Maturity Models

Organisations often view business processes as strategic assets. These processes are highly integrated and, like any strategic assets require investment if they are to mature and deliver on their full potential, (Tarhan et al 2016, Dijkman et al., 2015,; Skrinjar, Bosilj-Vuksic & Stemberger, 2008, Lockamy and McCormack 2004, McCormack & Johnson, 2001, Herbsleb, and Goldenson, 1996.) Thus process maturity as a term is becoming more widely used in corporations and there is a well-documented link between organisational success and process maturity (Tarhan et al 2016, Lockamy and McCormack 2004, Herbsleb, and Goldenson, 1996.) Process improvement maturity models originate from quality control models (Crosby, 1980), which have been historically adapted for software processes for example the Capability Maturity Model, and afterwards business processes and business process management (Ahern, Clouse & Turner 2004.) Process maturity is based on the concept that a process has a life cycle that can be assessed in the ways it is defined, managed, measured and controlled, thus identifying where on the life cycle the process currently is positioned, (Tarhan et al 2016, Lockamy and McCormack 2004, Herbsleb, and Goldenson, 1996.) There is a link between project management, software management and process management maturity models. As processes mature they move from an internally focused perspective to an externally focused perspective. A maturity level is reached when the process under study has reached a set of goals that relate to that level. Achieving each level of maturity establishes a higher level of process capability and performance for an organisation, (Tarhan et al 2016, Lockamy and McCormack 2004, Herbsleb, and Goldenson, 1996.)

Process maturity models evolved into business process improvement maturity models as organisations needed a framework to assist in improving their key business processes, support processes and enabling processes, (Pesic 2009.). The management and improvement of processes are a core task within organisational design, but this is something that many organisations require help and support with, (Roeglinger et al 2012.) These models, developed to help in this core task, are increasing in popularity and attention by business and academics, (Roeglinger et al 2012.) The aim is that a business process improvement maturity model enables managers to describe the current state of the enterprise from a process management maturity perspective (Pesic 2009.) According to Pesic (2009,) at the beginning of this century over 150 process maturity models exist, many based on Rummler and Brache's (1995) 6 levels of business excellence. A sample of business improvement maturity models, and one for Lean Six Sigma, are described over the following pages. These are tabulated with the leadership maturity models at the end of the chapter for a comparison study.

As seen earlier many of the process improvement maturity models have their roots in the Rummler and Brache (1995) book "Improving Performance: How to Manage the White Space on the Organization Chart." In this book, the authors explain the importance of driving competitive advantage through better management of the organisation, its people and its processes and describes 6 levels of business excellence:

Level 0: Managers are not aware about the need for business improvement

Level 1: The awareness to improve is there but no action

Level 2: There are some process redesign projects, but no sustainable CI management

Level 3: Significant results have taken place, but no continuous improvement is in place

Level 4: Processes which are relevant to customer satisfaction or key process are subject to continuous improvement

Level 5: All process, including key and supporting are subject to continuous improvement and management

These 6 increasing levels of maturity became the backbone of many future well cited process improvement frameworks and maturity models.

For example Lockamy and McCormack (2004) describe their own version of the classic 5 level approach to process maturity for the logistics and supply chain development function and includes:

Level 1: Ad hoc – process are unstructured and ill defined

Level 2: Defined – basic process are defined and documented

Level 3: Linked – processes are managed with strategic intent

Level 4: Integrated – stakeholders inside and outside the process become involved in the management of the process

Level 5: Extended – trust and mutual dependency exists between parties and collaboration within processes is the norm

Lockamy and McCormack (2004) scored 90 firms against their model to demonstrate how supply chain management as a process itself can be developed and improved.

A multi-dimension process improvement maturity model is one where levels of maturity are mapped against dimensions or processes of interest. Fisher (2004) developed a 2 dimensional business improvement maturity model due to his believe that the current 1 dimensional linear models available to managers was too simplistic to describe the complex organisations of the day. Fisher (2004) developed the following dimensions for process improvement maturity:

Strategy – the role of the entity, its position, focus and reason for being

Controls - the governance model for the entity, and evaluation techniques

Processes – the operating methods and practices of the entity

Technology – the enabling systems used by the entity to support their main processes

People – the human resource, culture and environment

Each dimension then is compared against a level of maturity from:

Level 1: Silo – operating in the context of functional silos, individual groups and sub optimal by departmental thinking

Level 2: Tactically integrated – starting to integrate processes at the tactical level, led typically by the IT department

Level 3: Process driven – realigning silos to form process thinking structures operating across the organisational entity

Level 4: Optimized enterprise – using the new structures to lever significant competitive advantage

Level 5: Intelligent operating network – expanding the benefits of process thinking across the whole eco system in which the entity rests

Once the grid is mapped out, of dimensions against levels, 25 scenarios or descriptors are described and it becomes possible to benchmark an organisation across the levels of maturity through the different dimensions regarded by Fisher (2004) as important to business improvement and change. Thus a company could be quite advanced in its process thinking and in its dealings with people and technology, but somewhat behind in the areas of strategy or control. However it is difficult to exist in the final level of maturity in just one area due to the dependencies across dimensions. For example a highly mature Process dimension would require a highly mature Technology dimension to truly function efficiency and effectively, (Fisher 2004.)

2.5 Lean Six Sigma Maturity Models

Lean Six Sigma, an approach to process improvement and explained in more detail in the following chapters, sits closely aligned with business process management maturity models, (Pesic 2009.) The way Lean Six Sigma projects are structured using the DMAIC approach of Define the problem, Measure the current state, Analysis the sources of variation, Improve the process and Control the drift can be argued itself as a form of project maturity, thus improving the process of process improvement, (Pesic 2009.) Pesic (2009) mapped the typical 5 levels of a capability maturity matrix against the DMAIC project structure of Lean Six Sigma – see figure 4 below: (note that Pesic (2009) used the term Implement rather than Improve when describing the 4th stage of DMAIC.) The aim was to demonstrate the characteristics of a successful Lean Six Sigma deployment.

	Initiate	Define	Measure	Analyse	Implement	Control
Level 5		Defining the links between process and key stakeholders	Connection of performance measures with strategy and objectives	Analysis of process performance influence on the enterprise objectives	Taking initiative from the top of the enterprise and formation of ideas	Monitoring and control of project for continuous improvement
Level 4		Defining the link between processes and process networks	Harmonization of process metrics	Analysis of mutual influence of processes on performance	Implementation of ideas for process improvement	Control of successfully implement improvement
Level 3		Defining support processes as well as key process	Measuring performance of whole processes	Complete process performance analysis		

Level 2		Defining the process from the beginning to end	Measuring processes within functions			
Level 1		Defining the processes inside function				
Level 0	Managers initiate program					

Figure 4: Pesci (2009) Five levels of Six Sigma deployment

For Lean Six Sigma to be successful it must have both technically and interpersonally competent facilitators, with a unique combination of resources and competencies so that the programme can be sustained in the long term, (Hilton and Sohal 2012.) Hilton and Sohal (2012) review the literature on the knowledge, skills, behaviours and competencies Six Sigma professionals required and described 8 technical constructs and 10 interpersonal constructs for Black Belt Six Sigma practitioners, with a further 6 technical and 3 interpersonal attributes for Master Black Belts. In addition 5 levels of influence were identified for Master Black Belts. This was presented in a manner similar to the maturity models developed in the 1990s using the capability maturity matrix framework. A Six Sigma programme involves a number of break through improvement projects developed with a project sponsor to significantly impact the bottom line. Quality, process efficiency, responsiveness and cost are often the measures of any Six Sigma programme success, (Hilton and Sohal 2012.)

Finally, He (2007) reviewed 90 Chinese firms deploying Six Sigma to design and develop a self-assessment tool to benchmark and describe their current maturity in Six Sigma. The final diagnostic assessment tool had 7 high level factors, 26 sub factors, called items, and 47 decision points, giving an organisation a total score out of 1000 point. Table 6 below demonstrates several companies' example scores, taking from He's 2007 research paper.

	Category								
Company	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**	**Years implementing six sigma**
A	82	72	60	124	74	152	164	728	3.5
B	76	80	68	148	76	199	202	849	6
C	80	52	68	128	66	158	162	714	3
D	82	52	52	134	70	140	162	692	2.5
E	68	64	48	129	76	152	138	675	2.5
F	78	48	40	125	80	142	132	645	2
G	80	64	52	136	64	174	188	758	5
Average	**78**	**62**	**55**	**132**	**72**	**160**	**164**	**723**	
Full Score	**100**	**80**	**80**	**170**	**100**	**230**	**240**	**1000**	

Table 6: Example of He (2007) scoring of 7 companies against his maturity model diagnostic

2.7 Creating a capability maturity model for a given concept

Maturity models are like theories: theories are constructed in order to explain, predict and master phenomena, (Cojocar 2009.) In many instances, theories are constructing models of reality. A theory makes generalisations about observations and consists of interrelated set of ideas and models, (Cojocar 2009.) This is no different from the manner in which maturity models have been developed over the years. Maturity models are created using specific design principles. These principles vary depending on the type of maturity model but all basically include, (Roeglinger et al 2012):

- their scope
- their purpose and use
- their development background
- the structure of the model or theory they are based on, including its stages, existing levels of granularity and maturity

Effective and efficient maturity models should also describe how they can be used and the target audience they have been designed for, (Roeglinger et al 2012.)

Below is a table across 3 pages summarising the performance of the models reviewed in this chapter against the Roeglinger et al 2012 criteria, the aim being to help the author draw out their own design principles for their Lean Six Sigma maturity model for higher education.

		Roeglinger et al 2012 criteria				
		Scope (descriptive vs prescriptive, or both)	Purpose and Use	Development background	Structure of model - 1 or multi dimensional	Clear Target Audience
1	Hersey and Blanchard (1977) – Situational Leadership	Descriptive	To illustrate how leadership styles change as situations vary	Early leader in the field of describing leadership styles and approaches - often used as a basis for current leadership thinking	Evolved from a simple linear model to a more complex one, however still linear in nature with one main dimension of maturity	Generic model designed for a wide audience
2	Earthy (1997) – Usability Maturity Model: Human Centeredness Scale	Descriptive	To understand culture and human centeredness in organisations - with the aim to make an organisation more centred on its staff	Links to ISO13407, and was developed using the System Engineering Capability Maturity Model and ISO 15504	Earthy categorised human centeredness in one dimension as X, A, B, C, D and E, where X is not recognised and A is low maturity or little human recognition and E mature or human systems are institutionalised.	Generic model designed for a wide audience. The document is written not as an academic paper but in the style of an ISO standard
3	Collins (2001) – 5 levels of leadership	Both	The aim is to allow leaders the ability to benchmark themselves and their leadership styles against his leadership maturity model and to consider the knowledge skills and behaviours they would need to become truly exceptional level 5 leaders.	Over a five year period Collins studied successful CEOs in international businesses and developed a relationship between performance and leadership style	Often presented as a pyramid with level 5 being at the peak, this model is still linear in nature with a single dimension. Other authors have added a 6th level in recent years but no evidence exists of taking a multi level approach to this model	Generic model designed for a wide audience
4	Prosci (2007) – Change Management Model	Both	Prosci (2007) developed what he called a change management maturity model, built around evolution not revolution dimensions. This model is to serve as a guide for organisations looking to manage change	Prosci (2007) are a research think tank working for government and large organisations developing change management models and concepts	The Prosci model is more akin Collins (1991) 5 levels of leadership rather than a traditional change management approach	Generic model designed for a wide audience
5	Sun et al (2009) – Change Management Model	Both	To support the change management in large capital projects	Built on the Prosci (2007) model above	Developed a second dimension to the Prosci (2007) model using levels of maturity similar to that used by the CMM	Specific model for the construction industry
6	Chen et al in 2010 – Supply and Demand Leadership	Both	Demonstrate the importance of supply and demand leadership within major IT projects	Built a model using the concepts of supply and demand leadership. Using research and interviews Chen created "dimensions", or key headings in his model, including dimensions he named as Human Capital, Structural Power and Organisational Support	Developed multi dimensional and non linear model. Each of the five original dimensions feed into either supply Side Leadership (pushing concepts, decisions and change onto the organisation by the leadership team) or Demand Side Leadership (pulling concepts, responding to the need for new concepts, decision and change placed on the leadership team).	Generic model designed for a wide audience - although focuses on the CIO of an organisation

7	Rummler and Brache (1995) Generic business excellence / process improvement	Descriptive	To demonstrate how process improvement can drive competitive advantage. Specifically through better management of the organisation, its people and its processes	This approach and book has become one of the main citations used by maturity model developers in the area of process improvement	Simple linear 1 dimensional 6 stage model of maturity	Generic model designed for a wide audience
8	Lockamy and McCormack (2004) Supply chain process improvement	Descriptive	To describe how competition in many industries has changed, no longer based mainly on strategic assets but based on capabilities, or "complex bundles of skills and accumulated knowledge, exercised through organizational processes" Thus, organizations need to develop strategically aligned capabilities not only within the company itself, but also among the organizations that are part of its value-adding networks.	Building directly from Rummler and Brache (1995) book, the authors developed a simpler 5 stage maturity model and tested it against 90 organisations supply chain departments	Simple linear 1 dimensional 5 stage model of maturity	Specifically designed for the logistics and supply chain functions within industry
9	Fisher (2004) business improvement maturity model	Both	Across all business functions this business improvement model is designed to measure and benchmark an organisations current maturity against 5 business functions - or factors	Building on a simple 5 factor business improvement model, Fisher combined this with 5 levels of maturity.	25 scenario 2 dimensional linear model. However it is difficult to exist in the final level of maturity in just one area due to the dependencies across dimensions	Generic model designed for a wide audience
10	Pee et al 2006 knowledge management model	Both	To develop better knowledge based management systems, procedures and protocols	Knowledge management has a strong research pedigree in maturity models which has resulted in many different variations of capability maturity models being developed. Its strong links with the original software institutes CMM has meant much has been written in this field of maturity models	5 factor model with a 1 - 5 scoring system, making it a 2 dimensional model	Specific model built in the world of IT and knowledge management systems
11	Kaner and Karni 2004 knowledge management model	Prescriptive	A Capability Maturity Model for knowledgee based decision making	Similar to Pee et al, Kaner and Karni overlay knowledge management and decision making concepts over a capability maturity matrix	Although they researched a variety of maturity models, both 1 and 2 dimensional, the authors end up with a simplified 5 level 1 dimensional linear model	Specific model built in the world of IT and knowledge management systems

12	Pesic 2009 six sigma maturity model	Both	To demonstrate how lean six sigma itself is a form of organisational maturity when deployed correctly	Using the standard 5 level business process maturity model and combining it with DMAIC to create a maturity matrix for deploying lean six sigma, and tested in several Serbian case studies	Due to the nature of the final design of the maturity model, 17 scenarios were created to both describe and provide a benchmark for organisations deploying lean six sigma	Generic model designed for a wide audience - with a focus on six sigma deployment
13	Hilton and Sohal 2012 developing six sigma competencies, viewed as a maturity model	Both	To demonstrate the knowledge, skills, behaviours and competencies required by practicing six sigma professionals and to show the journey of personal development through the different belts and phases of six sigma training	Reviewed the literature on successful competencies of six sigma black belts and master black belts and presented their findings within a capability maturity matrix - modelled on the original software Institutes CMM approach	Following a 1 dimensional linear approach, the model described 8 technical constructs and 10 interpersonal constructs for Black Belt Six Sigma practitioners, with a further 6 technical and 3 interpersonal attributes for Master Black Belts. In addition 5 levels of influence were identified for Master Black Belts.	Generic model designed for a wide audience - with a focus on six sigma training
14	He (2007) self assessment tool	Descriptive	To allow firms to diagnose their six sigma maturity against a scoring criteria	Drafting the criteria for Six Sigma maturity assessment, He (2007) adopted the Baldrige criteria and Motorola corporate quality system review (QSR) guidelines. In addition a team of 24 people (including Six Sigma Champions, Master Black Belts and BBs) from industry and academia joined the forum to design a framework, through consensus	The final diagnostic assessment tool had 7 high level factors, 26 sub factors, called items, and 47 decision points, giving an organisation a total score out of 1000 point.	Generic model designed for a wide audience - with a focus on six sigma maturity

Table 7: Review of maturity models

Of the maturity models and literature reviewed in this chapter, the following trends, conclusions and general characteristics of successful leadership and process improvement maturity models can be identified and defined by the author as:

Characteristic 1: The Type of Maturity Model

Process improvement and leadership maturity models are often designed around the original capability maturity model from the Software Engineering Institute at the Carnegie Mellon University. Capability maturity models are either Prescriptive or Descriptive, with a possible benchmarking or comparable element (Roeglinger et al 2012, He 2007, and Lockamy and McCormack 2004.) This ability to act as a benchmarking tool enables the reader to use the model to develop an action plan to progress and move through the levels of maturity.

Characteristic 2: The Scenarios of Maturity

Maturity models use design principles set around terms known as dimensions or factors, each with their own set of typically linear levels moving through time and maturity**.** The resulting scenarios, (graphical areas of intercept between the factors and then levels) become the knowledge descriptors which are then used to benchmark performance against the maturity model (Poppelbulb and Roglinger 2011, Pesic 2009 and Fisher 2004.) For example a 5 level maturity model with 4 factors would have 20 possible combinations, or scenarios, each scenario representing a potential maturity point in space, and thus a potential description of the current or desired level of maturity.

Characteristic 3: The Target Audience of Maturity

Capability maturity models can be applied to almost any situation, entity or process. The approach to designing maturity models outlined in characteristic 2 is applicable to a wide variety of entities including abstract concepts such as leadership, or descriptive concepts such as processes, for example order fulfilment or the sales processes, and physical products and projects such as an organisation's products, capital construction projects or information technology based projects, (Sun et al 2009, Cojocar 2009, Pee et al 2006, Kaner and Karni 2004, and Graeff 1997.) The application of maturity models is wide and varied, and therefore the idea can be applied to the author's desired aim of building a maturity model specifically for higher educational institutions trying to deliver a Lean Six Sigma agenda.

Characteristic 4: Challenging the Linearity of Maturity

Maturity models are often linear in their nature, often with unspecified target audience, which can however be a weakness in their simplicity. The best models are designed for specific entities, processes, industries or situations and can be circular, rather than linear in nature (Chen et al 2010, Pee et al 2006 Winston 2003, Earthy 1997.) A nonlinear model would require an element of "weighting" the scenarios, which could be done through the use of empirical quantitative research. For example, perhaps the reasons for successful implementation of Lean Six Sigma are wide and varied but not equally weighted – maybe leadership is more important that the tools used? Any weighting would need significant research to support the chosen prioritisation of factors or levels.

Characteristic 5: Testing the Maturity Model

Often new maturity models are designed through using existing models or concepts; building on previous findings, for example the success factors of successful project deployment. Factors and dimensions are the categorisation of subject matter knowledge into meaningful themes, and the levels are the representation and measurement of that knowledge, usually in a manner related to the reader. These categories (dimensions, factors ets) and representations (levels, stages etc) are confirmed through the use of questionnaires, interviews, and established thinking. The most respected maturity models are tested and refined using case studies, focusing on the target audience. However the samples, members or elements of the case studies are not same as those used to develop the original factors and levels, thus allowing the author the possibility of verifying the accuracy of the maturity model, (Hilton and Sohal 2012, He 2007, De Bruin and Rosemann 2005, Fisher 2004, and Kaner and Karni 2004.)

These 5 characteristics developed by the author will be used in later chapters to help shape and form his own maturity model. Before the author can successfully build and test his own maturity model an understanding of the current knowledge of Lean Six Sigma, and its links with academia will be required. The following chapter uses a systematic literature review to examine the historical and current knowledge of Lean Six Sigma in the academic sector. The aim of this systematic review is to meet the needs of characteristic 5 above, i.e. the categorisation of knowledge and themes for any future academic centred Lean Six Sigma leadership maturity model.

Chapter 3: Lean Six Sigma and Academic Leadership – a systematic literature review

3.1 Introduction to the review

One of the results of globalization is that countries often place a focus on educating their people using world-class universities, to enable their nation to prosper. Globalization is creating a series of trends which academic leaders must address. First, education has no borders: students can take classes anywhere in the world, which is driven by - and for - advances in technology. Increased choices have led the student to become a "customer" of learning, and competition between institutions now exists globally. Social welfare has weakened, and institutions need to raise more funds privately than ever before. In addition, universities are becoming more (not less) de-centralized, with more decisions being made at the local level. These trends require the Chancellor or President of a university to think about "organisation mission, unit productivity, and individual performance," (Mehmood et al., 2012; Shahmandi et al., 2011). However, the question remains - are these leaders of academia using the latest management thinking from industry to address these challenges?

3.2 The history of using Lean Thinking and Six Sigma to deliver change

The foundations of the Toyota Motor Company date back to 1918, (Holweg 2006), when Sakichi Toyoda sold his patents for his spinning machines to fund his son's, Kiichiro, ambition of establishing an automotive company and in 1937 the Toyota Motor Company was formed. In 1950 he sent his cousin, Eiji Toyoda to the USA to study American manufacturing methods. However it was not until Taiichi Ohno, with no experience of automotive methods, began arguing his "common sense" approach and criticism of American methods did the Toyota Production System began. Astonishingly, the Toyota Production System was not documented till 1965, when Kanban Systems, the indication to make, were rolled out into the supply chain, (Hall, 1983.) Toyota believed that the approach was too basic to merit documentation. Toyota made no secret of its developments in manufacturing systems and it attracted little interest until the oil crisis of the 1970s.

The term Lean was first used by an MIT graduate Krafcik in a paper published in 1988 called The Triumph of the Lean Production, however it arguably didn't gain real traction until 1990 when Womack, Jones and Roos published a book which was to arguably start the LEAN movement as we know it today. The Machine That Changed the World, written not for an academic audience, but for an industrial one, presented the findings of the authors' work studying Toyota's automotive approaches, and went beyond previous books to encompass supplier and new product development issues (Holweg 2006.) The Machine That Changed the World also for the first time used the term LEAN Production (Womack et al 1990)

Lean is a philosophy designed to improve competitive advantage of the organisation by placing the customer at the heart of its processes and eliminating all non-value adding activities, (Emiliani, 2005.) Lean exists within academic institutions, although often not recognized internally as Lean. Womack and Jones both had academic backgrounds and it made sense that eventually Lean would be tested and implemented at academic institutions and on academic processes to address the challenges faced by such institutions in the 21st century. As students demand more for less and as the market forces affect university balance sheets, these and other challenges faced by international universities should be tackled using the same tools and techniques academics had been advocating in industry for years (Emiliani, 2005.) Individuals within universities should participate in kaizen and Lean events to improve individual courses, degree programs, and student services. This will lead to what Emiliani calls "multiple characteristics" that clearly differentiate one school from another as seen by customers and lead to positive outcomes. Although there have been many examples of research in universities to improve processes, there are few examples of a holistic approach as advocated by Lean (Hines and Lethbridge, 2008.) The pursuit of quality and project focused continuous improvement activity, primarily in the USA, appears to dominate the research. Hines and Lethbridge (2008) illustrate successful Lean implementation as an iceberg; with processes, technology, tools, and techniques above the water; and strategy and alignment, behaviour and engagement, and leadership below the water. They stated that a combined top down and bottom up approach to implementation gives a university the greatest chance of successfully changing through a Lean implementation. The key word and concept that appears in all the Lean articles utilised in this literature review to complete the definition of Lean is “Leadership”. Leadership will be explained in more detail in the following sections; however, as a working definition Emiliani (2013) defined Lean and Lean Leadership as:

> *“Beliefs, behaviours, and competencies that demonstrate respect for people, motivate people, improve business conditions, minimize or eliminate organizational politics, ensure effective utilization of resources, and eliminate confusion and rework.”*

At around the same time LEAN was transforming the automotive world, Six Sigma was gaining traction in a different market. Bill Smith of Motorola originally developed Six Sigma in 1987 and targeted an aggressive goal of 3.4 parts per million (ppm) defects. In 1994 Larry Bossidy, CEO of Allied Signal, introduced Six Sigma as a business initiative to ‘‘produce high-level results, improve work processes, expand all employees’ skills and change the culture.’’ This was followed by the well-publicised implementation of Six Sigma at General Electric (Schroeder et al 2008.) Within just a few years, Six Sigma had become a philosophy for business improvement. Companies such as Motorola, GE and DuPont historically have all succeeded in reducing defects and minimising costs through Six Sigma strategies. In the 1990s the focus of Six Sigma moved away from product quality to business quality, becoming a “business centric system of management (Harry and Crawford 2005.) Companies in the USA which have deployed Six Sigma and its parent philosophy of Total Quality Management (TQM) enjoyed improved stock performance, operating income, sales and other benefits when compared to their non-Six Sigma/TQM counterparts. No company that ignores process excellence is successful in the long term (Pyzdek 2007.)

There are similarities between Six Sigma and TQM relating to the focus on customer, a process management approach and the use of quality tools, however there are significant differences in terms of the approach and emphases (Antony 2009.) First, there is a more structured approach in Six Sigma; for example, using the DMAIC acronym to structure projects. Typically, Six Sigma projects are led by a team leader and supported technically by a Master Black Belt, and culturally by a Champion or sponsor, who serves as a major link for top management. With such representation from senior management, which was not necessarily the case in TQM, the chances of commitment from top management, project completion, and implementation are enhanced.

Six Sigma is a project based business improvement methodology designed to deliver competitive advantage by understanding the needs of the customer and eliminating variation in processes. Six Sigma has less of a presence in academic life compared to Lean. Academic institutions are slightly different from business organizations (Jenicke et al., 2008.) They are similar to a business organization in the sense that top management in a university uses the vision and mission statements as tools to provide direction for the university; however, the individual constituents in a university, its academic colleges, departments and administrative units, often follow the principle of “academic freedom” that makes implementation of any campus wide initiative challenging. The nature of the product offered, the definition of customers, the measurements of quality and employee reward systems differ significantly from those of manufacturing. For example, who are the customers of education and research? Is the student the customer, the supplier or the process? How does society measure the impact of the presence of a campus university in its locality? In addition, building an organization-wide commitment in an academic system that values “scientific and creative experimentation” to a process that fosters “efficiency-based thinking” will be challenging. How do you focus an organisation in one direction when its rewards and values academic freedom and creativity? (Jenicke et al., 2008.) A key factor, identified by Jenike et al. (2008), in applying the Six Sigma methodology to academic institutions is to identify the best performance indicators that demonstrate academic success. These measures vary depending on your position in the organisation. Jenike et al. (2008) developed a three-tiered approach to setting Six Sigma performance measures including:

- Tier 1: University level – state funding, new buildings, national benchmarks
- Tier 2: College or School level – financial metrics, employer contracts, private funding
- Tier 3: Department or student level – New courses, student opinion surveys, better use of technology

Jenike et al. (2008) also notes that support area employees, such as administrative staff, can be managed and monitored, and rewards are recognized in ways similar to industry. However, academic faculty staff are pressured to improve areas where assessment is difficult, such as teaching effectiveness and quality of research. Setting realistic goals, which are quantifiable, will be significantly easier where measurement can be established. Lean Six Sigma is a methodology that maximises competitive advantage and value by achieving the fastest rate of improvement in customer satisfaction, cost, quality, process speed, and invested capital.

Lean and Six Sigma are not without their critics, (Pepper and Spedding, 2010) with the automotive industry itself demonstrating at times a lack of understanding of Lean, or the commitment needed by management. Outside of mass production environments, in jobbing shops or engineering firms, Lean has struggled to handle large product portfolios, variety in product characteristics and smaller firms struggling to match the dominance or resources which larger mass production players have deployed into their supply chains. Lean is often seen as pro company, not pro employee, with employees feeling threatening and management failing to address the issue (Pepper and Spedding 2010.) For all the advantages that Six Sigma has delivered over the decades, it too is not without criticism. Barriers such as cost of training and development, poor project selection, and an obsession with status can all hijack a Six Sigma deployment. In addition the dangers of alienation of staff through being seen as a "statistical heavy, technical approach" to business improvement is ever present and well documented, (Pepper and Spedding 2010.) A summary of the key challenges and limitations of Lean and Six Sigma are below (Cusumano 1994, Antony 2004, Antony et al 2019):

Lean Limitations	**Six Sigma Limitations**
Supply problems – geographical distances of suppliers can struggle to maintain just in time manufacturing supply chains	The presence of good, reliable, quality data in service driven processes is often difficult to acquire
Product variability and the trend for customisation increases variability and stock volume issues within the supply chain	Data driven solutions can be expensive and thus only partially delivered, failing to meet the full benefit calculated in the Define stage
The desire to push down inventory exposes the supply chains to shortages from relatively small macro business, political or environmental changes	Project selection by senior management teams can still be subjective

The reorganisation of plant and machinery to align with value streams rather than functionality can be expensive for some industries	Illogical to assume that all defects are equal – a failure in one process may be significantly more important than one elsewhere, however the sigma calculations often don't reflect the weighting of the defect
The training and development of staff, suppliers and third parties can be expensive, time consuming and logistically difficult to arrange in already labour stretched industries	Many of the quality tools utilise normal distributions of data – often not the case when measuring defects
Long time-served employees may find it difficult to change to new working practices, actively resist the change or not have the ability to work in new systems or processes	The standard 1.5 sigma drift may not be relevant in certain industries or processes
The need for leaders and managers to resist old styles of command and control type management practices, and embrace employee led change	There is significance variation in the quality, or training and development, of Black Belts and Green Belts across the world and across industries
Difficult to identify value and the customer in public sector organisations where there may be multiple stakeholders with conflicting agendas	Start-up costs to implement Six Sigma can be high due to the need to invest in training and the freeing up of resources to deliver initial projects
Lean historically has not focused on process control through statistical methods, lacks a scientific approach and has no formal structure for deploying Lean	There is a danger that Six Sigma initiatives can become bureaucratic exercises, becoming themselves a significant cost base
Due to its transformational nature, long term commitment is required from management, which can conflict with short term financial metrics	The overselling of Six Sigma by consultancy and training organisations has led it to be deployed in areas where it is not relevant, or better solutions exist

Table 8: Limitations of Lean and Six Sigma

The phrase "Lean Six Sigma" is an attempt to bring together these different approaches under one unifying umbrella of business improvement. An example of how bringing these two philosophies together improves the whole relates to way in which these two approaches are often separately implemented: LEAN as a bottom up, shop floor driven, high employee engagement activity, compared with the Six Sigma, top down, highly trained individual and project-centric approach.

Arguably the founding father of Lean Six Sigma, Michael L. George states that Six Sigma lacks speed, and LEAN can lack a quality emphasis (George 2002). Lean cannot bring a process under statistical control and Six Sigma alone cannot dramatically improve process speed or reduce invested capital. Michael George goes on to define Lean Six Sigma as a methodology that maximises shareholder value by achieving the fastest rate of improvement in customer satisfaction, cost, quality process speed and invested capital.

Shah et al (2008) identify quality management practices, typically included in defining, describing, and measuring LEAN and Six Sigma, as the main link between the two philosophies, and that taking the older philosophy of LEAN and combining it with the statistically robust, project driven approach to continuous improvement delivered significantly better results than those companies which did not deploy or combine LEAN and Six Sigma.

The purpose of this chapter is to explore the research in academic leadership utilizing approaches such as Lean, Six Sigma, and Lean Six Sigma to address the challenges faced by academic institutions today. The chapter is outlined as follows: The concept of Academic Leadership in Higher Education is first presented. A systematic literature review, utilizing Design of Experiments, a Lean Six Sigma technique, is then employed to identify any literature that exists which investigates the Academic Leadership requirements of a Lean Six Sigma initiative within an academic institution. Potential research questions and next steps in addressing the gaps in research identified by the systematic literature study are then highlighted.

Within all the research highlighted above, managing change is still part of the picture and helps explain why some universities are looking to industry for solutions to their cost, delivery, and quality problems. Industries have wrestled with similar cost, delivery and quality challenges, although in a different context, and have developed successful strategies such as Lean, Six Sigma, and, more recently, Lean Six Sigma to meet these challenges and deliver exceptional value. Universities therefore have the potential to gain similar value by adopting similar strategies.

As previously defined in chapter 1, academic leadership can be translated into leaders with positional power, leaders with expertise power, leaders with networking power, and leaders with personality power. The author defines academic leadership as someone in a “position” to identify the need to allocate resources to actively manage change, monitor and motivate, and deliver change within higher education, both at the institutional level, school or college and the departmental level. An example could be a Dean of a school realizing that they are under pressure to improve performance, cut costs, and attract more research opportunities deciding to utilize Lean Six Sigma tools and techniques to fundamentally change the department both culturally and physically. This definition relates closest to Kotter and Cohen’s (2002) and Collin’s (2001) Leadership definition of managing change not managing complexity, and level 5 leadership, respectively. The similarities of academic leadership and traditional leadership are such that universities can recruit exceptional “outsiders” to run institutions and that, at its core, academic leadership is no different from traditional leadership; rather operating in a different context, which needs to be understood.

3.3 Research methodology for a systematic literature review

There are 5 main types of literature review available to the researcher (Dudovskiy 2018): Narrative, Argumentative, Integrative, Theoretical and Systematic.

A Narrative literature review critiques the literature and summarizes the body of a literature. Narrative review also draws conclusions about the topic and identifies gaps or inconsistencies in a body of knowledge. The main disadvantage of the narrative review is that you need to have a sufficiently focused research question to start and conduct a narrative literature review.

An Argumentative literature review, as the name implies, examines literature selectively in order to support or refute an argument, deeply imbedded assumption, or philosophical problem already established in the literature. The main disadvantage with the argumentative review is the potential for an author’s bias to become evident.

An Integrative literature review critiques, reviews and synthesizes secondary data about research topic in an integrated way such that new frameworks and perspectives on the topic are generated. This is a useful approach if the researcher is not planning on collecting their own primary data; however difficult if working in a completely new field of study.

A Theoretical literature review focuses on a pool of theory that has accumulated in regard to an issue, concept, theory, or phenomenon Theoretical literature reviews play an instrumental role in establishing what theories already exist, the relationships between them, to what degree the existing theories have been investigated, and to develop new hypotheses to be tested. Similar to the integrated approach the main disadvantage is in new areas of research where little or no theory has been developed.

The Systematic literature review requires a more rigorous and well-defined approach compared to most other types of literature review (Dudovskiy 2018.) A Systematic literature review is comprehensive and details the timeframe within which the literature was selected. It attempts to collate all empirical evidence that fits pre-specified eligibility criteria in order to answer a specific research question and is widely used by the medical research community to pull together the relevant research in a particular field to meet a particular research question (The Cochrane Collaboration, 2011.) A strong systematic review uses explicit, systematic, and repeatable methods that are selected with a view to minimizing bias; thus, providing more reliable findings compared to traditional approaches, from which conclusions can be drawn and decisions made (Antman et al., 1992; Oxman and Guyatt, 1993.)

The key characteristics of a systematic literature include (Cochrane Collaboration (2011, Oxman and Guyatt, 1993, Antman et al., 1992):

1. A clearly stated set of objectives with pre-defined eligibility criteria for studies
2. An explicit, reproducible methodology
3. A systematic search that attempts to identify all studies that would meet the eligibility criteria
4. An assessment of the validity of the findings of the included studies, for example through the assessment of risk of bias and

5. A systematic presentation, and synthesis, of the characteristics and findings of the included studies.

These key characteristics have similarities with one of the most powerful techniques available to Lean Six Sigma professionals - Design of Experiments (DoE). The Lean Six Sigma continuous improvement tool of process mapping is a useful approach to demonstrate the key steps and activities involved in a systematic literature review using the technique of Design of Experiments. Figure 5 below shows the process (highlighted in yellow) and examples of the decisions made at each process step (highlighted in pink.)

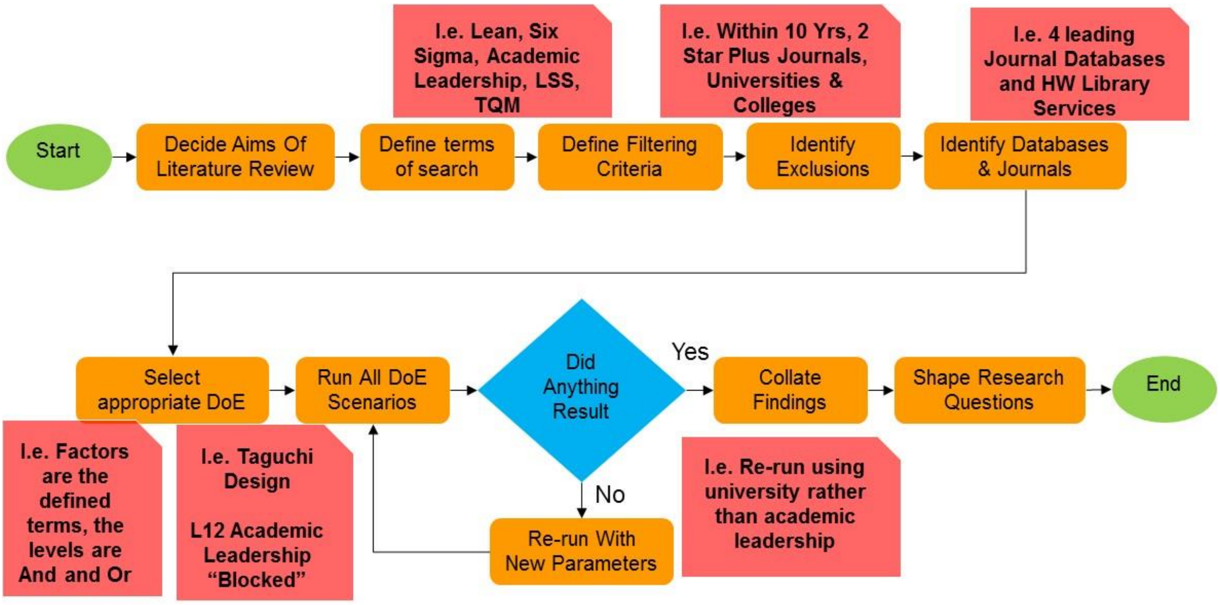


Figure 5: Process map of the systematic literature (Anthony and Antony 2016)

Within the business improvement philosophy of Six Sigma rests a set of statistical tools under DoE. DoE is a systematic approach to identify, understand, and optimise the key factors, sometimes known as inputs that influence a product or process, and has been used extensively in manufacturing for many years. It adds structure and purpose to piloting an engineer's ideas on the best way to configure products and processes (Montgomery, 1991; Antony, 2003; Kumar et al., 2013.)

There has been limited empirical research on the use of DoE outside of manufacturing applications with the aim of optimising processes through configuration of inputs and appreciation of interactions and their combined effect on efficiency and effectiveness (Aboelmaged, 2009; Antony et al., 2013; Jevnaker et al., 2015.) Although few in number there are also examples of DoE being used in the academic environment, for example to improve teaching, (Antony and Sivanathan 2013.) It is important to dispel the myth that DoE is only valid in manufacturing processes or at best only applicable to higher educational administrative processes. Teaching can be improved through the use of DoE and, through using statistical tools to analysis the results of the DoE, teaching outcomes can be analysed and improved, (Antony and Sivanathan 2013.)

However, no evidence has been found of researchers using DoE as a tool to structure and analyse a systematic literature review prior to this author's work. Therefore one of the purposes of this chapter is to demonstrate the power of DoE when applied to conducting a systematic literature review and to demonstrate its value to future research applications. It is important to the authors' own research approach to demonstrate how Lean Six Sigma tools can be applied to academic processes outside of traditional administrative or simple transactional processes to start the cultural change towards better integration of Lean Six Sigma within HEI.

3.4 Conducting a DoE

Design of Experiments enables researchers to optimize their products or processes they need to identify the "output" characteristics they are interested in optimising and modelling. Then the individual factors, or inputs, need to be selected. These are usually drawn from a larger pool of inputs and are regarded as the "key process inputs;" sometimes identified through a filtering experiment or other such systematic way to identify the important factors. The "settings" or levels that these factors are to be modelled at are then decided. The simplest design assumes that all relationships are linear, and that simply picking a low and high setting is sufficient. The assumption being that if a relationship is linear then only the start (low) and end point (high) of the relationship is needed.

Levels within a manufacturing context could relate to machine settings; for example, with pressure settings, an input could have levels of low pressure and high pressure. The input "line speed" could have levels of fast and slow. Within a non-manufacturing context, inputs and levels could relate to process configuration; for example, IT systems (the input) being switched on or off as the levels; or hospital admission (the input) with emergency or non-emergency as the levels.

A design is then chosen from the myriad of DoE options available; the simplest being a Full Factorial Design, which includes all inputs set at all levels and in all combinations. Table 9 provides an example of how a DoE could be structured for both a traditional manufacturing and a Higher Education setting.

Key DoE Elements	Manufacturing Example	Higher Education Example
The key output(s) to be optimized	The quality of a paper product produced on a continuous paper mill	Identify current key literature to address a key research question: What is the impact of Lean Six Sigma on higher educational establishments?
The key inputs to be modelled	Machine settings: - Moisture settings - Draw speeds - Oven temperatures - Drying temperatures	Key words to search, for example: Academic Leadership combined with: - Six Sigma - Lean
The key levels/settings	Use simple HIGH and LOW settings for each machine characteristic	Use database string attachments of AND and OR
The Design	Full factorial design, 2^4 scenarios, or 16 experiments. Potentially replicated 3 times to collect sufficient evidence to find the optimum settings for 48 experiments.	Full factorial design, 2^2 scenarios, or 4 experiments. – see Table 2 for the experimental design. Potentially replicated the searches across 5+ database search engines attached to particular research journals of interest.

Table 9: Structuring the DoE

Table 10 highlights the four possible scenarios relating to academic leadership when it is combined with the terms Six Sigma and Lean. Academic Leadership is a “blocked” factor. Blocking is often used in DoE to group scenarios together for pragmatic, sometimes cost effective, reasons. Blocking is used in this research as a way to represent that academic leadership needs to be included in every scenario and will not be omitted from any searches.

Scenario / Experiment	**Academic Leadership (blocked)**	**Six Sigma**	**Lean**	**Result**
1	Ac. Leadership	OR	OR	x
2	Ac. Leadership	OR	AND	x
3	Ac. Leadership	AND	OR	x
4	Ac. Leadership	AND	AND	x

Table 10: Scenarios of a 2 to the power of 2 full factorial design

Once the design has been finalized, it becomes possible to repeat the design across selected journal databases. This is known in DoE as repetition, which is the process of repeating the experiments with no randomization to the order of the scenarios. Replication involves the randomization of scenarios within the DoE. Therefore, data on research articles is collected from a variety of sources relating to the research question’s known field of publications.

The challenge with any Design of Experiment is selecting the key factors. If a researcher is not sure of the correct key words to use in their literature review, then some form of screening is required to identify those key words. There are several solutions available to screen for unrelated factors and a common approach is to use Taguchi Orthogonal Arrays. This approach is utilized to enable a large number of key words to be used in search strings and to gain optimum information from a minimum number of trials/scenarios. Genichi Taguchi is famous for his pioneering methods of robust quality engineering. One of the major contributions that he made to quality improvement methods is Taguchi arrays for the use in screening design of experiments, (Scibilia 2017.) These experimental designs have been utilized widely in engineering analysis to optimize the performance characteristics by studying the effects on them utilising combinations of design parameters. The Taguchi approach is also a powerful tool for the design of high quality management and operational systems. To achieve quality improvement, Taguchi pioneered the use of robust parameter design. Robust parameter design is an engineering method for product and process design that focuses on minimizing variation and/or sensitivity to noise – inputs which are difficult to control, (Das and Sahoo 2010.) This ability to manage noise in the design of experiment it what give Taguchi the edge over other screening design of improvement techniques such as fraction factorial design. Taguchi designs have been used in non-manufacturing sectors, for example in measuring customer satisfaction in the banking sector, however the use of Taguchi outside of manufacturing is unusual (Barboza et al 2016.) With the Taguchi approach the scenarios can be run across the repetitions and replications required to collect the data for analysis. Once the data has been collected, the process can be optimised; usually within an engineering application this involves some form of regression modelling, however with regard to a literature review further filtering is the next step. For example, a systematic filtering approach may include:

- Removing duplications
- Removing articles from lower grade journals, websites or conference papers
- Removing articles not published in a native language
- Removing articles before a certain date or year of publication

Once the final list of articles has been assembled, the researcher can complete their review, pulling together and synthesizing the key learning from the key articles identified in the review. The next section completes a systematic literature review linking academic leadership with business improvement approaches such as Lean, Six Sigma, and Lean Six Sigma.

3.5 Results from the systematic literature review

The following systematic literature review was conducted to identify any gaps in research relating to academic leadership and the successful implementing of change using business improvement methodologies such as Lean, Six Sigma, Lean Six Sigma, Maturity Model, Continuous Improvement, and Total Quality Management. A systematic literature review of key words such as Academic Leadership, combined with Lean, Six Sigma, Lean Six Sigma, Maturity Model, Continuous Improvement, and Total Quality Management could potentially yield thousands of individual search results. To create a method of refining this search in a manner that will allow the most appropriate literature to be obtained, a screening approach taken from the world of Design of Experiments (DoE) is to be used. Systematically searching for these seven key phrases using two different combinations of search strings would yield 2 to the power of 7 scenarios (128 combinations) repeated across four leading journal databases and one university database (not journal specific) results in over 500 individual searches, a very time consuming activity. However, the L16 grid allows for 16 scenarios rather than 128, based on one factor – Academic Leadership being "blocked" and held at a particular level to ensure it appears in all searches, and the remaining 6 factors being held to 2 levels. Thus, across 5 repetitions fewer than 100 searches would be required.

To make sure that any design of experiment if conducted efficiency and effectively a structured approach is required, (Antony 2003):

- Planning phase: *The planning phase includes problem recognition, selection of factors, and levels and interactions of interest.*
- Designing phase: *The design phase is where the most appropriate type of design is chosen that can handle the combination of factors and levels, and the pragmatic and cost requirements of completing a study.*
- Conducting phase: *The conducting phase is where the planned experiments are completed, and results collated and evaluated.*
- Analysing phase: *The analysis phase is where the results are analysed, validated, and conclusions drawn.*

The problem faced by any researcher is to obtain the relevant literature to enable them to identify the gap in knowledge their research can address as efficiently and effectively as possible. The factors to be selected are Academic Leadership, Lean, Six Sigma, Lean Six Sigma, Maturity Model, Continuous Improvement, and Total Quality Management.

Certain factors have been excluded, including change management, business process reengineering, agile, and systems thinking. It is noted that these exclusions run the risk of missing key pieces of data; however, the more factors included in the experiment the larger the study. These factors, if deemed important could become part of future studies. To enable a systematic literature review to be assembled using a L16 grid, a maximum of 2 levels are required. The levels are the settings each of these factors will be configured to within the search string. The two levels are “AND” and “OR”. Additional levels are not required due to the impracticality of using for example NOT or AND/OR in gaining any additional results. The scenarios created by the L16 design will be replicated across four leading academic publisher databases and one university library database, which includes books in addition to journals, to identify the maximum number of relevant articles. These included Emerald, American Society for Quality, Taylor and Francis, Elsevier, and Herriot-Watt University Information Services Database.

Once the unique literature count for each replication is captured, along with the individual piece of literature, a filtering process is applied to select the most appropriate articles. Table 11 illustrates the literature which will be included and which will be excluded.

Included	***Excluded***
Articles published in two star, three star, and four star journals (according to ABS Journal ranking list)	Articles published in one star or less journals (These journals, in general, publish research of a recognised, but more modest standard in their field. Papers are in many instances refereed relatively lightly according to accepted conventions, Academic Journal Guide 2018)
Articles relating to higher educational institutions	Articles relating to schools and sixth form colleges
Academic journals	Books, websites, online publications, and Grey Literature (conference, reports, working papers, etc.)
Articles published in English language	Articles published in non-English languages or journals
	Any duplications across databases or key word searches
Articles between 2004 and early 2020	Any articles older than 15 years old

Table 11: Filtering criteria for the DoE

Table 12 below outlines the L16 grid for the search strings to be used to obtain literature across five databases whose output will form the final literature review.

Experiment	Academic Leadership	Lean Six Sigma	Lean	Six Sigma	Maturity Model	Continuous Improvement	Total Quality Management	Total Number of Results	After filtering and duplication removed
1	And	And	And	And	And	And	No string required		
2		And	And	Or	And	Or			
3		And	Or	And	Or	And			
4		And	Or	Or	Or	Or			
5		Or	And	And	Or	Or			
6		Or	And	Or	Or	And			
7		Or	Or	And	And	Or			
8		Or	Or	Or	And	And			
9		And	And	And	Or	Or			
10		And	And	Or	Or	And			
11		And	Or	And	And	Or			
12		And	Or	Or	And	And			
13		Or	And	And	And	And			
14		Or	And	Or	And	Or			
15		Or	Or	And	Or	And			
16		Or	Or	Or	Or	Or			

Table 12: L16 Taguchi grid

The factor Academic Leadership was blocked; therefore, the first level will always be “And”. For example, all 16 scenarios start: Academic Leadership AND Lean Six Sigma. The last column has no level formally attached since it relates to the previous input. For example scenarios 1, 3, 6, 8, 10, 12, 13, and 15 end with Continuous Improvement AND TQM. The statistical software, Minitab version 17, was used to create a 6 factor, 2 level Taguchi L16 grid, (Bass 2007.)

An example string could be experiment 5: *Academic Leadership AND Lean Six Sigma OR Lean AND Six Sigma AND Maturity Model OR Continuous Improvement OR Total Quality Management*

In all searches the terms were identified in the abstract or title. The full list of string used, based on the Taguchi L16 grid includes

1. “Academic Leadership” AND “Lean Six Sigma” AND “Lean” AND “Six Sigma” AND “Maturity Model” AND “Continuous Improvement” AND “TQM”
2. “Academic Leadership” AND “Lean Six Sigma” AND “Lean” AND “Six Sigma” OR “Maturity Model” AND “Continuous Improvement” OR “TQM”
3. “Academic Leadership” AND “Lean Six Sigma” AND “Lean” OR “Six Sigma” AND “Maturity Model” OR “Continuous Improvement” AND “TQM”
4. “Academic Leadership” AND “Lean Six Sigma” AND “Lean” OR “Six Sigma” OR “Maturity Model” OR “Continuous Improvement” OR “TQM”
5. “Academic Leadership” AND “Lean Six Sigma” OR “Lean” AND “Six Sigma” AND “Maturity Model” OR “Continuous Improvement” OR “TQM”
6. “Academic Leadership” AND “Lean Six Sigma” OR “Lean” AND “Six Sigma” OR “Maturity Model” OR “Continuous Improvement” AND “TQM”
7. “Academic Leadership” AND “Lean Six Sigma” OR “Lean” OR “Six Sigma” AND “Maturity Model” AND “Continuous Improvement” OR “TQM”
8. “Academic Leadership” AND “Lean Six Sigma” OR “Lean” OR “Six Sigma” OR “Maturity Model” AND “Continuous Improvement” AND “TQM”
9. “Academic Leadership” AND “Lean Six Sigma” AND “Lean” AND “Six Sigma” AND “Maturity Model” OR “Continuous Improvement” OR “TQM”
10. “Academic Leadership” AND “Lean Six Sigma” AND “Lean” AND “Six Sigma” OR “Maturity Model” OR “Continuous Improvement” AND “TQM”
11. “Academic Leadership” AND “Lean Six Sigma” AND “Lean” OR “Six Sigma” AND “Maturity Model” AND “Continuous Improvement” OR “TQM”
12. “Academic Leadership” AND “Lean Six Sigma” AND “Lean” OR “Six Sigma” OR “Maturity Model” AND “Continuous Improvement” AND “TQM”
13. “Academic Leadership” AND “Lean Six Sigma” OR “Lean” AND “Six Sigma” AND “Maturity Model” AND “Continuous Improvement” AND “TQM”
14. “Academic Leadership” AND “Lean Six Sigma” OR “Lean” AND “Six Sigma” OR “Maturity Model” AND “Continuous Improvement” OR “TQM”
15. “Academic Leadership” AND “Lean Six Sigma” OR “Lean” OR “Six Sigma” AND “Maturity Model” OR “Continuous Improvement” AND “TQM”
16. “Academic Leadership” AND “Lean Six Sigma” OR “Lean” OR “Six Sigma” OR “Maturity Model” OR “Continuous Improvement” OR “TQM”

The systematic literature review was initially completed in December 2014 and updated in March 2020 and the following results achieved. The first series of searches through the four databases of journals and university library chosen created no published research papers linking “Academic leadership” with any of the Lean Six Sigma related factors once the authors own work had been removed; however, when “Academic Leadership” was replaced with the term “University” and all 16 scenarios repeated several interesting articles emerged.

	Total Number of Results				
Experiment	Emerald	ASQ	Taylor and Francis	Elsevier	HW Libriary
1	0	0	0	0	0
2	2	0	3	0	7
3	0	0	0	0	0
4	2	10	2	0	14
5	3	9	1	0	22
6	0	0	0	0	0
7	1	2	2	0	5
8	0	2	0	0	2
9	2	9	3	0	14
10	0	0	0	0	0
11	1	1	1	0	3
12	0	1	0	0	13
13	0	0	0	0	0
14	1	1	1	0	3
15	0	1	0	0	10
16	23	10	7	3	52

Table 13: The DoE results

Once duplications were removed and the filters applied, the following were the total number of unique articles identified under each database:

- Emerald – 22 results
- American Society of Quality – 2 results
- Taylor and Francis – 6 results
- Elsevier – 2 results
- Herriot-Watt University Information Services Database – 3 results (not including all the articles identified from the other 4 databases which all appeared in the Herriot-Watt searches)

In total 35 unique articles were identified using the 16 search strings across the five repetitions.

To validate the process undertaken, the process was repeated replacing the terms academic leadership and university with leadership, with the aim of identifying a significant number of the articles that exist linking leadership with Lean, Six Sigma, and Lean Six Sigma. The Taguchi approach, the article filtering criteria, the connecting strings, and the highest achieving database from the systematic review (Emerald) were utilised and the results are below:

Leadership	Lean Six Sigma	Lean	Six Sigma	Maturity Model	Continuous Improvement	Total Quality Management	Total Number of Results
And	And	And	And	And	And	No string required	0
	And	And	Or	And	Or		1005
	And	Or	And	Or	And		119
	And	Or	Or	Or	Or		1924
	Or	And	And	Or	Or		98
	Or	And	Or	Or	And		104
	Or	Or	And	And	Or		999
	Or	Or	Or	And	And		4
	And	And	And	Or	Or		1554
	And	And	Or	Or	And		98
	And	Or	And	And	Or		999
	And	Or	Or	And	And		4
	Or	And	And	And	And		0
	Or	And	Or	And	Or		1013
	Or	Or	And	Or	And		98
	Or	Or	Or	Or	Or		2572

Table 14: Verification results

It is interesting to note that the largest number of articles that link Leadership with some form of continuous improvement terminology (scenario 16) generates over 2500 results within one database. When “Maturity Model” and “TQM” were optional (scenario 2), over 1000 articles were identified. If such a large number of articles can be identified within one publisher using this method it is fair to assume that the systematic literature review for “academic leadership” and “university” linked with “Lean Six Sigma” and the other terms is valid and that the risk of missing any relevant research will be small and that articles relating to academic leadership, universities, and Lean Six Sigma are few in number. Higher educational institutions often wrestle with a variety of customer centric and process based problems. However, few are utilizing the methodologies of industry based continuous improvement to address these needs.

Returning to the author’s original structured literature review one of the main objectives of using DoE is the ability to study the effect inputs have on output characteristics and within Taguchi experiments it is possible to complete what is known as a Main Effects plot. Figure 6 provides a Main Effects plot for the case study linking University with six business improvement approaches, specifically demonstrating the effects relating to: Lean Six Sigma, Lean, Six Sigma, Maturity Model, Continuous Improvement and Total Quality Management.

A steeper line between the first level (AND) and the second level (OR) indicates a large effect of input on the output. For this example, the phrase “Total Quality Management” generates the most results across the five databases, and the phrase “Maturity Model” generates the least number of results when added to a key word search string.

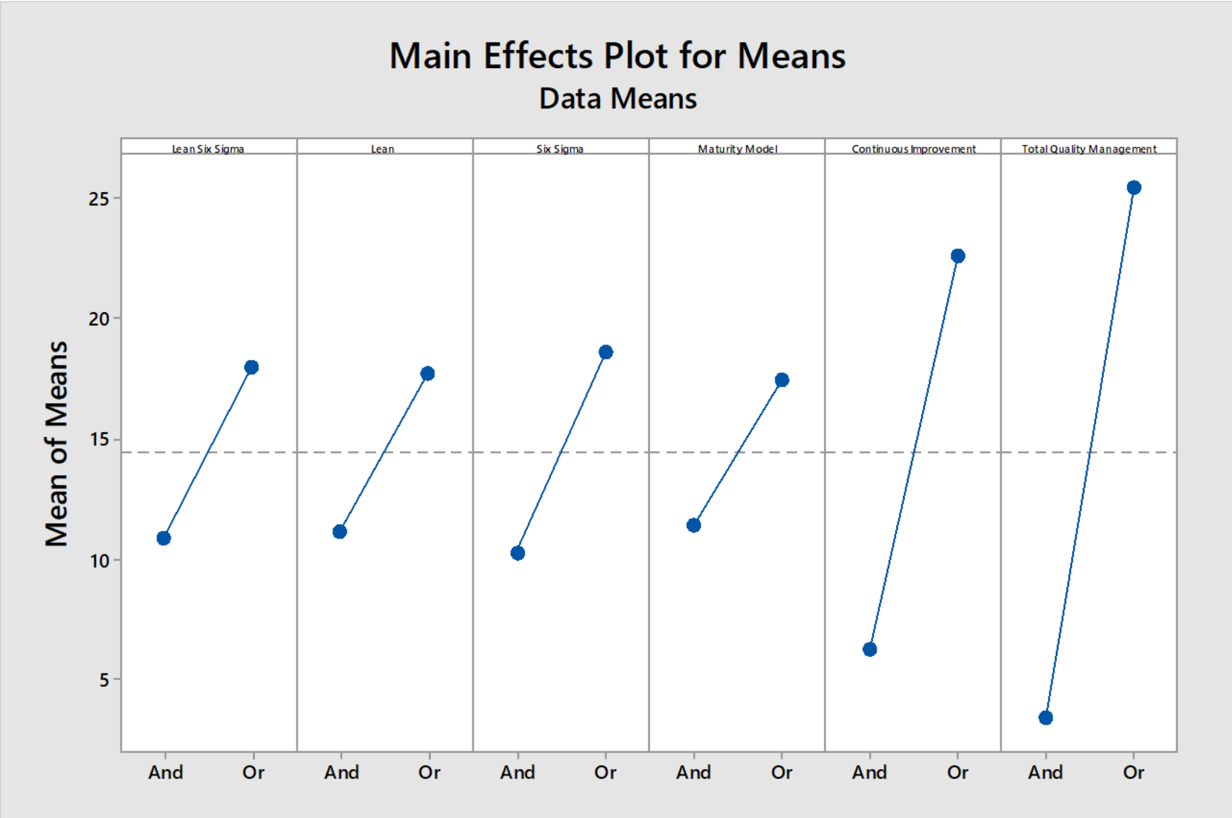


Figure 6: Main effects plot linking number of articles with the six business improvement terms – Specifically: Lean Six Sigma, Lean, Six Sigma, Maturity Model, Continuous Improvement and Total Quality Management

As demonstrated earlier, there is currently no published research directly linking the term “Academic Leadership” with “Lean Six Sigma” outside the authors own work. However, when the search criterion was widened, there are references to leadership requirements of universities in implementing Lean Six Sigma in an academic environment. These 35 articles identified using “university” in the key word/title search rather than “academic leadership” can be broken down into four discrete areas including:

1. The generic idea that quality management methodologies such as Lean, Six Sigma or TQM can be applied to the university sector to deliver change (12 articles)

2. The factors which needs to be addressed in the university sector to enable the implementation of such methodologies (5 articles)

3. The learning derived for academic institutions when implementing a quality management methodology, such as Lean or Six Sigma, specifically from case studies (15 articles)
4. The potential implementation models which could be used to implement quality management methodologies in an academic environment (3 articles)

Charting the results by year demonstrates how this field of research has grown over the last 15 years:

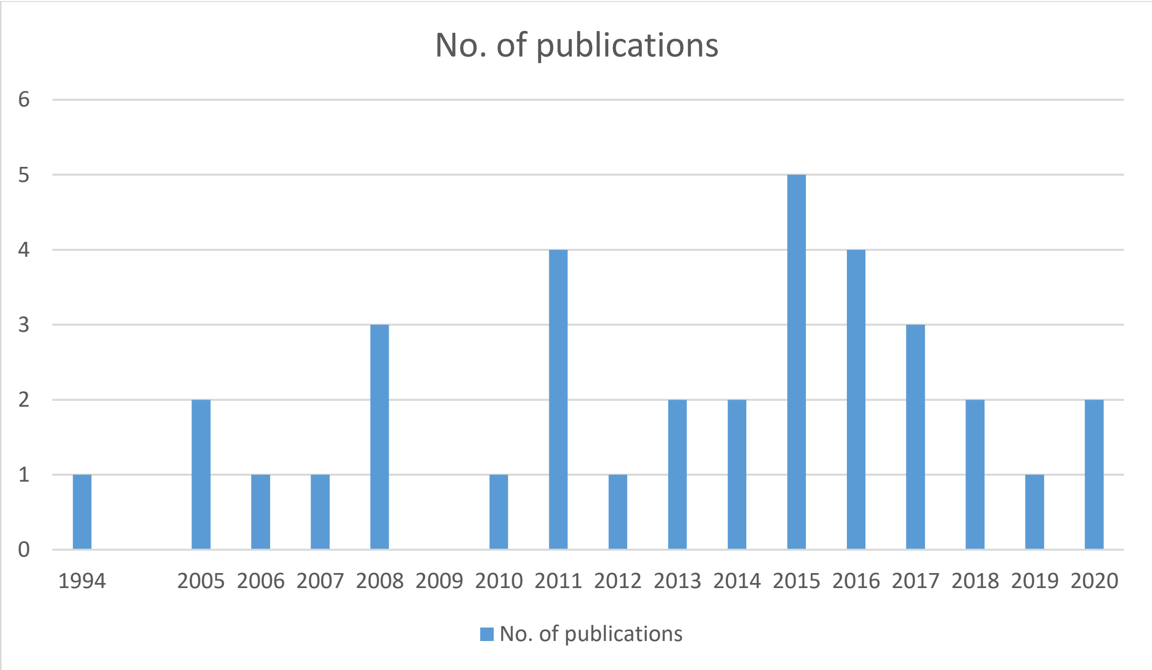


Figure 7: Total publications identified by year in the systematic literature review

Specific findings from the 35 articles identified in the structured literature review across the 4 discrete themes:

1. The generic idea that quality management methodologies such as Lean, Six Sigma or TQM can be applied to the university sector to deliver change (12 articles)

It appears that many universities are slow in pursuing continuous improvement initiatives. Those that have, have focused on administrative or maintenance based processes. Therefore, it is not surprising that teaching and research based processes have been excluded from continuous improvement initiatives because of the inherent variation in teaching and research styles and the unique nature of these processes (Temponi 2005.) A key impact of this variation is the difficulty in comparing researchers and educators in higher education, and measuring performance. What does good really look like? Temponi (2005) highlights the concerns regarding continuous improvement initiatives in academia, specifically:

- The perception that the student is a customer and that by focusing on the student as customer they attain too much influence over the institution.
- Professor's lack of full control over course content, the perceived loss of academic freedom.
- Faculty concerns over continuous improvement in education. Immature students that lack academic goals should not steer an institution's direction.
- Faculty concerns over continuous improvement and the academic system. Is continuous improvement activity within the teaching and research fields documentable? Will the pursuit of improvement activities reduce the volume of research completed?
- Student's ability to be involved in collaborative improvement. Will the knowledge and experience of the professor be lost; will the student demand the customer is always right?

To overcome these challenges Temponi (2005) suggests that continuous improvement initiatives should utilize respected educational quality standards such as the European Quality Improvement Standard (EQUIS). EQUIS is the quality assurance scheme run by the European Foundation for Management Development. It is a globally recognized standard, and has an underpinning characteristic and assumption that continuous improvement is at the heart of the educational institution. However, it is important to maintain the quality of the accreditation, there are many manufacturing quality standards which also have at their heart continuous improvement, for example the ISO9000 family of quality standards, and yet companies which don't fully embrace improvement methodologies still gain the accreditation.

In an attempt to see if continuous improvement can work in universities, Sakthivel (2007) completed a study of Indian universities. Sakthivel (2007) found a strong correlation between successful top management commitment and leadership within academic institutions, and his six education service design and delivery factors. He also showed that TQM, as a method of improving academic institutions, was also highly correlated to these six factors. The six factors identified by Sakthivel, which he called the university overall engineering educational excellence (OEEE) include customer focus, course delivery, communication, campus facilities, congenial learning environment, and continuous assessment and improvement. Sakthivel attempted to link the proposed concept of OEEE with the traditional Lean concept of overall equipment effectiveness (OEE); therefore, helping to create a linkage of manufacturing based continuous improvement concepts back into academia. Hines and Lethbridge (2008) believe that there is considerable potential in improving the customer value and eliminating the waste in universities; however, these old monolith institutions do not change quickly and the strategic structures do not make continuous improvement easy. Coleman et al. (2013) discuss building a critical mass of continuous improvement champions within an academic institution to drive change and address some of the challenges outlined by Temponi (2005.) The critical mass is made up of three elements: The Spine, the Sustainability, and the Momentum. The spine is made up of key people, in a formal continuous improvement culture. This includes the Lean Advisory Board, who set vision and direction, the Continuous Improvement (CI) Steering Committee, who are responsible to delivering the vision and direction, and the CI team, who are responsible for individual projects and initiatives in accordance with a team charter. Sustainability is comprised of a four-tiered training and development program including the team leader, coach, CI Master apprentice, and full event CI master, (Coleman et al. 2013.) As continuous improvement professionals move through the tiers, new members join at Team Leader level and a move towards coaching and mentoring and less focus on delivery becomes the main objective of a CI master. Finally, momentum relates to the roll out of these trained individuals, initially focusing on quick wins before moving on to more challenging approaches.

Sadeh and Garkaz (2015) argued that since the student can be viewed as the primary customer of higher education then a methodology such as TQM and the benchmarking approach of EFQM could be used to develop better processes and services to support these student customers. Their study attempted to explain the mediating role of service quality between quality management enablers, taken from the EFQM model, and students' satisfaction in HEIs. The key enablers being:

- Leadership in higher education
- Policy and strategy development and deployment in higher education
- Improvement of People in higher education
- Partnerships and resource deployment within higher education
- Processes and process management within higher education
- Service quality in higher education
- Student satisfaction within higher education

Khadijah et al (2016) demonstrate a potential model for deploying TQM in Saudi universities, specially making references to the success of King Abdul-Aziz University in adopting TQM. Khadijah et al (2016) go on to reference the Plan Do Check Act improvement cycle as a basis for implementing TQM in a Saudi university. Khadijah et al (2016) believes there is much to gain from combining TQM with other methodologies such as Lean and Six Sigma. Balzer et al (2016) believe that overall, Lean appears to have significant and measurable value when used to improve academic and administrative operations in higher education. Such improvements are effective at the department/unit level or throughout the entire institution. However, Balzer et al (2016) believe that implementing Lean within an institution is a serious undertaking that is most impactful if it involves long-term, strategic planning. Antony (2017) stated that Lean has been embraced by many higher education institutions at a global level to seek improvements in response to the demands of the higher education marketplace. However, Six Sigma has not been widely adopted yet in many higher educational institutions due to various challenges including: lack of quality data, lack of understanding of the benefits of Six Sigma methodology, fear of statistics, cultural barriers and misconception that Six Sigma is confined to the manufacturing processes which exhibit variation, and so on. Antony (2017) explains that the reason why Lean Six Sigma has been adopted by many organisations today instead of using Lean or Six Sigma on its own is linked to the benefits they bring to each other. Organisations can benefit from Lean thinking, particularly in the areas of elimination of waste and acceleration of process flow. Moreover, organisations can benefit from Six Sigma thinking, particularly in tackling problems with unknown solutions or chronic business problems where the previous solutions have not been effective. For these reasons, practitioners of Lean and Six Sigma started to develop the thinking towards a merger of the two approaches and Lean Six Sigma was born. Lu et al (2017) expose the lack of quantitative research with respect to the application of Lean Six Sigma in higher education and suggest further development of higher educational leaders are required. Lu et al (2016) proposed the following areas for institutions to develop leadership competencies within when trying to develop a culture of Lean Six Sigma:

- Aligning top-level management goals with those of faculty
- Employee engagement
- Data-driven decision
- Cultural change
- Reward and recognition
- Timely completion of projects

Cudney et al (2020,) having reviewed the literature on Lean and Six Sigma implementations, believe there is no widely accepted model or approach to implementing the Lean Six Sigma strategy for effective and efficient improvements in higher education. Cudney et al (2020,) goes on to state that implementing successful Six Sigma and Lean strategies is complex and the individuals executing it should be proficient, so that the quality of education can be improved without excessive costs. Finally, Cudney et al (2020) states an improved education system using Lean and Six Sigma approaches promote academic management, improve student satisfaction, and academic success.

2. The factors which needs to be addressed in the university sector to enable the implementation of such methodologies (5 articles)

Having defined academic leadership in its widest context earlier in chapter 2, there are key success factors identified across the five papers in this section. Antony (2014), Antony et al. (2012), and Zargar (1994) all identified some form of “Key Readiness” factors to enable successful implementation of quality based change management initiatives. Zarger in 1994 proposed the implementation of “modern” manufacturing quality techniques – at the time Total Quality Management (TQM) - as a solution to the challenges faced by academia and is one of the earliest articles promoting quality management methodologies to drive continuous improvements.

In 2012 Antony et al. introduced 12 barriers and challenges faced by universities if they were to embark on a Lean Six Sigma journey, including:

1. Problem of terminology – Lean Six Sigma is taken from manufacturing and uses “production” language
2. Process problems don’t occur in isolation – a Systems view is often needed in universities
3. Lack of awareness of basic concepts
4. Especially strong need to have university executive buy-in from the beginning
5. Needs long term framing – not seen as a short term fix
6. Universities are not structured around processes or process ownership – everything is treated as a task or activity
7. Need for visionary leadership
8. Cultural changes regarding peoples involvement in improvement activities
9. Lack of understanding on the concept of “customer”
10. Poor communication across a university re-enforces silo mentality
11. Perceived lack of resources and time – continuous improvement is not seen as a value adding activity to a job role
12. Challenge of linking long term continuous improvement activity to long term business strategy

Antony (2014) lists 5 readiness factors, with additional “variables” or definitions, including:

- Leadership and vision: 13 variables identified including the presence of support from leaders, the understanding that Lean Six Sigma will benefit “customers” and that leaders understand the long term nature of any implementation.
- Management commitment and resources: 7 variables identified including metrics in place to demonstrate outcomes, visible involvement, and the presence of management in Lean Six Sigma projects.
- Linking Lean Six Sigma to university strategy: 5 variables identified including projects aligned with university goals, senior management communicating the strategy, completion of smaller projects prior to tackling bigger challenges.
- Customer focus: 6 variables identified include keeping the customer at the centre of the process, accepting that universities have many “customers” and employees are driven by the mantra “how can I please the customer?”
- Selecting the right people: 8 variables including cross functional and ability teams, open mindedness and people have the right tools and techniques.

Balzer et al (2015) stated that the success of any significant organizational change effort, including Lean in higher education, will hinge on whether the university is adequately prepared to implement system-wide change. Following on from readiness to change, Balzer et al (2015) identified several key factors which will drive success in delivering Lean:

- Create the right workplace climate
- Develop the correct leadership practices
- Use pilot projects to gain visibility and credibility
- Create structures to launch and support Lean
- Facilitate institutional wide activity

Sunder (2016) describes the need for quality becoming more significant for higher education institutions across the globe, over the passage of time. Both global and national forces are driving change within and across individual countries and their higher education institutions, and hence adopting a quality excellence framework becomes essential for the higher educational institutions. Sunder (2016) identified 12 factors driving the need for quality management systems within higher education institutions:

1. Global and national forces
2. Complexity in the system
3. Preparing students for the meaning of life
4. Higher standards
5. Budget crunches
6. Need to safe guard investments
7. Need for a measurement system
8. Customer satisfaction
9. Practical learning for students
10. Need for process improvement
11. Need for innovation
12. Key performance indicators

Sunder (2016) concludes that from the literature review it is evident that the higher educational institutions, having realised the importance of quality excellence, have adopted various quality practices, however, they have not yet reaped complete benefits due to their own shortcomings and what is needed are more sector related case studies.

3. The learning derived for academic institutions when implementing a quality management methodology, such as Lean or Six Sigma, specifically from case studies (15 articles)

It is interesting to note that the majority of case studies could be regarded as relating to “administrative” type activities rather than the core elements of teaching and research. For example, four of the case studies relate to implementing Lean Six Sigma, or other quality techniques, into the university library processes (Tang, 2013; Kim, 2010; Voyles, 2008, and; Kumi and Morrow, 2006). Tang (2013) focuses on quality assurance in Australia, Kim (2010) focuses on Six Sigma in South Korea, Volyes (2008) focuses on Six Sigma in USA, and Kumi and Morrow (2006) focus on Six Sigma in the UK. In all examples, the processes were seen as simple “transactional” processes, with a clear customer, usually the student. These cases are unique in the way that they can clearly identify a “customer” of the process, in this case the student. However the role of student as a customer is often heavily debated in academic circles, (McGlinchey 2014.) All had a focus on quality as a key driver and all utilized methods to improve fault finding and increase student autonomy in interacting with the library. One institution, Newcastle University in the UK, made reference to using outside consultants, rather than internal professors or doctoral students in the quality field to bring expertise, experience, and a fresh view to the problem. Kim (2010) identified the most important factors for success within their academic environment. The top of their list was strong leadership of the top management. There are other examples of Lean and Six Sigma methodologies being used in academic institution to drive change. Emiliani (2005) discussed the use of Kaizen to improve business school degree programmes. A Kaizen blitz approach, with a 12 person strong cross-functional team over a period of several days, structured in a similar way to how manufacturing organisations may blitz a production line, identified 11 potential improvement activities that would enhance and improve the experience for students on the business degree programs. The acceptance of this approach was due to several factors including the collegiality of the group, industrial experience, proposals stemming from academics rather than administrators, a desire to improve the quality of the courses, and a willingness to try new approaches.

Another case study of note is from a medical university, focusing on operating rooms and the processes associated within them. In the USA these processes are the largest contributor to financial success (Cima et al., 2011) but also the biggest cost. Through a pure desire to become more efficient and more profitable the organisation embarked on a Lean Six Sigma journey. Typical positive results were generated; however, the reason for inclusion here is the reference to the ability of Lean Six Sigma to be applied across a diverse range of university hospital practices, without increased expenditure on resources or infrastructure, a common concern in university hospitals when trying to implement improvements. Cima et al. (2011) state that the successes witnessed, combined with the support from the institutions' leadership at all levels, made it their preferred choice for future improvement activity.

Isa and Usmen (2015) utilised Lean Six Sigma methodologies to improve design and construction services offered through facilities management departments. After being identified as deficient, one of the major related practices at a university, the General Improvement Review Form, was analysed by constructing process maps and Pareto diagrams, and further analysed by the CE matrix and FMEA methodologies using relevant Key Process Input and Key Process Out Variables. Time and costs associated with revisions and rework involving design proposal, schematic design, cost estimation and actual construction were identified as the most important factors with negative effects on project duration, quality and cost. Interesting to note again that this case studies focuses on an administrative processes within the periphery of the university function.

Hess and Benjamin (2015,) while discussing potential areas for future case studies outside of administrative processes, again debated the role of student. Hess and Benjamin (2015) believed that few institutions openly identify their students as "customers". Regardless of labels (student or customer), every institution desires to attract and retain them – surely the role of every marketing department in any other industry? If focused honestly on this goal, Hess and Benjamin (2015) believe that the culture of process improvement can be achieved. To achieve full continuous improvement higher educational institutions should develop case studies in areas including (Hess and Benjamin 2015):

- Curriculum delivery, for example through the use of student competency frameworks, measuring student performance or best use of teaching resources
- Business and auxiliary services, for example institutional revenue enhancements or overhead cost reduction projects

- Administrative, enrolment and marketing process, for example applying Six Sigma techniques to marketing data, evaluating the retention process, or standardisation of enrolment across campus
- Research, for example reducing error rates in laboratory experiments, creation of research focus groups, aligning research facilities to government requirements, and resource allocation.

Thomas et al (2017) conducted a short survey of 8 institutions across the UK to gain their understanding of Lean Six Sigma and concluded with the following 4 observations:

1. Little systematic widespread use of Lean Six Sigma was seen. In virtually all cases it was the Lean methodology that was seen as the strategy of choice in higher education. Lean and Lean Six Sigma is used as a tool-driven concept rather than a philosophical approach; with little attention being paid to the concept of Lean thinking and variation reduction.
2. Most tools employed were simplistic and standardised in nature (VSM, C+E, Pareto, SIPOC, etc.). Whilst these seemed to work correctly and effectively, the study suggested that the Lean Six Sigma projects were somewhat simplistic in nature and as a result yielded modest improvements in system performance.
3. Of the two institutions who claim to employ the Lean Six Sigma approach, neither institution had attempted to fully integrate both Lean and Six Sigma in to a coherent system of operation, preferring to use mainly the Lean tools whilst backing up specific areas through the application of some simplistic Six Sigma tools.
4. Of the institutions who employed Lean, the overwhelming response as to why Lean Six Sigma had not been considered for adoption was due to the institutions failing to see the benefits of employing the Six Sigma element of the method.

Gupta et al (2020) while investigating how student drop out numbers can be reduced through the use of Six Sigma identified several key themes from the higher educational institutions studied, including the ambiguity on dropout definition – a problem which could be addressed with Lean Six Sigma voice of the customer or problem definition techniques, and incomplete or no data set on the reasons behind students drop out – a problem which could be solved through better data collection, statistical methods and measurement systems analysis techniques. Gupta et al (2020) concluded by describing their lessons learnt from their case studies in the form of a drop out strategy, mapped against the DMAIC problem solving acronym – see figure 8 below:

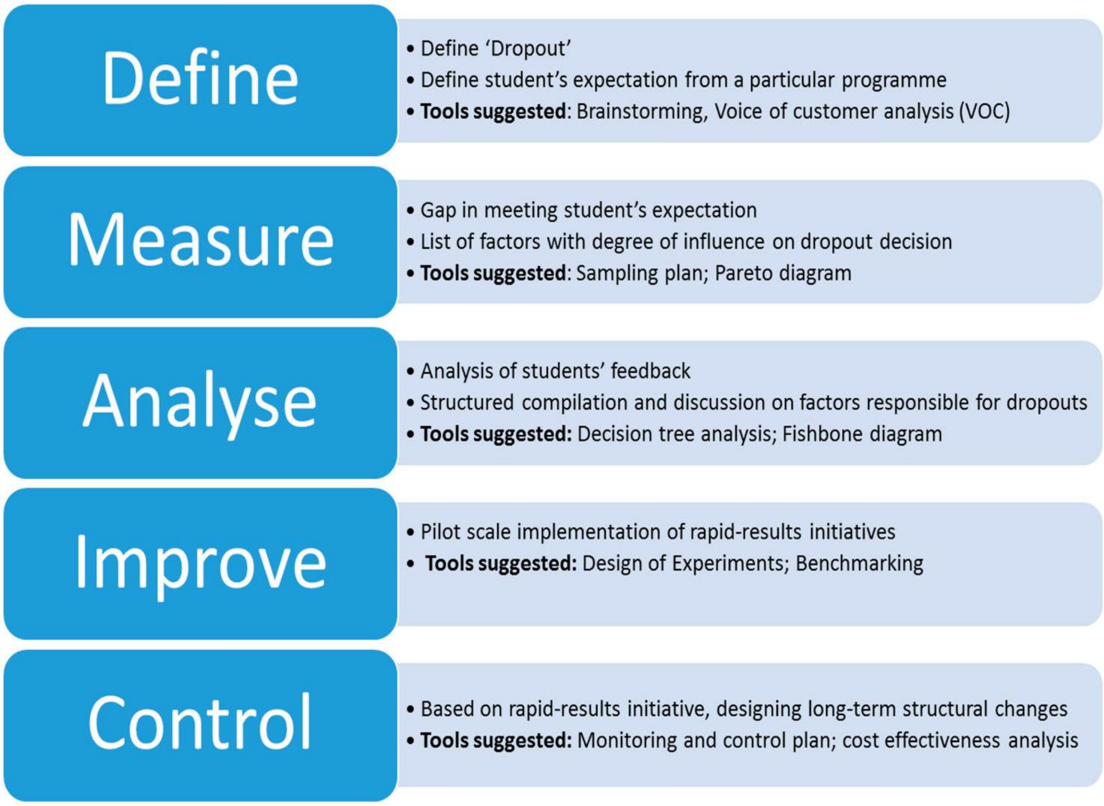


Figure 8: Dropout control strategy suggested by Lean Six Sigma experts, Gutpa et al (2018)

Many of the case studies presented here are international in nature, demonstrating the need across all higher educational institutional to strive for improvement, irrespective of their history, governance, or macro political structures they find themselves working within. Haerizadeh and Sunder (2018) are no different as they describe the challenges faced by Allameh Tabatabai University in Tehran, Iran with regards to student complaints and student satisfaction. The key lessons from the case study include:

- The importance of a project management approach and the experience based learning which Lean Six Sigma provided to the students.

- The role of the pilot projects in providing an opportunity for the students to engage with a wide group of stakeholders and understand the Lean Six Sigma toolkit
- The application of statistical and management tools and the importance of measuring data.

Finally, Haerizadeh and Sunder (2018) concluded by stating that a framework or roadmap is required to embark on the Lean Six Sigma journey and that academic leadership is vital for success.

Antony et al (2018) while studying the journey undertaken by a university deploying Lean Six Sigma identified the following key lessons learned from the execution and implementation of a series of Yellow Belt projects:

- Taking the right measurements is a significant challenge for HEIs.
- Terminologies taken from manufacturing and engineering industries are not readily accepted in the higher education sector.
- Quantifying process improvement savings was extremely difficult.
- The devolved nature of some HEIs creates challenges for establishing ownership of key processes and ensuring all stakeholders are active participants in improvement activities.
- In order for staff to feel they are part of the organization and openly talk about their improvement suggestions, there needs to be a culture of openness, trust, and acceptance
- Most of the projects carried out by staff members were at the operational level.
- For sustainability of a process improvement initiative such as Lean Six Sigma, it is critical to have a dedicated Lean Six Sigma deployment champion who can report directly to the executive team of the university about the progress and the nature of strategic projects.
- There was no formal reward or incentive system in place.

4. The potential implementation models which could be used to implement quality management methodologies in an academic environment (3 articles)

Three papers propose frameworks and models for implementing Six Sigma, EFQM, or TQM into a university environment. Jenicke and Holmes (2008) developed a three-tier approach to implementing the DMAIC cycle and related key performance indicators. The idea was to maintain coordination across a complex and disparate organization such as a university. Jenicke and Holmes' (2008) three tiers are mapped against the DMAIC cycle as follows:

- Tier 1 was at the university level (Define part of DMAIC).
- Tier 2 was at the college or school level (Measure and Analyse part of DMAIC).
- Tier 3 was at the departmental or major level (Improve and Control part of DMAIC).

The performance indicators were split between: institutional reputation, student quality, faculty quality, and fiscal position, and are across all three tiers. The paper is unclear on how one would roll out Lean Six Sigma, and the authors' assumption is that the relevant key performance indicators would drive project activity. Jenicke and Holmes (2008) conclude by stating that top management is critical for success.

Campatelli et al (2011) utilizes the European Foundation for Quality Management (EFQM) model to evaluate the efficiency of a process, and then Six Sigma methodologies to address the corrective action plan. The EFQM evaluation is applied to discrete administrative processes rather than the whole organisation. Campatelli et al (2011) suggests an annual audit of processes using the EFQM model, especially after they have undergone a Six Sigma improvement cycle.

The assessment is made up of a simplified EFQM model, utilising not the original nine areas but four. Each area having a series of audit questions (Campatelli et al 2011):

- Results – e.g. the trend of the process results?
- Approach – e.g. constant approach each time the process is run?
- Improvement – e.g. can improvement be measured?

- Deployment – e.g. is the process well defined?

The main reason cited for using Six Sigma to deploy any improvement activity within a university administrative function is the systematic and structured nature of a DMAIC project.

Sunder and Antony (2018) explain that the Lean Six Sigma methodology is preferred over any other quality excellence methodology for service industry due to the following advantages:

- A structured approach to eliminate the root cause of the problem;
- Stakeholder involvement at every stage of the roadmap;
- Statistical as well as walk-the-floor approach combination;
- Breakthrough and sustainable improvements for customer delight;
- Improves teamwork and involvement;
- Easy to document and share for best practices;
- Cuts across cross-functional barriers;
- Reduces handoffs and improves process flow;
- Reduces both process waste and process variation; and
- Systematic deployment approach.

Sunder and Antony (2018) introduce a staged framework – see figure 9 below:

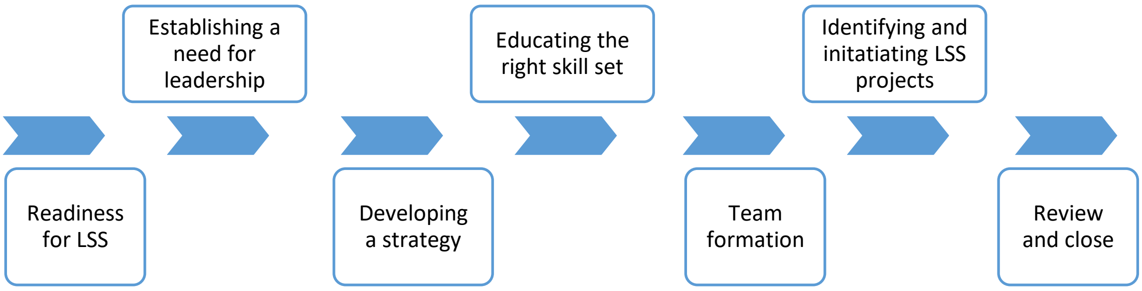


Figure 9: Sunder and Antony (2018) framework for deploying Lean Six Sigma (LSS) in higher educational institutions

When it comes to Lean Six Sigma project management in HEIs, Sunder and Antony (2018) suggest that their proposed model could be used for improving both academic and administrative processes of HEIs.

In essence, there is no “true” maturity model similar to Collins (2001) Leadership Maturity Model, which has been developed or tested for implementing Lean Six Sigma in higher education. A gap, therefore, has been identified, to create a model with a focus on academic leadership that could enable and support leaders in the university sector in implementing change through Lean Six Sigma as a business improvement strategy. The final chapter of this review outlines the authors’ plans to research and address this gap and develop potential research questions, building on the observations so far in this literature review.

3.6 Key Research gaps and development of research questions

The author has identified 8 potential research gaps from the systematic literature review and wider definition of terms work in previous chapters:

1. Academic leadership is still in its infancy when applied to continuous improvement methodologies such as Lean Six Sigma and more research is required to understand how specifically academic leadership can improve the chances of success within the higher educational sector.
2. Terminology needs to be adapted and developed to enable continuous improvement practitioners and change agents the ability to engage with the widest possible stakeholder group within the higher educational institution.
3. Need to move beyond addressing challenges within administrative processes, with more case study research required to demonstrate the power of continuous improvement methodologies when applied to teaching, research and other academic processes and practices.
4. Within these new case studies, higher educational institutions must embrace the wider Lean Six Sigma tool kit, moving beyond simple tools and utilising more complex approaches such as Design for Six Sigma or advanced statistical tools such as process control charting.

5. Research is required to conclude the debate of the “student is customer” argument. Higher educational institutions cannot on one hand recruit, retain, and court students with promises of successful futures, while on the other hand treat them with disdain and mistrust with regards to their educational expectations and desires. This conflict causes difficulty at the start of every Lean Six Sigma project where the student is at the heart of the process under study. If the student is not a customer, what are they?
6. Measuring success and the value higher educational institutions offer is both potentially easy, with respect to administrative processes, and difficult with respect to academic processes. A key element of any Lean Six Sigma project is the ability to measure impact after the project is concluded. Robust data and statistics are required, but also alternative ways of measuring success is required if projects are to move into non administrative areas such as teaching or research.
7. Although simple implementation models exist, no formal leadership maturity model or detailed implementation maturity model exists to advise, benchmark and guide higher educational institutions on their journey to becoming a market leader in the deployment of Lean Six Sigma.
8. Sustainability of Lean Six Sigma is not addressed anywhere significantly within the literature, with no thought to how Lean Six Sigma can mature, grow and develop along with the growth and development of the higher educational institution.

Taking themes from several of these research gaps, specifically numbers 1, 6, 7 and 8, the author wishes to focus on trying to address the following research question, the aim of this thesis:

If academic leaders need to change their institutions to remain relevant in the modern world how can they use tools and techniques from other industries such as Lean Six Sigma to deliver successful change?

The author will break down the research question into 3 achievable objectives:

Objective 1: What is the role of academic leadership in delivering change in HEIs and is their context and approach similar to that of or industries and is there a need for a separate definition for academic leadership?

Objective 2: What is the current situation within UK HEIs with respect to implementing Lean Six Sigma to delivery change? Is this approach different from HEIs from around the world and is it different from the manufacturing sector – the traditional home of Lean Six Sigma? For example: how is Lean Six Sigma (or similar) continuous improvement programme success measured, monitored and sustained in a higher educational institutions and how does this differ from non-academic applications? What type of Lean Six Sigma (or similar) continuous improvement programmes exist within higher educational, how do they translate across to a typical Lean Six Sigma programme in industry, and do they vary depending on whether it is being applied institutionally wide, localised within a department, or within an administrative, research or teaching process?

Objective 3. Does a hierarchy of successful academic leadership exist, like the Collins maturity model, for implementing Lean Six Sigma (or similar) continuous improvement programmes in higher educational institutions – and if so how is that hierarchy constructed, what language does it use, is it similar to the Collins maturity model, and how could higher educational institutions benchmark themselves against this hierarchy or model?

The following chapter describes the authors own research philosophy and the approach undertaken to meet these three research objectives.

Chapter 4: Research Methodology

4.1 Introduction to research philosophy:

The pursuit of knowledge requires the author to understand their own view of the world, their strengths, their weaknesses, their assumptions and their internal and external conflicts when it comes to conducting research. Before the author moves into the area of gathering new data to combine with their systematic literature reviews it's important to try and understand how this data could be influenced by the author's own paradigm and bias.

Knowledge and its creation can be described as sitting on a continuum, (figure 10) where on the left all research and knowledge is developed for pure academic purposes and on the right its sole purpose is for commercial application or problem solving (Saunders et al. 2009.) Both are equally valid and ultimately depends on the view of the researcher. For example, some believe that research must not be purely academic but have practical applications (Tranfield and Starkey 1998) where others believe application cannot exist without first "blue sky" thinking (Linden 2008.) The term blue skies research implies a freedom to carry out flexible, curiosity-driven research that leads to outcomes not envisaged at the outset. This research often challenges accepted thinking and introduces new fields of study (Linden 2008.)

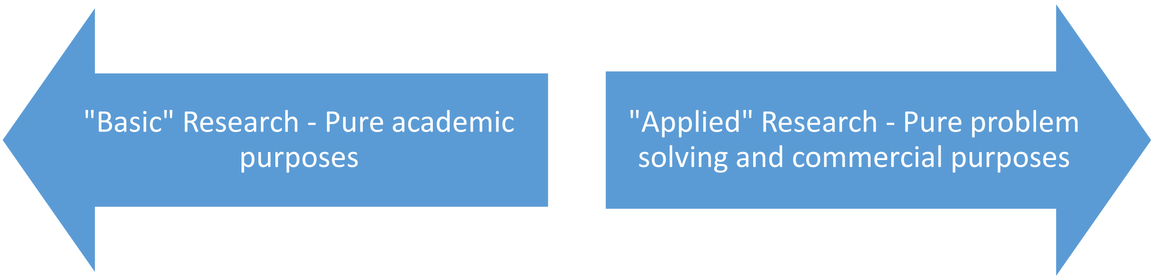


Figure 10: The research continuum, Saunders et al (2009)

Wherever the researcher sits on this continuum, the process of conducting research can be described as a “research onion” (Saunders et al 2009.) Like the vegetable itself the process of research is made up of several layers:

Layers of the “Onion”	Choices available
Philosophies	Positivism, Realism, Interpretivism, Pragmatism
Approaches	Deductive, Inductive
Strategies	Observation and Interviews, Case studies, Narrative Ethnography, Theory, Discourse Analysis, Historical Methods, Data Modelling, Multilevel Modelling, Meta-Analysis, Surveys etc.
Methods	Mono Method, Mixed Method, Multi Method
Time Horizon	Cross sectional, Longitudinal
Techniques and Procedures	Data collection and analysis

Table 15: The research onion, Saunders et al 2009

However, there is another layer which needs to be applied above this research process – the researcher’s own ontological and epistemological positional held – sometimes called the research paradigm (Guba and Lincoln 1994.) This paradigm will drive the researcher’s choices from the above table and their biases need to be understood, (Johnson and Clark 2006) since these world views may skew the research or affect the manner in which the researcher defends his findings (O’Gorman and MacIntosh 2014.)

4.2 The Research Paradigm

Specifically Ontology is the researcher’s view on how the world works and how reality is understood. There are two types of ontology (Meredth et al 1989); Objectivism and Subjectivism. Objectivism relates to the scientific approach, where reality is fact irrespective of the researcher. The aims here are always to discover the “facts”. Subjectivism views the world as constantly changing and reality is dependent on the person viewing it. Thus “facts” are fluid and views and interpretations become important.

For example, the author of this thesis heralds from a strong engineering background, is the son of a working class miner, studied engineering at university and has had a 20 year career in Six Sigma and heavy industry; which means that although he values individual opinion, he will always seek the “facts” in any situation - closely aligning to a objectivism ontology.

Epistemology relates to the research philosophy. These are the beliefs held by the researcher which will shape how they approach a particular problem or question. There are three common types: Positivism, Interpretivism and Realism. (Easterby –Smith et al 2004.)

Positivism is generally linked to deductive and, but not exclusively, quantitative approaches to research and sits comfortably with the Objective ontology. The assumption underlying this approach is that the field of study can be “measured” rather than described subjectively (Remenyi et al 1998.) Positivism stresses the importance of pure data as well as facts without being influenced by interpretation of bias from human observations (Scotland, 2012; Saunders et al 2012.) Another indicator of this approach is that findings can be universally applied and are highly repeatable, for example in the optimisation of manufacturing processes (Gill and Johnson 1997.) According to Chua (1986), Positivism is mainly involved in the testing, verification and falsification, and prediction of generalisable theories about an objective reality and is associated with hypothesis testing deriving from existing theory through measuring observable social realities.

Interpretivism developed through critique of positivism with subjective perspective can be viewed as the complete opposite to Positivism. Interpretivism is more concerned with in depth variables and factors related a context, it considers humans as different from physical phenomena as they create further depth in meanings with the assumption that human beings cannot be explored in a similar way to physical phenomena, (Saunders et al., 2012; Bhattacherjee, 2012, Myers, 2008). Interpretivism is highly related to the subjective ontology and tries to develop theory from several individual viewpoints. This approach is highly effective in social science applications where complexity is difficult to measure or describe using traditional scientific techniques (Saunders et al 2009.)

The third approach, Realism, in some ways overlaps with the previous two and relates to how the researcher's own senses portray reality (Saunders et al 2009.) Direct Realism is where the researcher can accurately portray reality, whereas Critical Realism is where they only receive feedback from a point of view and may not give the researcher a complete understanding of the true reality (Saunders et al 2009.) For example leadership research needs to embrace abstract concepts, varied contexts and square this with the idea of leadership as a process which can be taught to potential leaders (Kempster and Parry 2011.) Kempster and Parry (2011) suggest a move to Grounded Theory (a form of Interpretivism) through the lens of Critical Realism which resonates more closely to this more complex view of Leadership compared with Positivism.

Grounded Theory is the discovery of theory from data systematically obtained from social research (Glaser and Strauss 1967.) In general, Grounded Theorists seek to move in a systematic way from categorising data related to a phenomenon towards linking those categories. From this an integrated picture and story is developed and an explanation of the context based phenomenon should emerge.

Critical Realists believe an entity is real if it has causal efficacy, i.e. it has an effect on behaviour or makes a difference. Fleetwood (2005) explains 4 different types of "reality". The concept of Leadership closely matches the second, Ideally Real; The others being Materially Real, Artefactually Real and Socially Real.

For example although the researcher has come from a strong engineering background and sits comfortably in the world of Positivism, the subjectiveness of academic leadership as described early in the literature reviews leads the author towards a more Interpretivist and Critical Realism approach. However the author wishes to be able to apply his findings in a wider context and hopes his conclusions will be repeatable – traits associated with positivism and grounded theory.

4.3 Research Approach:

Moving through the research onion the authors' next decision is around research approach.

There are two approaches described by Saunders et al (2009) – The deductive and inductive approaches. The deductive approach is used to test established theories or hypotheses. Data is collected and conclusions drawn on whether these theories are correct or not. The inductive approach is where data is used to develop new theories or hypotheses which can then go onto be tested in a deductive manner with more additional data. There is no reason why a researcher cannot use both approaches within the same thesis to both build and test theory (Saunders et al 2009.)

Within these two approaches the purpose of the research can be considered to be exploratory, descriptive or explanatory (Saunders et al 2009.) Exploratory research has the aim to better understand a particular topic. Typically the author starts at a very broad level of understanding with the aim of developing a more specific research question to answer later. Descriptive research aims to define the current state of a problem or process (Robson 2002.) It is interested in creating knowledge centred on what is actually happening. Explanatory research tried to develop knowledge around not what is happening but why it is happening (Phillips and Pugh 2005.) Again there is no reason why a researcher's own thesis cannot utilise all of these approaches in developing their understanding and strategy for answering their own research questions (Saunders et al 2009.) For example, in earlier chapters the author has used the concept of a literature review to identify the gaps in our understanding of how academic institutions are using Lean, Six Sigma and Lean Six Sigma to deliver change in their respective institutions. From this gap analysis the author has identified the need for a leadership maturity model unique for academia. This model now needs to be designed, built and then ideally tested to meet the author's own desire for any outcome to be repeatable and widely applicable – his positivism surfacing again. The author has moved from initially a broad question of how universities are using Lean, Six Sigma and Lean Six Sigma to one where it is centred on a leadership maturity model for implementation, an exploratory approach, however to build this model the author needs to understand what is and is not unique to the world of academia, and this requires some descriptive and explanatory approaches. Table 16 below summaries the characteristics, of the three different approaches deployed by the author:

	Exploratory	Descriptive	Explanatory
Aim: (Saunders et al 2009, Robson 2002, Phillips and Pugh 2005)	Typically the author starts at a very broad level of understanding with the aim of developing a more specific research question to answer later	Descriptive research aims to define the current state of a problem or process	Explanatory research aims to develop knowledge around not what is happening but why it is happening
Starting Hypothesis and level of understanding of key variables (Saunders et al 2009, Jackson 2011)	No starting hypothesis, tends to create hypotheses rather than test them, and key variables under study not defined	Speculative initial hypothesis and key variables defined	Specific hypothesis documented and key variables and key relationships between variables defined
Research methods deployed, along with numbers from a doctorial study in a USA university (Miller 2011)	Exploratory was the most popular within the study: Survey - 57 Interview - 55 Case study - 30	Survey - 33 Interview - 19 Case study - 9	Explanatory was the least popular within the study: Survey - 9 Interview - 7 Case study - 5
Data type, limitations and examples (Sue and Ritter 2012)	Data from exploratory studies tends to be qualitative. Examples include brainstorming sessions, interviews with experts, and posting a short survey to a social networking website.	Data from descriptive research may be qualitative or quantitative, and quantitative data presentations are normally limited to frequency distributions and summary statistics, such as averages; for example customer satisfaction surveys.	The data is quantitative and almost always requires the use of a statistical test to establish the validity of the relationships. For example, explanatory survey research may investigate the factors that contribute to customer satisfaction and determine the relative weight of each factor, or seek to model the variables that lead to shopping behaviour

Table 16: Reviewing the different research approaches

4.4 Research Methods

There are many different approaches available to the researcher to assist them in developing knowledge in a manner which fits their ontology and epistemology. Figure 11 illustrates some of the many options available and a selection of these are explained in detail below. The choice of method is linked strongly to the research philosophy and approach already defined by the author.

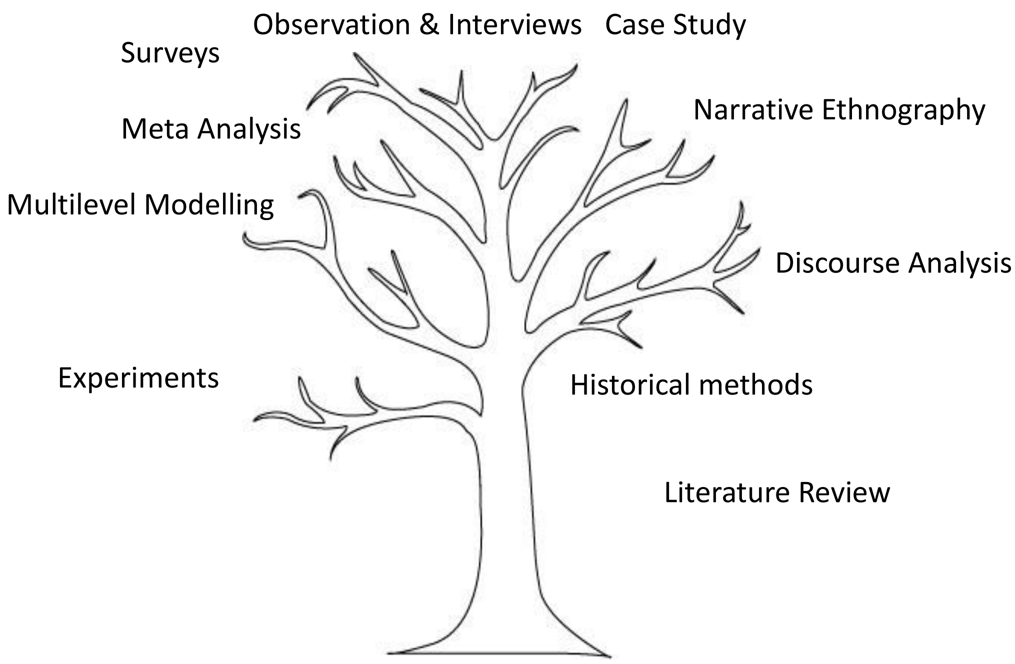


Figure 11: Different research methods, adapted by the author from the research methods course attended at The University of Strathclyde, November 2013

4.4.1 Author's self-reflection and selected methods

Having reviewed the different research paradigms, the author has attempted to complete a self-assessment against the research philosophies, methodologies and approaches – see table 17 below. This will enable the author to frame their research questions more accurately, develop a strategy for collecting empirical research, defend their findings, and enjoy the experience of this period of their life:

Research philosophies, methodologies and approaches		
1. Continuum	Basic	**Applied** (the author wishes to try to develop a model which can be applied and used by higher education, Saunders et al 2009)
2. Ontology	**Objective** (the author wishes to use a fact based, scientific approach, Meredth et al 1989)	Subjective
3. Epistemology	**Positivism** (the author wishes to adopt an deductive and quantitative approach, (Remenyi et al 1998) Direct Realism	Interpretivism **Critical Realism** (the author has only limited experience of academic life and therefore will rely on feedback from others from within the sector, Saunders et al 2009)
4. Approach	Deductive **Exploratory** **Descriptive** **Explanatory** (the author wishes to use all three approaches in a joined up approach to develop, build and test a maturity model, Saunders et al 2009)	**Inductive** (the author wishes to use data to create and test theory, Saunders et al 2009)
5. Research Method	**Mixed** (the author wishes to use a variety of techniques to develop, build and test the maturity model, Saunders 2009)	**Literature Review, Surveys, Semi Structure Interviews, Test Case Studies,** (the author wishes to test the model using similar approaches which were used to build the model, and are tried and tested in higher educational research, Saunders et al 2009)

Table 17: The author's research self-assessment

However, the author recognises that being on the extremes of any of these characteristics is not ideal and he acknowledges the benefits of being aware of the opposing view point. The author accepts that his own strong positivism view point will need to be tempered by critical realism and a mixed method approach to enable him to build, develop and test his ideas.

Below is a summary of the authors chosen research methods:

4.4.2 Literature Review

A literature review is the process used to establish the current and historical research of a given topic or area of interest for the researcher. For any researcher this is an important starting point for their work since it will often provide direction for research, identify gaps for new theory or provide justification for the researchers question (Bruce 1994.) The four main types are: Traditional, Systematic, Meta-Analysis and Meta-Synthesis.

Traditional literature reviews summarise the existing literature in a manner which ensures rigour but often lacks structure. It is often used to generalise a field of study and share current thinking about a topic or subject matter (O'Gorman and MacIntosh 2014.) For example the author conducted a traditional literature review in chapter 2 in order to define academic leadership.

Systematic literature reviews apply a logic and an approach to answering a specific research questions. They are often structured using logic queries and specific database searches (Jesson et al 2011.) For example the author in chapter 3, wishing to identify the gaps in literature around a maturity model for deploying Lean Six Sigma in HEI, utilised a structured literature review based on a Lean Six Sigma technique known as Taguchi Design of Experiments. This approach help identify the lack of knowledge in this area and thus help justify the remaining research.

If the author wishes to specifically analyse the findings of any literature review using a statistical method this is known as Meta-Analysis (Coughlan et al 2007). However if a non-statistical approach is adopted, for example summarising findings in a table, this is known as Meta-Synthesis O'Gorman and MacIntosh 2014.)

4.4.3 Surveys

Surveys and questionnaires enable the researcher to be robust when interviewing individuals about their field of research. If structured well they can negate the bias that may exist within the researcher's own research paradigm and provide a large sample size of respondents quickly and efficiency (Saunders et al 2009 and O'Gorman and MacIntosh 2014.) However surveys are not without their problems. Vogt (2013) states the aim of questionnaires is often less to discover a causal link between variables (internal validity) and more to generalize a finding from a sample to a population (external validity.) The best known example is in election surveying. The population of likely voters is identified, a random sample is taken using more or less complicated sampling techniques, and respondents are asked about their voting plans – whether they intend to vote and if so, for whom. Attempting to survey samples from populations whose members are rare or unknown raises complicated uncertainties. One cannot very easily sample from a population when it is difficult to find, or when one does not know what it is. So the first step becomes defining or identifying the population rather than sampling from it (Vogt 2013.) In addition surveys rely on a certain amount of self-reporting (Kirk Smith 1998) and this is acknowledged to include measurement error in the form of bias and inconsistency of answers.

Most researchers use one of five types of surveys (Porter 2004.) "Fill in the blank" surveys, which use sheets of paper with check-off boxes and blank spaces for written responses, is the most familiar method of administering a survey. Two additional types of paper surveys have become more common because they are machine-scannable. The first is called an optical mark recognition survey, often referred to as a "bubble" survey because of the small circles that must be filled in to indicate particular responses. The second is referred to as an optical character recognition survey. Each of these surveys appears similar to the other; the difference lies in how each is scanned. Optical mark recognition survey scanners can read only markings such as bubbles. Optical character or recognition surveys combine optical scanners and sophisticated text-recognition software, so these surveys can use not only bubbles but also check boxes. More important, the software can read text written by the respondent and convert it into an electronic format similar to that provided by a word processor. Finally, many researchers have adopted one of two types of electronic surveys. The first type is a survey sent via e-mail, either as text in the body of the e-mail itself or as an electronic attachment. The second type is the more familiar Web survey, an HTML form that is posted on a Web site, of which respondents are notified (Porter 2004.) Table 18 below highlights the main differences between the 5 types of survey:

<table>
<tr><th>Fill in the blank paper surveys</th><th>Optical mark recognition surveys</th><th>Optical character recognition surveys</th><th>Email based electronic surveys</th><th>Web based electronic surveys</th></tr>
<tr><td>Lowest equipment cost option</td><td>Requires scanning equipment</td><td>Requires scanning and text recognition software equipment</td><td colspan="2">Limited equipment required, however dedicated software is needed</td></tr>
<tr><td>Data needs to be manually entered into data bases</td><td colspan="2">Automatically scanned into database, although requires manual loading of scanner</td><td>Responses need to be manually collated and entered into database</td><td>Dedicated software automatically collates results</td></tr>
<tr><td colspan="3">Costs associated with survey production – printing, postage and return envelopes</td><td colspan="2" rowspan="2">Costs associated with production, implementation and distribution are regarded as negligible</td></tr>
<tr><td colspan="3">Costs associated with survey implementation and distribution – through either postage or telephone</td></tr>
<tr><td colspan="2">Limited ability to handle open ended questions</td><td>Text recognition software able to handle free text</td><td colspan="2">Eligibility of handwriting not an issue for electronic surveys</td></tr>
<tr><td>Typically longest project duration time</td><td colspan="2">Medium project duration time</td><td colspan="2">Shortest possible project duration time</td></tr>
</table>

Table 18: Main differences between survey types (Porter 2004)

All five forms share a common process covering five stages (Edwards and Thomas 1993.)

1. Identify the purpose of the survey and challenge if a survey is the most applicable method of answering the research question
2. Develop the survey, its form and approach
3. Identify the desired number and profile of respondents and distribute the survey
4. Collect the results and complete analysis
5. Communicate the results to interested parties

When designing survey questionnaires, it is critical to ensure the survey is structured and designed in a suitable manner, and that questions cannot be misinterpreted by the reader (O'Gorman and MacIntosh 2014.) One way to avoid this misinterpretation is through the use of a pre-testing or a pilot survey (Moser and Kalton 1971.) Pre-testing or piloting a survey gives the researcher a chance to gauge the meaning attributed to the survey questions before substantial investment is made in the wrong questions or approach (Bowden et al 2002.) The pre-testing involves a numbers of steps:

1. Establishing the intended meaning of each question – for example by creating a description of the meaning and intention of the question to check against future responses.

2. Agreeing a set of criteria to judge the appropriateness of each question – see table 19 below for examples of ways to assess the appropriateness of each question.

3. Agreeing a method to test each question – for example using a targeted group where questions can be debated within the group to test their language, how they are interpreted and if they need to be debated first before answering.

4. Reviewing each question based on the feedback from the pilot survey to decide whether to include, revise or exclude from the survey.

Criteria for assessing the appropriateness of each question:	Assessment Result?
1. No negative questions and no double negative answers	
2. There are not two questions in one	
3. Level of language is appropriate for the audience	
4. The question is grammatically correct and free from jargon	
5. The singular and plural “you” is clear	
6. The same idea is not contained in another question	
7. The meaning and interpretation of the question is clear	
8. A “yes” or “no” is unambiguous in meaning	
9. Any time related periods are clear	
10. The questions capture current views and issues	

Table 19: Criteria for judging the appropriateness of survey questions, adapted from Bowden et al 2002

Often survey questions use a scale to score responses – for example measuring customer satisfaction on a scale of 1 to 5, where 1 is poor customer satisfaction and 5 is excellent customer satisfaction. These scales are known as Likert scales, (Joshi et al 2015.) The Likert scale was developed in 1932 and devised in order to measure responders’ attitudes to certain situations in a scientifically accepted and validated manner, (Joshi et al 2015.) The Likert technique is referred to as a summated rating scale because the responses received from each item are summed (or averaged) to obtain the respondent’s score on the scale (Vaske et al 2017.) Cronbach’s alpha, often symbolised by the lower case Greek letter α, is commonly used to examine the internal consistency or reliability of summated rating scales (Cronbach, 1951) Cronbach’s alpha measures the extent to which item responses (answers to survey questions) correlate with each other. In other words, Cronbach’s alpha estimates the proportion of variance that is systematic or consistent in a set of survey responses. The statistic alpha “typically” ranges from 0.00 to 1.00, but a negative alpha value can occur when the items are not positively correlated among themselves, (Joshi et al 2015.) The final Cronbach’s alpha value is a function of the number of items in the scale, and although alpha is a function of the item inter-correlation, it needs to be interpreted with the number of items in mind, (Cortina 1993.) It is accepted that an ideal Likert scale will have a Cronbach's alpha of greater than 0.75, (Cortina 1993,) however Cortina (1993) concluded that the more items utilised in the scale the less accurate as a measure of reliability and inter-correlation the Cronbach's alpha becomes. For example with 20 items on the scale, the alpha can still be greater than 0.75 but have a small correlation coefficient between items. Thus Cortina (1993) recommended using the Cronbach's alpha carefully when designing complex, multidimensional multi-item survey analysis.

Once the survey is designed and a plan to analysis the results is in place, the researcher needs to identify their target audience, or "sample" from the wider "population" (Breakwell et al 2004.) There are several sampling strategies available to the researcher; table 20 below highlights the main differences between the approaches. The approach taken depends on several factors: the type of measurements and data to be collected; the nature and structure of the population to be used, sometimes called the sampling frame; the complexity of the survey or research method; and the resources available, (Breakwell et al 2004.)

	Simple Random Sampling (SRS)	**Stratified Random Sampling (STRS)**	**Cluster Sampling Procedure (CSP)**	**Quota Sampling (QS)**	**Theoretical Sampling (TS)**
Aim:	To achieve a random sample from the population sample frame by using probability approaches	The population is grouped in "stratas", allowing SRS techniques to be applied to smaller sample frames.	Creating geographical clusters of populations to draw random samples from	Creates samples using targets and quotas for particular groups	Aim not to develop population parameters but develop pure theory by selecting groups to provide theoretical insight This sampling method is closely associated with grounded theory methodology.

Ad-vantages	Ensures a high degree of representations Reduces the potential for researcher bias SRS permits the full use of statistical techniques in analysing the data	Guarantees key groups will be within your random sample Reduces the potential for researcher bias	Cost effective approach when studying large geographical areas or international based studies Clusters may allow for larger sample frames to be studied, improving the final recommendations and generalisations	Cost effective way to represent a population	The approach improves the rigour and creates structure for the development of theory This type of sampling usually integrates both inductive and deductive characteristics, thus increasing comprehensiveness of studies.
Dis-advantages	Difficult to achieve a truly random sample with large sample sizes without some form of sampling interval approach Can be time consuming to create the full sample frame	Initially the researcher may not have the required information to create the stratas Can become more expensive to complete, as a statistical significant sample within each strata is required	Geographical clusters may have a tendency to attract entities with similar characteristics. It is therefore possible that selecting a cluster may completely remove certain key groups from the researcher's sample frame	Several selection biases from the researcher may render the samples unrepresentative, groups outside the quota system may be over looked Can result in generalisation comments being invalid Difficult to calculate sample error due to lack of randomness in the sample frame	Because it is a highly systematic process, application of theoretical sampling methods may require a larger sample size compared to many other sampling methods. Overall, theoretical sampling is the most complicated compared to other sampling methods

Table 20: Sampling strategies, their advantages and disadvantages (Breakwell et al 2004, Chaudhuri and Stenger 2005, and Glaser and Strauss 2012)

The author is researching how higher educational institutions are adopting Lean and Six Sigma methodologies. Because these institutions can be broken down into different groups, for example UK universities, UK colleges, International Institutions etc. this tends towards developing a stratified random sampling approach. This approach has been used in a variety of higher educational based studies including: Yusuf and James (2010) investigating the use of university libraries, Garkaz et al (2011) researching the factors which affect student performance within a university, and Sultan et al (2018) investigating leadership styles within Islamic universities. In addition, stratified random sampling has been used to support research into adoption of improvement methodologies, including: Kumar and Antony (2008) investigation into the differences between quality management practices within SMEs, Zahraee (2016) research into the way in which Lean has been deployed in manufacturing companies, and Ahmed et al (2018) research into how Six Sigma has been adopted by hospitals.

4.4.4 Interviews

An interview involves the researcher in a one to one discussion with the interviewee. The aim is to gain valuable depth of understanding. An interview can be structured, unstructured or both in its design, however the more unstructured the approach, the more difficult it will be for the researcher to analyse the findings later and create generalised theory which is transferable to other situations (O’Gorman and MacIntosh 2014.) Unlike interviewer administered questionnaires, interviews comprise a relatively free-flowing interchange of views between two or, in the case of group interviews, three or more people, (Saunders & Townsend, 2016.) The main drawbacks of an unstructured interview are the collection of irrelevant data or potentially the interviewee’s answers being affected by the researchers own bias (O’Gorman and MacIntosh 2014.)

Table 21 below illustrates the different types of interview, their strengths and weaknesses and usefulness in the research:

	Structured Interview	**Semi Structured Interview**	**Unstructured Interview**
Development and process	Questions are planned and created in advance. All candidates are asked the same questions in the same order, typically closed questions, creating yes / no answers Sometimes called Standardised Interviews	The researcher has a list of key themes, issues, and questions to be covered, rather than a detailed hypothesis to test The interviewer asks only a few predetermined questions while the rest of the questions are not planned in advance.	Questions are not prepared in advance. Instead, questions arise spontaneously in a free-flowing conversation, which means that different candidates are asked different questions In an unstructured interview the researcher has to be a good listener and note new or interesting data the interviewee gives
Advantages	Easier to compare responses against the same base question Interviewer bias is potentially removed	Gain the advantages of both structured and unstructured interview approaches Allows the interviewer the ability to probe in more detail a responder's story if required Can vary the sequence of questions to maintain the interest of the interviewee	Free flowing conversations Personal touch and relationship builds between interviewee and interviewer Allow future interviews to be improved and enriched by earlier interview responses
Disadvantages	Require more planning	Compared with structured interviews,	Inappropriate for inexperienced

	Can appear cold and lacking personal feel during the interview Can be influenced by the tone of the interviewer Respondents may not understand the question and be unable to answer it.	semi-structured interviews are less objective and difficult to compare Inexperienced interviewers may not be able to ask prompt questions or probe into a situation to gather real meaning.	interviewers. The interviewers may be biased and ask inappropriate questions or respondents may talk about irrelevant and inconsequential issues Hard to compare responses

Table 21: Different types of interview, adapted from O'Gorman and MacIntosh (2014,) Knox and Burkard (2009,) and Kajornboon (2005,)

Another decision that qualitative interviewers face involves the actual means of completing the interview: Should participants be interviewed by phone or in person (i.e., face-to-face)? Knox and Burkard (2009) summarised some of the advantages of phone interviews over face to face interviews - Phone interviews use economic and human resources efficiently (e.g., reduce the need for travel, thereby widening the net researchers may cast for participants and enabling expedient data collection); minimize disadvantages of in-person interviews (e.g., researchers can take detailed notes of an interview without making participants feel uncomfortable, response bias may be reduced in the absence of facial expressions, the anonymity afforded by the phone may enable participants to be more open in their responses); allow research appropriate relationships to develop between interviewer and interviewee; and improve the quality of data collection (e.g. enable greater supervision and support of interviewers, allow those who may have reading/writing difficulties to participate in research).

Face-to-face interviews, on the other hand, allow the observation not only of verbal but also nonverbal data, the participant and interviewer have access to facial expressions, gestures, and other para-verbal communications that may enrich the meaning of the spoken words. This enrichment allows the interviewer the ability to build the rapport that may enable participants to freely disclose their experiences more effectively (Knox and Burkard 2009.)

Focus groups expand the one to one interview to a one to many relationship, where the researcher can interview multiple interviewees simultaneously (Breyman and Bell 2003.) By conducting interviews this way interviewees "bounce" ideals off each other and the quality of the discussion becomes more than the sum of its individual interview contributions (O'Gorman and MacIntosh 2014.) However, it is a different skill set for the researcher to master, moving from a simple interviewer to a group facilitator is not easy. Their role is one to encourage conversation and debate but not lead or steer discussions (Krueger and Casey 2002.) Due to the subjective and qualitative nature of focus groups they are often best when combined with more traditional quantitative type survey techniques (O'Gorman and MacIntosh 2014.)

Krueger and Casey (2002) describes the considerations and skills needed by a successful focus group facilitator to gain the most from this quantitative approach:

- Select the right moderator - exercise mild unobtrusive control of the group and hold adequate knowledge of topic
- Use an assistant moderator to handle logistics, take careful notes and monitor any recording equipment
- Be mentally prepared and alert and free from distractions.
- Use purposeful small talk to create warm and friendly environment. Observe the participants for seating arrangements and make a smooth & snappy introduction
- Use pauses and probes for example "Would you explain further?" "Would you give an example?" "I don't understand."
- Record the discussion either with media such as tape recorders or through written notes
- Control reactions to participants due to imparting your own bias onto their responses, avoid "that's good", "excellent"
- Use subtle group control, think about how to handle the "extroverts" the "dominant talkers", the "shy participants" and the "ramblers"

- Use an appropriate conclusion - Summarise with confirmation of understanding, review the focus group purpose and ask if anything has been missed, finally thanking and dismissing the group formally

In conducting interviews, ethical issues are one of the main concerns and confidentiality must be given (Kajornboon 2005.)

Kajornboon (2005) identified some of the ethical issues and potential responses from the researcher:

- Interview purpose – the researcher must explain the purpose of the inquiry to the respondent.
- Promises and reciprocity – the researcher must state what the respondent will gain, if anything, from the interview.
- Risk assessment – the researcher must consider in what ways the interview might put the respondent at risk in terms of stress, legal liabilities, ostracism or political repercussion.
- Confidentiality – the researcher must offer and reflect on the extent to which promises of confidentiality can be met.
- Inform consent – the researcher must gain consent if any is required.
- Data access and ownership – the researcher must evaluate who has the right to access data and for what purpose in the future, and abide by current information commission guidelines.
- Mental health - the researcher must consider how interviewer and interviewee mental health may be affected by conducting the interview.
- Advice – it is best practice that the researcher should appoint an adviser on ethical matters during the course of the study.
- Data collection boundaries – the researcher must review how hard they are prepared to push for data. What lengths will you go to in trying to gain access to data you want? What won't you do? How hard will the interviewer push interviewees to respond to questions about which they show some discomfort?

When an interview has been completed and is considered a good interview, the respondents ought to know more about themselves and their situation. However, the researcher must remember that the purpose of research is to collect data and not to change the respondents or their opinions Kajornboon (2005.)

Appendix 1 includes the author's own ethical practices document, which was shared with the interviewees prior to any interview being completed.

Whichever approached is adopted thought must be given by the researcher to how participants are chosen. Similar to surveys, sampling the target audience is key to the success of any research (Kumar et al 2020.) The researcher needs to identify conflicts of interest and provide acknowledgement and minimise bias, were possible in their participant sample, (Meyrick 2006, Robinson 2014.) This implies the need not just to state the number of interviewees but also the characteristics and potential interests of those interviewed, (Saunders & Townsend 2016.)

To a large extent, random sampling is used in quantitative research and often the sample size is defined at the beginning of the research and remains constant. In contrast, sampling in qualitative research is less direct, as sampling in qualitative research involves a sequence of decisions, to be made by the researcher, throughout the research journey, (Kumar et al 2020.)

In an ideal environment the number of interviews completed will be open-ended, until saturation or informed redundancy is reached and this is considered the "gold standard" by many for interview based researchers (Morse 1994, Lincoln and Guba 1985.) However, not all researchers agree, where saturation is not reached this mealy means the phenomena is not fully explored rather than the findings being invalid, (Saunders & Townsend 2016.) More importantly the key is to ensure coverage through variation amongst interview participants, and not to rely heavily on participants the researcher has access to, (Saunders & Townsend 2016.)

The exact recommended number of participants varies widely in research and thus it is possible to justify almost any number, and there is no method to determine the sample size as the sample size is a function of the study objectives (Kumar et al 2020.) However several researchers have made recommendations on sample size, for example: Alder and Alder (2012) advise a range of between 12-60 participants, Marshal et al (2013) recommends 20-30 participants for grounded theory and 15-20 participants for case studies, Saunders and Townsend (2016) stated a range of 15-60 is typically observed in publish research and finally, Kumar et al (2020) defined 3 approaches to justify sample size including guidance based on doctoral thesis of between 20 -30 participants, (the other two being Guidance by experts and Guidance by saturation.)

4.4.5 Case study

The aim of this method is to research - through a mixture of observation, document review and interview - the drivers for change, the approaches taken, the results achieved, the challenges faced, and the leadership knowledge, skills and behaviours deployed and developed. At the centre of the process, driving the observations, document review and interviews would be the researcher's main research questions thus maintaining focus in what would be inevitably an interesting environment for the researcher (Yin 2009.) This research approach is known as a form of "qualitative research", and the output of this research is a "case study". It is essential to be able to define the unique characteristics of the case under study and different approaches can be undertaken (Stake 1995.)

Brynman (1989) outlined a fourfold typology for approaches in qualitative research:

- Type 1: Total Participant: where the researcher is a full observer in one or two organisations.
- Type 2: Semi Participant: where the researcher is an indirect observer in one or two organisations.
- Type 3: Interview Based: where the researcher collates data through interviews in one to five organisations. Observations may occur between interviews.
- Type 4: Multi-Site: where the researcher is collected using interviews in 6 or more different organisations and observations

The advantage of studying just one case is that the depth of understanding and insight can be invaluable for the host case. However the benefit of a multi case approach is the ability to compare and contrast findings, and thus being able to generate transferable theory and knowledge (O'Gorman and MacIntosh 2014.) Eisenhardt and Graebner (2007) suggest that building theory from case study research requires one or more cases to create theoretical constructs, propositions and midrange theory from case based empirical evidence. They go onto cite Yin (1994) stating that case studies are rich empirical descriptions of particular instances of a phenomenon that are typically based on a variety of sources. Case studies can accommodate a variety of data sources, including interviews, archival data, surveys, ethnographies and observations and case studies are an increasing and popular way to build theory (Eisenhardt and Graebner 2007.) Eisenhardt (1989) developed an eight stage process for building theory from case study research:

- Getting Started: definition of the research question and prior constructs
- Selecting Cases: theoretical not random sampling
- Crafting Instruments and Protocols: qualitative and quantitative data combined
- Entering The Field: data collection and analysis
- Analysing The Data: within case analysis, and cross case analysis
- Shaping Hypothesis: tabulation of evidence, relationships and reasons
- Enfolding Literature: comparison with both conflicting and supporting literature
- Reaching Closure: ending the process of adding cases

Eisenhardt (1989) concludes with the statement that the strength of building theory using case studies is the likelihood that it will generate novel and genuine new theory and that creative insight will arise from contradictory or paradoxical evidence.

There are several different types of case studies available to the researcher. Cunningham (1999) describes 3 types: Intensive, Comparative, and Action Research.

- Intensive case studies are designed to develop theory through intensive understanding of events and practices of one person, group or organisation. These events and practices become the basis for developing theory from an understanding of the context in which these events occur. Four approaches for gathering data for this form of case study are Narrative, Tabulations, Explanations and Interpretations. Narrative cases are often used for summarizing interviews, meetings and documents. Tabulated cases allow the researcher to tabulate information and count occurrences. Explanatory cases are designed to provide accurate events and explanations. Interpretative cases are less rigorous since the data is more like testimonials of individuals and companies and are often created with heavy author bias.

- Comparative case studies aim to develop not just theory but also concepts through the use of several case studies, since multiple case studies allow the researcher to study common effects, events and practices across cases studies. There are three main approaches for carrying out a comparative case study: Case Survey, Case Comparisons, and Creative Interpretation. The case survey is where a large number of cases are studied and tabulated using common factors or categories. In case comparison the researcher develops an explanation for one case and then replicates the process with a similar set of cases. Creative interpretation cases provide criteria that organisations and individuals may wish to emulate. The classic example is the "comparisons of successful businesses" type of book, where authors review the success criteria of businesses or leaders deemed to be successful, or other such criteria of comparison, to allow others to emulate their success.

- Action research case studies is a catch-all term for the type of case study which focuses on research and learning through observing the process of change. It is an ongoing process of learning and change between the researcher and the case study and they work together on a common issue or problem. Two main fields have developed: Experimental Action Research (EAR) and Diagnostics Action Research (DAR.) EAR develops concepts and theory through the use of experiments, whereas DAR developed concepts and theory through the use of feedback and discussion.

4.4.6 Data collection and analysis

Data, for the purpose of research, can be broken down into two main groups - qualitative and quantitative (Richards 2007.) Figure 12 below illustrates examples of the different types of data that exists under these two main groups (Richards 2007):

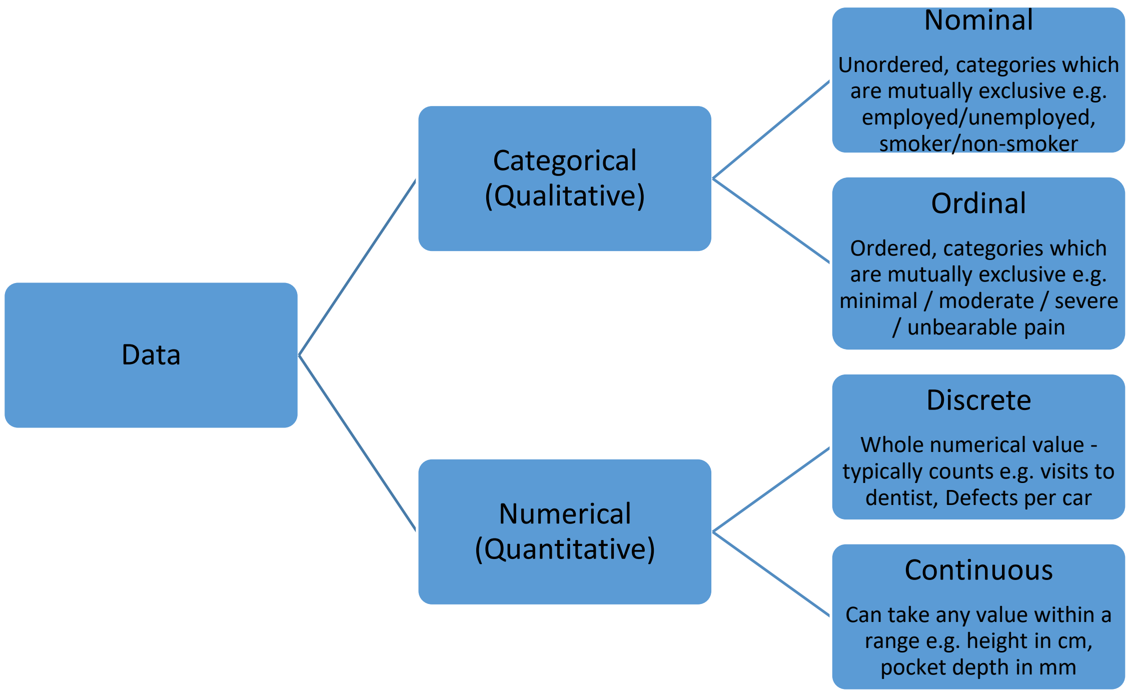


Figure 12: Different data types

Data collection, irrespective of group, is often categorised as either primary or secondary data. In primary research the data is collected by the researcher for the sole purpose of their research.

A distinction that involves all primary data collection techniques is that the data will be either solicited or spontaneous (Hox and Boeije 2005.) In experiments, surveys and many forms of qualitative research, the researcher uses a stimulus, for example a survey question or experimental variable, to elicit information from the research subjects. Explicitly soliciting information in this way has the advantage that the researcher can design the data collection in a way which directly answers their research question. However, the disadvantage is that the researcher subjects are aware of the process and may react differently if they were not aware they were under study, (Hox and Boeije 2005.) The alternative are non-reactive or non-intrusive primary data collection methods. These spontaneous methods include covert observation and monitoring. These techniques can lead to both qualitative and quantitative data. Examples include monitoring and scanning approaches such as tracking internet behaviour, or television habits (Hox and Boeije 2005.) Table 22 below summarises the potential different methods associated with solicited or spontaneous data, adapted from Hox and Boeije (2005.)

	Solicited	Spontaneous
Quantitative	• Experiments • Surveys (Interview, Mail, or Web) • Structured diaries	• Passive observation • Monitoring • Internet history
Qualitative	• Open interview • Focus groups • Unstructured diaries	• Participant observation • Images and sounds

Table 22: Examples of primary data in social science research

Secondary research data was originally collected for another purpose and is being accessed and used by the researcher, usually to save time and be more efficient (Bryman and Bell 2007.) Secondary data analysis is useful as a way to explore alternate relationships among variables or from different research perspectives as well as to conduct research studies using statistical methodology that may not have been available at the time of the original data collection, (Mueller and Hart 2010.) If a secondary data set comes from previous research, it should be considered in light of the fact that this secondary data was collected originally to answer a research question. Choices will have been made regarding which information was going to be collected and which was going to be ignored. How well these choices fit the current problem is a matter of judgement and secondary researchers must consider carefully whether this data actually fits their research question (Hox and Boeije 2005.) Secondary data can be particularly useful when compared to primary data with the aim of confirming the conclusions drawn from the primary research. This form of comparison is known as triangulation (Bryman and Bell 2007.) Triangulation adds credibility to research findings and provides a vehicle to allow the researcher to encompass different viewpoints efficiently (Bryman and Bell 2007.) There are five types of triangulation approaches: Data Sources, Investigation, Methodological, Theoretical, and Data Analysis, (Thurmond 2001.)

- Data Source Triangulation entails obtaining data from different sources to confirm a researcher's hypothesis and to test the results of a primary data source. Data sources can vary based on the times the data were collected, the place, or setting and from whom the data were obtained, (Thurmond 2001 and Turner and Turner 2009.)

- Investigator triangulation involves using more than one observer, interviewer, coder, or data analyst in the study. Confirmation of data among investigators, without prior discussion or collaboration with one another, lends greater credibility to the original observations, (Thurmond 2001 and Turner and Turner 2009.)

- Methodological triangulation involves using more than one method to gather data is the most common approach is to combine qualitative and quantitative measures. Methodologic triangulation can further be classified into two types: "within method" triangulation and "between or across" method of triangulation. For example "within method" could use two quantitative approaches and "between or across" could use one qualitative and one quantitative approach, Thurmond 2001 and Turner and Turner 2009.)

- Theoretical triangulation is the use of multiple theories or hypotheses when examining a phenomenon. The perspectives or hypotheses used in the study may be related or have opposing viewpoints and this approach is often generally rigorously discussed (Thurmond 2001 and Turner and Turner 2009.)

- Data-analysis triangulation is the combination of two or more statistical methods of analysing data, for example, comparing hypothesis test results and regression techniques to confirm a relationship between two variables (Thurmond 2001 and Turner and Turner 2009.)

Quantitative and qualitative research differ somewhat in their approach to data analysis. In quantitative research, data analysis often only occurs after all or much of data have been collected. However, in qualitative research, data analysis often begins during, or immediately after, the first data are collected, although this process continues and is modified throughout the study, (Burnard et al 2008.)

There are two fundamental approaches to analysing qualitative data, although each can be handled in a variety of different ways: the deductive approach and the inductive approach: (Hoyos and Barnes 2012, Burnard et al 2008, Burnard 1991.) The deductive approaches involve using a structure or predetermined framework to analyse data. Essentially, the researcher imposes their own structure or theories on the data and then uses these to analyse the interview transcripts. This approach is useful in studies where researchers are already aware of probable participant responses. However, while this approach is relatively quick and easy, it is inflexible and can potentially bias the whole analysis process as the framework has been decided in advance, which can severely limit theme and theory development. The inductive approach involves analysing data with little or no predetermined theory, structure or framework and uses the actual data itself to derive the structure of analysis. This approach is comprehensive and therefore time-consuming and is most suitable where little or nothing is known about the study phenomenon, (Hoyos and Barnes 2012, Burnard et al 2008, Burnard 1991.).

Within both in deductive and inductive approaches the most widely used method to categorise the data is known as coding. This method was developed out of those described in the grounded theory literature, (Maxwell and Chmiel 2014, Burnard et al 2008.) The aim is to produce a detailed and systematic recording of the themes and issues addressed in the interviews and to link the themes and interviews together under a reasonably exhaustive category system. In coding, the data segments are labelled and grouped by category; they are then examined and compared, both within and between these categories. Coding categorisation is a means of sorting the descriptive data the researcher has collected so that the material of interest can be physically separated from other data, (Maxwell and Chmiel 2014.) Three distinctive types of categories exist: organizational, substantive, and theoretical. Organizational categories are broad areas or issues that are often established prior to data collection. Substantive categories are primarily descriptive, in a broad sense that includes descriptions of participants' concepts and beliefs; Theoretical categories, in contrast, place the coded data into an explicit theoretical framework, (Maxwell and Chmiel 2014.)

Coding and categorisation of qualitative data is not without its problems or critics. Qualitative research methods often are accused of being a manipulative approach that enables researchers to speculate on the meaning of data and thus pursue a personal agenda, (Kapoulas and Mitic 2012, Burnard 1991.) Other challenges include, to what degree is it reasonable and accurate to compare the comments and believes of one person with those of another? Are 'common themes' in interviews really 'common' and can the researcher assume that one person's world view can be linked with another person's? (Kapoulas and Mitic 2012, Burnard 1991.) Within the method of categorisation and themes problems arise. During categorisation it is difficult for the researcher to maintain the same logical and congruent level of abstraction and degree of interpretation in each step, from subcategories through categories to the main category. Themes within categories are usually quite abstract and therefore difficult to catch and pick up by the researcher, (Graneheim et al 2017.) The key is for the researcher to distance themselves from the interviews and interviewees and consider what they are telling the researcher, not necessarily what the researcher wants to hear. (Graneheim et al 2017, Morse, 2008.)

4.5 The authors approach to meeting the research objectives:

The approach taken by the author will follow a four stage mixed method approach to structuring research, similar to the one described by Evans et al (2011):

Stage 1: introductions and establishing the problem statement

Stage 2: the background, history and current theory linked to the problem statement

Stage 3: the core new research, proposals and results created by the researcher

Stage 4: the Synthesis, analysis, discussion and testing of the new work

The authors chosen approach:

Stage 1: Establish the research gap and question through an initial traditional literature review and following systematic literature review (chapters 1 – 3.) Based on the research generated from the literature reviews the author has been able to identify the final research position to answer the research question raised in the previous chapter:

"To develop, build and test a maturity model specifically for an academic institution wishing to deploy Lean Six Sigma"

Stage 2: Through the use of survey techniques, including questionnaires, and focus groups the author will benchmark the current academic involvement in Lean Six Sigma in the UK and identify potential academic institutions in the UK who could be taken to stage 3 and used to develop case study research and semi structured interviews, (chapter 5.) The survey population is to be expanded to include higher educational institutions and Lean Six Sigma Master Black Belts from around the world to triangulate any results from the initial UK findings. A summary of the responder's geographical location is in Table 23 below.

Location	Responders from Higher Educational Institutions	Expanded responders from Master Black Belts and Black Belts populations
UK	21	7
Europe (not UK)	3	1
USA	11	1
Middle East	2	0
India	3	0
Asia	2	0
Total	**42**	**9**

Table 23: Summary of geographical locations of survey responders

Stage 3: Focusing on UK institutions, the author will develop a Lean Six Sigma maturity model through the use of four case studies and collections of semi structured interviews within those case study institutions (chapter 6.) A total of 15 semi structured interviews will be completed across the four case study higher educational institutions. The semi structured interviews will build on the data from the initial survey and facilitated using questions and debating points generated through the earlier questionnaire responses and literature. Table 24 below summarises the position within the higher educational institution of the interviewees:

Case study	Leadership team	Change Management lead	Change management practitioners	Academics	Admin staff	Total:
1	0	0	0	2	2	4
2	1	0	0	5	1	7
3	0	1	1	0	0	2
4	0	1	1	0	0	2
Total:	**1**	**2**	**2**	**7**	**3**	**15**

Table 24: Summary of case study semi structured interview responders

Stage 4: Test the model against a further four academic institutions from both the UK and USA, and from a panel of Lean Six Sigma professionals who operate across a range of sectors, including manufacturing, government, third sector and academia, to refine and to develop a final model to be presented and communicated at the end of this thesis (chapter 7.) Table 25 below summarises the position within the higher educational institution of the interviewees:

Test Subjects	Leadership team	Change Management lead	Change management team / practitioners	Academics	Admin staff	Total:
3 UK universities	1	2	8	0	1	12
1 international university	0	1	0	1	0	2
UK MBB and BB	0	0	5	0	0	5
LSS International Conference workshop	0	2	3	5	0	10
Individual international (USA) academic interviews	0	0	0	4	0	4
Total:	**1**	**5**	**16**	**10**	**1**	**33**

Table 25: Summary of test case study semi structured interview responders

The final chapter will conclude with conclusions, discussion points and recommendations for future research building on the findings of the author's own work over the past 7 years.

Chapter 5: Lean Six Sigma in Higher Educational Institutions – the initial questionnaire

5.1 Introduction to the survey

In earlier chapters the author has concluded that academic institutions are facing many challenges in today's globalised educational world. For example, public funding cuts, commercially driven credit based curriculums, accountability, quality assurance, the student as customer, and performance based management are all key themes being wrestled with by academic leaders, (Laing and Laing 2011, Kurniawan and Puspitaningtyas 2013.) In addition, management language such as "excellent academic performance", "organise effectively", "efficiently", "sustainably", and "accountability" have sneaked into the language used by academic leaders, (Kurniawan and Puspitaningtyas 2013.) Thus it was only going to be a matter of time before terms such as Lean Six Sigma would start to appear commonplace in higher educational institutions (Antony 2014). In addition, universities are benchmarked evermore by outside institutions – for example, in 2017, The Times' world rankings of universities ranked the University of Oxford as the first UK university to top The Times Higher Education World University Rankings in the 12-year history of the table. It replaced the five year leader, the California Institute of Technology, into second place and this has been maintained by Oxford for the last four years, with Oxford still top of the table in the World University Rankings in 2020. The Times' report in 2017 starts with the phrase: "World University Rankings 2016-2017: Standing still is not an option." The article attributes Oxford's success to improved performances across the four main indicators underlying the methodology of the ranking – teaching, research, citations and international outlook (Baty 2016.) In addition the institution's total income and research income is rising faster than its staff numbers, its research is more influential, and it has been more successful at drawing in international talent, (Baty 2016.) In 2020 the criteria for judging universities expanded to include a fifth criterion. The five criteria are (Bothwell 2020):

1. Teaching – the learning environment accounting for 30% of the final score

2. Research – volume, income and reputation accounting for 30% of the final score
3. Citations – the influence of the research accounting for 30% of the final score
4. International outlook – staff, students and research numbers accounting for 7.5% of the final score
5. Industry income – knowledge transfer accounting for 2.5% of the final score

Universities are expected to be efficient and cost effective, flexible in their offerings while being responsive to the student expectations, (Joyce and Boyle 2013.) Leading universities in this list by The Times are presented with unique challenges; because of the organisations' complexity, its multiple goals, and its traditional values – but how are universities meeting this challenge?

This chapter highlights the findings from over 50 responses, across 21 universities in the UK, a further 21 universities from across the world, and 9 Lean Six Sigma Master Black Belts from industry. Initially only UK higher educational institutions were contacted, however due to the poor response rate and the quality of the responses from the UK institutions it is clear that few higher educational institutions in the UK are adopting Lean Six Sigma practices. Thus the author expanded the study and completed a longitudinal data collection strategy, over an 18 month period, completed in January 2018. This longitudinal study included international institutions and Master Black Belts from industry. Table 26 below highlights where the responses came from.

Location	Responders from Higher Educational Institutions	Expanded responders from Master Black Belts and Black Belts populations
UK	21	7
Europe (not UK)	3	1
USA	11	1
Middle East	2	0
India	3	0
Asia	2	0
Total	**42**	**9**

Table 26: Summary of geographical locations of survey responders

A total of 172 UK institutions, 25 international institutions and 15 Master Black Belts from industry have been contacted giving a UK response rate of 12% and an overall response rate of 24% when the international institutions and Master Black Belts are included. The level of the response rate is a critical factor in assessing the value of the research findings (Baruch and Holtom 2008.) A high rate of non-response creates a heightened probability of statistical biases in the results, (Tomaskovic-Devey et al., 1994.) Response rates in social science research have been falling in recent decades with several studies showing a significant decline over the last 30 to 40 years (Tomaskovic-Devey et al., 1994, Dey 1997, Johnson and Owens 2003, and Baruch and Holtom 2008.) For example, Baruch and Holtom in 2008 reviewed 490 articles published in 2000 and 2005 across a variety of journals and sectors, including education, to understand the variation in response rates and compare them to earlier studies. Table 27 below summarises some of their findings:

Trend	**1975**	**1985**	**1995**	**2000**	**2005**
Average RR	64.4	55.7	48.4	48.4	48.3
Standard Deviation RR	16.8	19.4	22.5	21.1	22.2
Method	**Number**	**Min RR**	**Max RR**	**Average RR**	**Standard Deviation RR**
Mail	309	19.7	94.0	44.7	21.8
Internal Mail	79	3	92.2	55.5	18.3
In Person	31	30	83	62.4	16.9
Email	11	23.7	89.0	54.7	23.9
Phone	10	10	86.2	49.1	24.1
Web	6	10.6	69.5	38.9	15.1
Sector	**Number**	**Min RR**	**Max RR**	**Average RR**	**Standard Deviation RR**
Education	15	10	84	49	24
Manufacturing	48	14.4	91.2	50.3	22.2

Table 27 Summary of response rates in academic journals over 30 years from 1975 – 2005 (created from Baruch and Holtom, 2008)

Although the authors response rate of 24% is on the lower side of many of the articles published in 2000 and 2005 it is still well within the variation seen by Baruch and Holtom in 2008 both at sector and method level, (Baruch and Holtom, 2008.) The author primarily used email and web-based technologies to interact with the responders. The goal of the author in using this survey method was to identify suitable higher educational institutions for: future research, comparison with an international audience, and a new maturity model for implementing Lean Six Sigma in higher education. In addition, it was expected that significant insight would come from the actual survey itself.

5.2 Surveys and Quantitative Research

Quantitative research refers to the systematic empirical investigation of social phenomena via statistical, mathematical or numerical data or computational techniques (Given, 2008.) The main objective of quantitative research is to develop mathematical models, theories and/or hypotheses pertaining to certain phenomena. It is expected that the data collected from a questionnaire targeting the universities in the world which teach Lean, Six Sigma, and Lean Six Sigma should create some significant observations and identify which universities practice internally what they are delivering to an external audience.

Vogt (2010) states the aim of survey questionnaires is often less to discover a causal link between variables (internal validity) and more to generalize a finding from a sample to a population (external validity.) The best known example is in election surveying. The population of likely voters is identified, a random sample is taken using more or less complicated sampling techniques, and respondents are asked about their voting plans – whether they intend to vote and if so, for whom. Attempting to survey samples from populations whose members are rare or unknown raises complicated uncertainties. One cannot very easily sample from a population when it is difficult to find or when one does not know what it is. So the first step becomes defining or identifying the population rather than sampling from it (Vogt 2010.) The assumption for the author is that universities which teach Lean, Six Sigma or Lean Six Sigma will potentially also be using these methods to improve their organisational processes. During the summer of 2015, the author researched all 172 UK universities to identify which of them offered Lean Six Sigma as a standalone course as part of their undergraduate or postgraduate degrees. Also, the author looked into those universities which offer Lean Six Sigma training to industry and offer certification. For example, the ISRU unit at Newcastle University offers public and in-house courses on Lean Six Sigma and the use of industrial statistics to solve process problems (http://www.isru.ncl.ac.uk/lean-six-sigma.) Of the 172, 118 appeared to have no recognisable Lean Six Sigma courses offered as part of the curriculum in the University or in the form of formal training for professionals in organisations, leaving a population of 54 to approach. However the contact details remain of the

118 and it was decided that in January 2016, all 172 institutions would be contacted electronically via the Vice Chancellors Office and requested to complete a simple questionnaire. The questions identified would need to be grounded in research, for example any question relating to the interactions of leadership and successful Lean Six Sigma implementation would relate back to the work of Mayo and Nohria (2005) in relation to the importance of complex interactions in leadership success. Using the key findings from the author's earlier literature reviews, each question was supported by a reference and piece of literature. Table 28 below highlights the 10 questions issued to the 172 UK higher educational institutions at the start of 2016. The author hoped to gain significant insight into the process of implementing Lean and Six Sigma in academic institutions since several higher educational institutions within the UK have their own business process improvement teams, whose goal is to drive continuous improvement. For example the Lean HE Hub started by Coventry University, The Process Improvement Unit at the University of Sheffield and the Business Improvement Team at Aberdeen University. It is worth noting though that no pure Six Sigma business improvement teams appear to be operating in UK universities at this time (2020) and all process improvement activity within higher educational institutions appears to have developed from the Lean school of thinking. Following the initial contact of the 172 UK institutions, a year later 25 international universities were contacted and 21 responses were gleaned allowing a comparison to be made between the UK and those universities in the rest of the world that were publicising Lean Six Sigma activity at academic conferences and in papers. These 25 institutions were identified from the 2015 and 2016 Lean Six Sigma Conferences held in the UK by Professor Jiju Antony at Herriot Watt University who founded this conference in 2012. Across the whole survey population the author gained responses from all 4 parts of the UK (England, Scotland, Wales and Northern Ireland) and, once the survey was expanded to the rest of the world, gained responses from: Greece, India, North Macedonia, Malaysia, Saudi Arabia and the USA. Finally the 15 Master Black Belts from the Institute of Six Sigma Professionals who currently, or have in the past, sat on their accreditation and standards committees were contacted and 9 responded to the questionnaire. Their role was to enable the author to compare the academic world to industry, and although not the main driver for the thesis helped to provide

context and comparison to the current maturity of the academic world in deploying LSS. Table 28 below summarises the research populations:

Source	**Leaders**	**Change Manage-ment lead**	**Change management team / practitioners**	**Academics**	**Total respond-ed**	**Total contact-ed**	**Response rate**
UK Universities	5	2	2	12	**21**	**172**	**12%**
International Universities	2	2	4	13	**21**	**25**	**84%**
MBB / BB	1	0	8	0	**9**	**15**	**60%**
Total:	**8**	**4**	**11**	**25**	**51**	**212**	**24%**

Table 28: Initial questionnaire research summary

The survey itself contained 10 questions linked to the critical success factors of implementing Lean Six Sigma identified in the earlier literature reviews. These included the drivers and purpose for change, the institution's history of change with respect to continuous improvement, the approach and methodologies adopted to facilitate change, who is leading and managing the change, and finally, how change will be sustained. Table 29 below highlights the 10 questions issued to the survey candidates and the link back to research and justification for inclusion.

Question:	Grounded In Research
1. Are you currently undergoing, or planning to implement, a continuous improvement programme / change agenda within the university?	Maleyeff (2014), Mehmood et al 2012, Shahmandi et al 2011, Temponi (2005)
2. What is your objective, or reason for undergoing this continuous improvement programme / change agenda?	Radnor and Walley (2008), Jenicke et al 2008
3. How will success of this continuous improvement programme / change agenda be measured?	Manville et al (2012), Snee (2011), Siddique et al 2011, Sakthivel (2007)
4. Are you using a methodology, philosophy or structured approach, such as Lean or Six Sigma, for this continuous improvement activity - if so what kind of approach are you using?	Hines and Lethbridge 2008, Heuvel, 2005, Antony (2014), Jenicke and Holmes (2008)
5. Are you utilising outside expertise to assist in the continuous improvement programme / change agenda?	Kurniawan and Puspitaningtyas (2013), Kumi and Morrow (2006)
6. Does the higher educational institution have a history of successful projects, change programmes or continuous improvement activity using structured approaches such as Lean, Six Sigma or Lean Six Sigma or your chosen approach?	Azis and Osada (2010), Antony et al (2012)
7. Who is leading this continuous improvement programme / change agenda and where do they sit within the organisation?	Snee's (2007), Snee and Hoerl (2002)
8. Who is responsible at board or executive level for strategy and vision of the continuous improvement / change agenda?	Collins (2001), Loethen (2008), Bryman (2009)
9. What characteristics, competencies, knowledge, skills and behaviours within the leader/leadership team were particular required or identified for this programme to be given the best chance of success?	Mayo and Nohria (2005), Emiliani (2013)
10. How will the institution sustain any gains and successes made through the continuous improvement programme / change agenda?	Antony et al (2012), Jenicke and Holmes (2008)

Table 29: Questions issued electronically to 172 UK institutions in 2016 and a further 25 international institutions in 2017

5.3 The Trends and Key Findings – The UK vs Rest of the World perspective

Before explaining the specific findings in detail, several clear trends have emerged from this research:

5.3.1 The main reason for institutions embarking on a programme of continuous improvement or change agenda within a UK university was to improve the staff and student experience within the institution. However this is not born out in the detail since many of the improvement programmes are focused on administrative rather than teaching, research or pastoral based processes. For the rest of the world (RoW,) the key drivers were explicit cost reduction challenges or outside accreditation and recognition. The driver of cost reduction was also mirrored by the 9 industry Master Black Belts indicating that the RoW is closer aligned to that of industry when it comes to the drivers for change. This difference may exist because international institutions have, in general, more experience of, and exposure to, implementing Lean Six Sigma and thus have matured from simple administrative improvements to more challenging cost reduction or research/teaching aligned projects.

5.3.2 Where measures of success do exist in the UK, the National Student Survey forms the main measure of success. However this appears to be a very simplistic approach to measuring success. Any survey suffers from the bias of the most recent history skewing the results. For example if there has been a recent pay cut to staff and then an employee survey is released enquiring about staff engagement in Lean Six Sigma it is likely to gain negative results, even if the previous 11 months have demonstrated successful projects. The RoW appear to rely heavily on internal and external surveys as well, however there is also evidence of strong project management and time management based performance indicators. This reliance on external metrics and surveys, for both the UK and RoW, such as the Times List and the National Student Survey is probably driven by the need to attract the best local and international students to the institution, thus maintaining revenues and reputation. The commercially driven Master Black Belts from industry were insistent that measures of success are needed in any Lean Six Sigma programme and regard financial benefits and increased competitive advantage as the key measure of Lean Six Sigma project success.

5.3.3 Virtually all improvement activity in UK institutions is Lean Thinking based, rather than Six Sigma, Lean Six Sigma, or other business improvement approaches such as Systems Thinking, Kaizen Events or Theory of Constraints. These Lean Thinking approaches are almost universally applied to administrative based processes – this may be due to Lean having significant roots in several leading UK universities such as Cardiff, St Andrews or Buckingham, whereas Six Sigma appears to have struggled to gain academic acceptance beyond a few professors, institutions and courses. The 9 Master Black Belts selected are all using Six Sigma or Lean Six Sigma to structure their improvement activities. In addition, 2 were using Lean techniques to manage specifically day-to-day operations, such as 5S, Visual Management and Gemba walks, and Six Sigma techniques to deliver step change and long term continuous improvement through the delivery of time based projects, such as 100 day DMAIC projects and Design for Six Sigma product innovation projects.

5.3.4 Typically UK universities are using a team based approach, led by a continuous improvement champion or project manager to implement the continuous improvement programme / change agenda. These individuals comes from a variety of backgrounds and will not necessary hold formal qualifications in Lean Six Sigma. The RoW tend to deploy Lean Six Sigma using a more senior manager or senior academic to lead the programme. For example the Director or Dean of a department. In addition, institutions are using external support from consultancies and third parties to supplement their internal resource on a typical 80% internal / 20% external mix in the UK and 65% internal / 35% external in the RoW – there appears to be a reluctance to use internal academic expertise within the UK compared to the RoW, relying on outside consultants or administrative managers within the institutions studied. This reluctance is clearly also re-enforcing the fact that all programmes studied are administratively based in the UK, whereas there is some evidence that Lean Six Sigma has moved beyond administrative functions in the universities from the RoW population. Again the

RoW appears more closely aligned that that of the industry Master Black Belts who stated that programmes within their organisations are led by senior engineers, managers or scientist, who have sector experience, and are formally trained and accredited in Lean Six Sigma techniques – usually to a minimum of Black Belt level.

5.3.5 Over 60% of respondents have never embarked on a continuous improvement programme / change agenda before starting this one, with only one institution in the UK contacting another university for assistance and guidance in implementing Lean – it is interesting that these leaders do not recognise the high volume of IT infrastructure or capital projects and construction activity within their institutors and have not realised that, for example, building new student accommodation, implementing a new web based enrolment system or the creation of new counselling facilities is an improvement activity, whereas several RoW respondents cited IT, construction and commissioning projects as sources of learning when implementing a continuous improvement or change agenda. These projects in the UK may not need the full set of Lean Six Sigma tools and techniques, however they are a form of continuous improvement, and could gain significant benefit and insight from using the Lean Six Sigma techniques. All our industry Master Black Belts come from organisations and sectors which have a history of running continuous improvement programmes and recognise the need to continually change and improve. They recognise that improvement projects come from a variety of sources within the organisation, for example customer audits, risk assessments and capital expenditure needs, and that all forms of improvement can benefit from Lean Six Sigma thinking.

5.3.6 Within the UK higher educational institutions, the Registrar appears to both lead the programme at operational level and represent the strategy and approach at board level. Again this re-enforces the role played by Lean Six Sigma to be one centred within the administrative rather than teaching or research fields. A more varied response existed within the RoW with leadership of the programme typically sitting at a director level, and governance sitting with the board. This structure mirrors closely the industry experience of having project managers or continuous improvement managers leading projects, supported by a sponsor from the board to help with cultural challenges and reporting financial benefits into the board usually through head of operations.

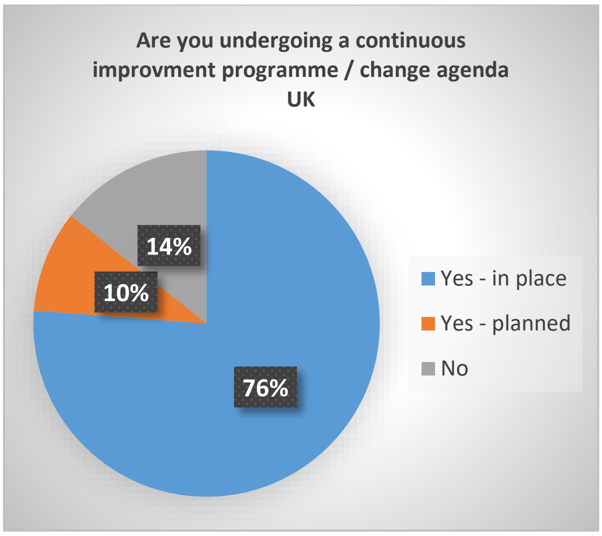
5.3.7 There is no real evidence in the UK to support ongoing sustainability strategies or tools beyond additional training and current performance management techniques. Sustainability challenges have plagued manufacturing companies for decades, however organisations try, through the use of Poka Yoke, SPC, Control Plans, Auditing, Process Drift Measurement, and Standard Operating Procedures etc, to build long term control and stability into their processes. The lack of any tools being reference by the UK in this study is a concern as well as possibly an opportunity for future research and development. There is some evidence of sustainability within the RoW, however this was not as strong as expected. Noone in academia appears to have made the link that they can build their continuous improvement programme into systems and structures that already exist within the organisation, to help build the mind-set or paradigm that continuous improvement needs to be in the DNA of the institution if it is to survive and flourish. One of the Master Black Belts commented on how they are trying to build their Lean Six Sigma strategy into existing systems such as their Quality Management System, which is externally audited every 3 years, as a way to embed the process on continuous improvement into their company.

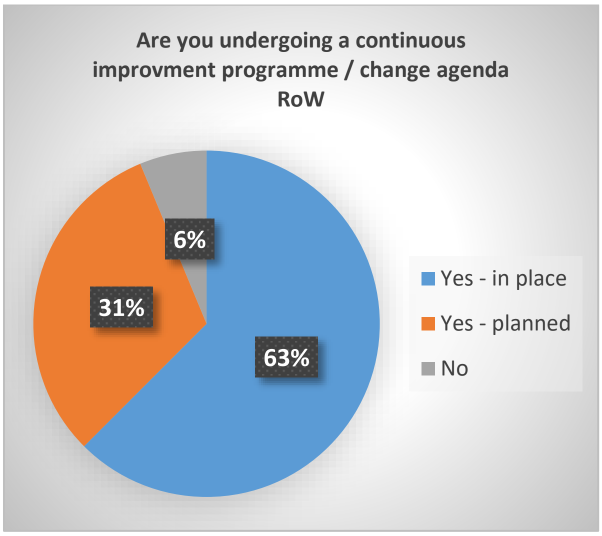
5.3.8 The final trend in the data identified, and probably the most important, is that within the UK a lack of continuous improvement maturity exists, demonstrated by the answers of some of the questions given, with several answers relating to simple continuous improvement activity, such as process mapping, and the main knowledge, skills and behaviours recorded were “basic project management skills”, rather than, for example, leadership, root cause analysis, process capability studies, statistical process control, design of experiments, and data analysis skills. In addition, much has been written in academic journals on how organisations can successfully implement Lean Six Sigma and leadership is always at the top of the critical success factors of any industrial organisation trying to implement Lean Six Sigma. It appears that higher educational institutions in the UK have a long way to go before they can truly claim to be Lean, or a Six Sigma university. There is evidence from the responses to the survey that the RoW is slightly ahead of the UK, however not by as much as first thought based on the answers given by institutions which are attending conferences around the world professing their expertise in Lean, Six Sigma and Lean Six Sigma.

5.4 Key findings of the survey

The detailed responses to the survey are outlined below. The analysis has been split between the three main population groups – The UK, Rest of the World, and Industry Master Black Belts. Sample responses have been placed in the appendix for reference by the reader if required.

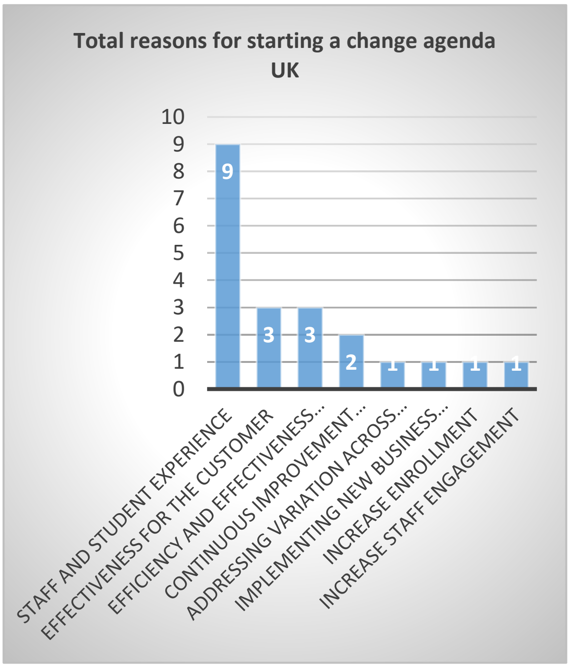
5.4.1 Question 1: Are you currently undergoing, or planning to implement, a continuous improvement programme / change agenda within the university?

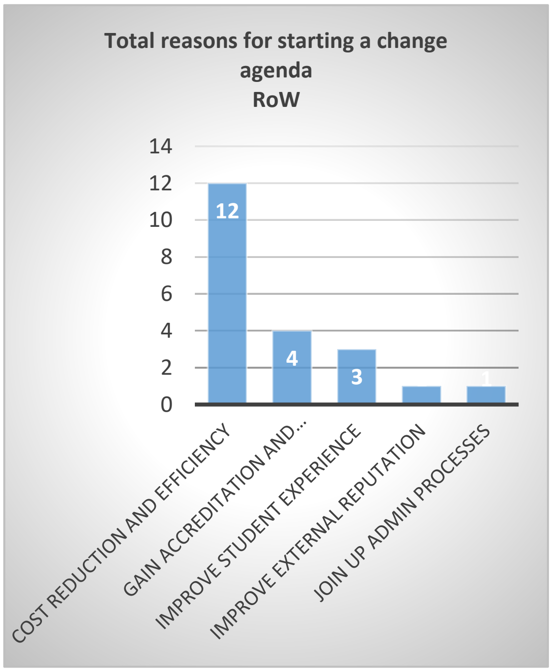


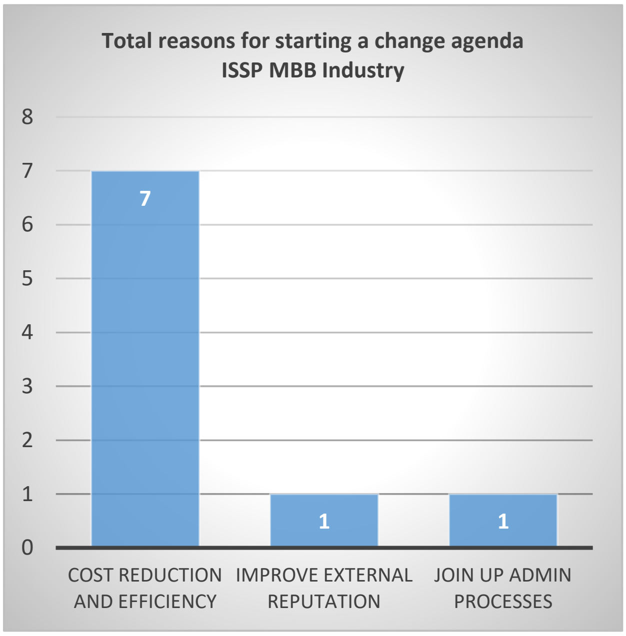


86% of UK responses either have or are planning a continuous improvement or change agenda programme in the next 12 months, compared with 94% in the RoW. All 9 responders from the ISSP Industry based Master Black Belts are undergoing an improvement programme or change agenda.

5.4.2 Question 2: What are your objectives, or reasons, for undergoing this continuous improvement programme / change agenda?

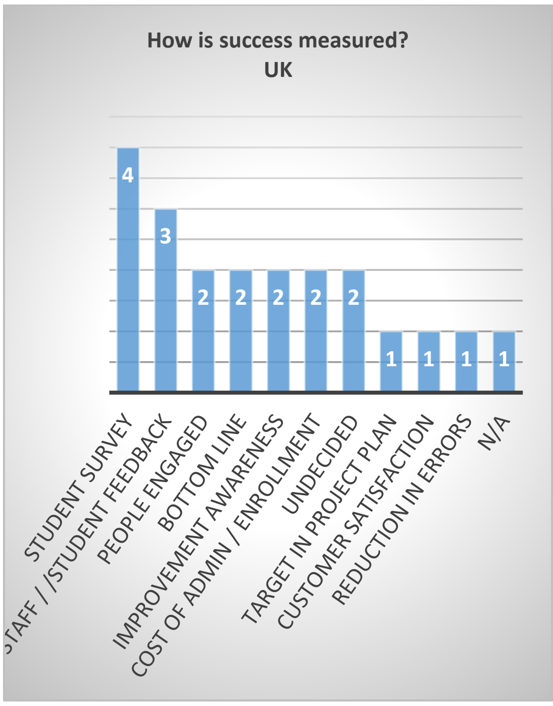


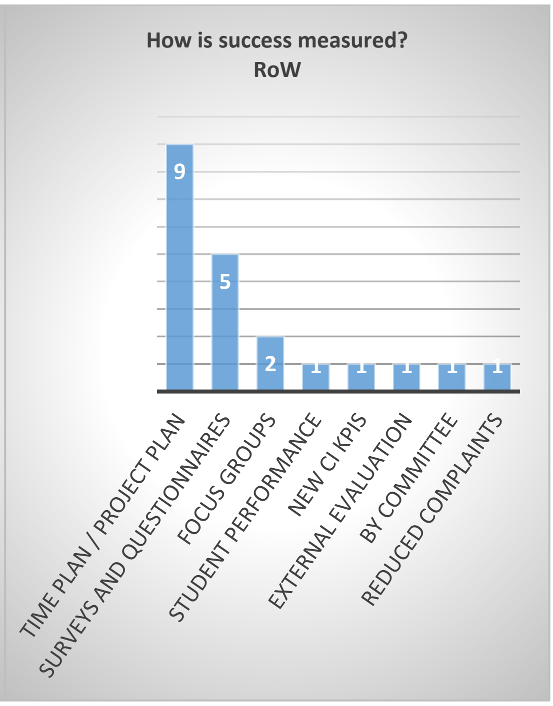


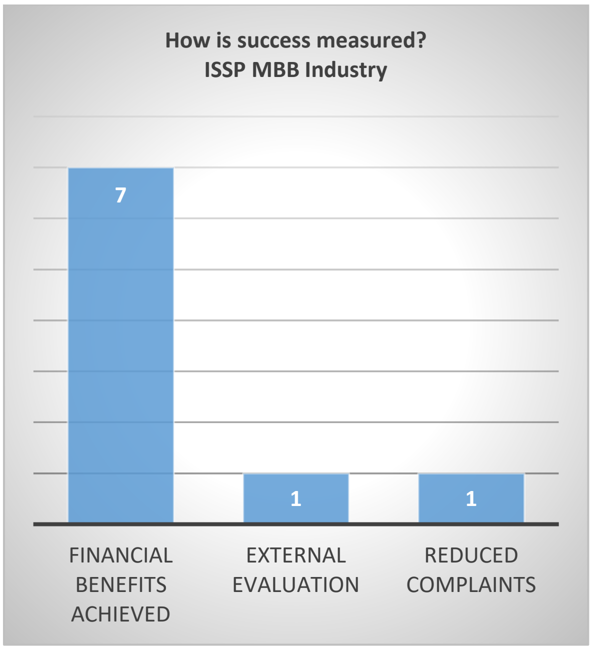


The main drivers for UK institutions to implement a continuous improvement or change agenda programme is to improve the staff or student experience and drive improvements in customer experience and efficiency. The RoW has cost reduction and efficiency as its main driver followed by accreditations and outside recognition and benchmarking. The industry led Master Black Belts are dominated by the need for cost reduction and efficiency gains.

5.4.3 Question 3: How will success of this continuous improvement programme / change agenda be measured?

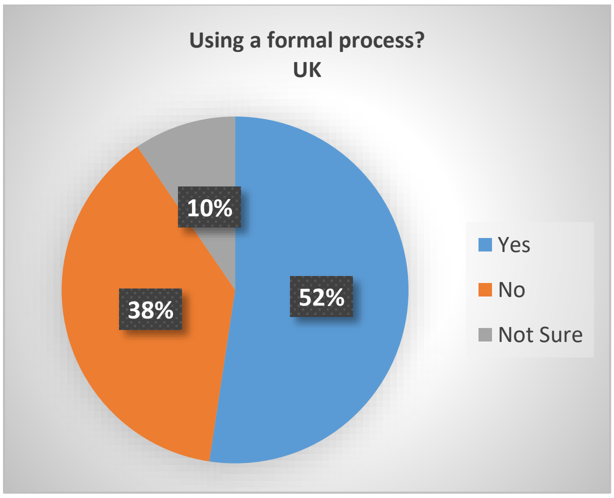


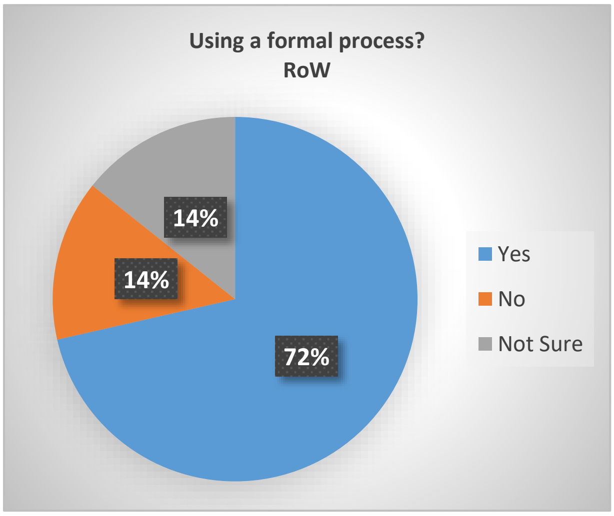




The UK institutions rely heavily on national and local surveys to measure the success of their programme, with over half of the respondents relating success to a survey result. Whereas the RoW use more traditional project management techniques with nearly 50% using time plans and project plans milestones as measures of successful project completion. The majority of the Master Black Belts expect positive financial benefits to be achieved if the programme is to be defined as a success.

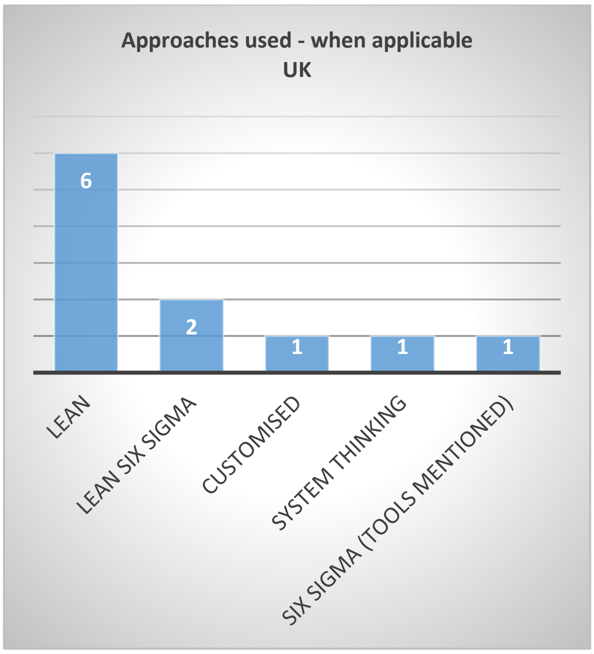
5.4.4 Question 4: Are you using a methodology, philosophy, or structured approach, such as Lean or Six Sigma, for this continuous improvement programme / change agenda?

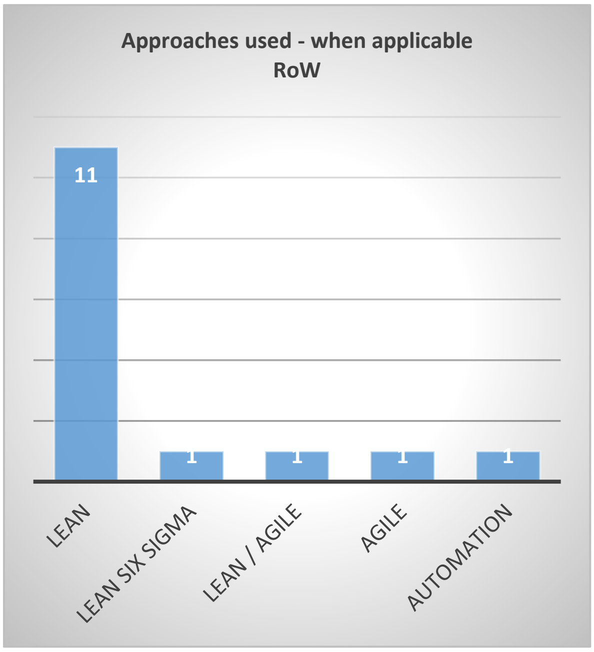




Only 52% of UK institutions are using a recognised improvement methodology or process to drive change and continuous improvement. This is significantly less than the 72% observed in the RoW, who are using a recognised approach to implementing change or continuous improvement. All 9 industry Master Black

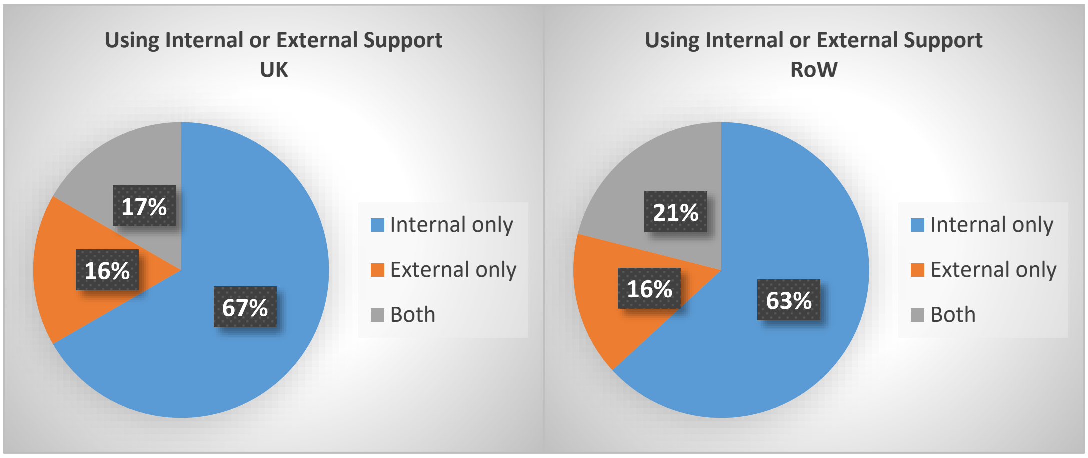
Belts stated they are using DMAIC to manage change or continuous improvement projects.





It is interesting to note that Lean is both heavily represented in the UK and RoW and the main approach, when named, to drive change or deliver continuous improvement. All 9 responses from the Master Black Belts were using Six Sigma as their structured approach to delivering change and continuous improvement within their organisations.

5.4.5 Question 5: Are you utilizing external or internal expertise to assist in your continuous improvement programme / change agenda?



A similar split between UK and Row exists for the first time on the number of responders who are using only internal resource – around 65%. The majority, 8 out of 9, of the industry responders are using a mixture of both internal and external expertise to support their programme of work.

For the UK, the main sources, for "external only" and "both" types of support were:

- Large consultancy firms (2 responders)
- Small consultancy firms (1)
- Specialist units from within other universities (1)

For the RoW the main sources, for "external only" and "both" types of support were:

- External auditors (3 responders)
- Large consultancy firms (2)

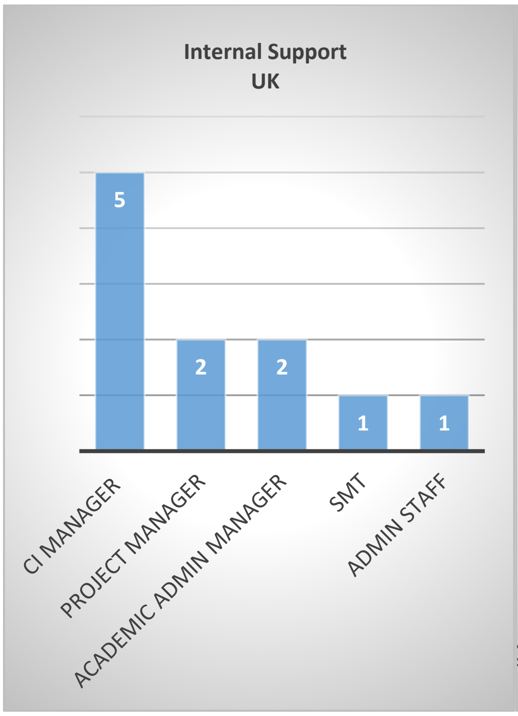
For the industry Master Black Belts the sources, for "external only" and "both" types of support were:

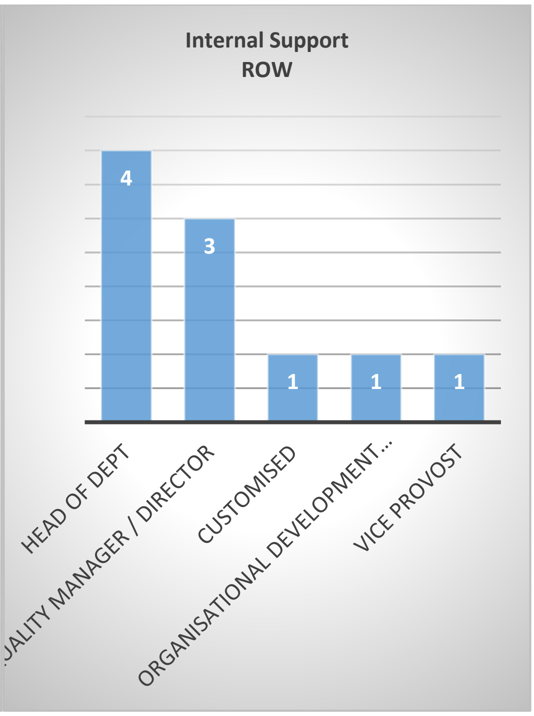
- Large consultancy firms (2 responders)
- Small consultancy firms (2)
- Internal auditors (1)

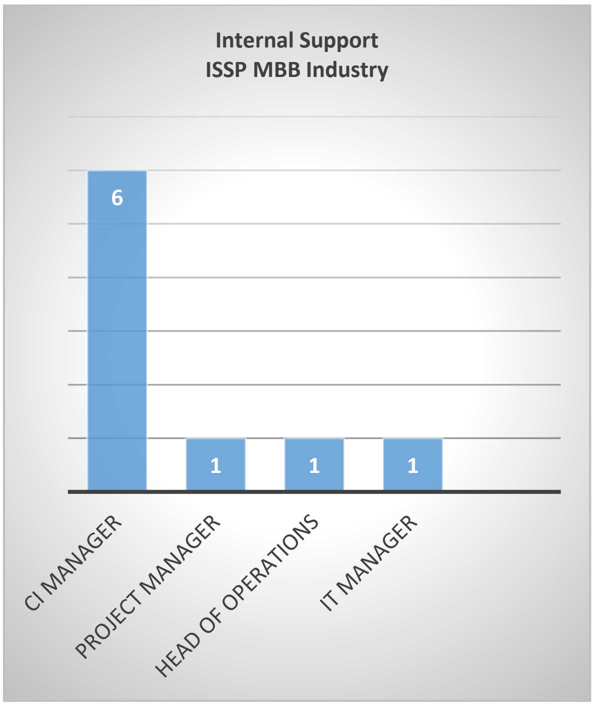
There were 3 respondents from the UK that used both internal and external support for their programme. The average ratio of resource allocated between internal to external support was 80% internal 20% external for the UK.

There were 7 responders from the RoW that used both internal and external support for their programme. The average ratio of resource allocated between internal to external supports was 65% internal and 35% external for the RoW. There were 5 of the industry Master Black Belts that used both internal and external support for their programme. The average ratio of resource allocated between internal to external support was 60% internal and 40% external for the industry Master Black Belts.

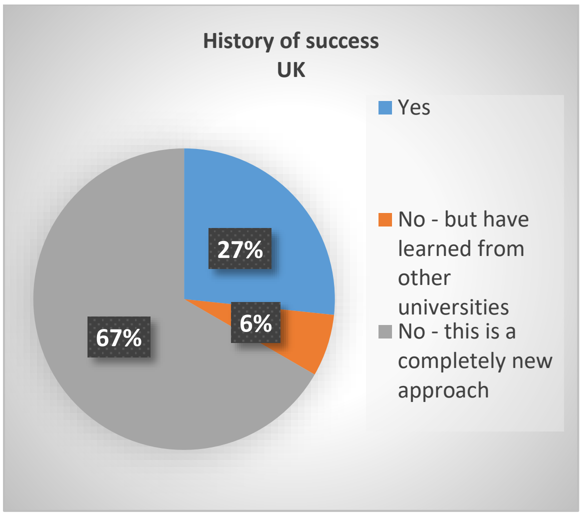
The main positions of the individuals responsible for providing the lead on internal support are below:

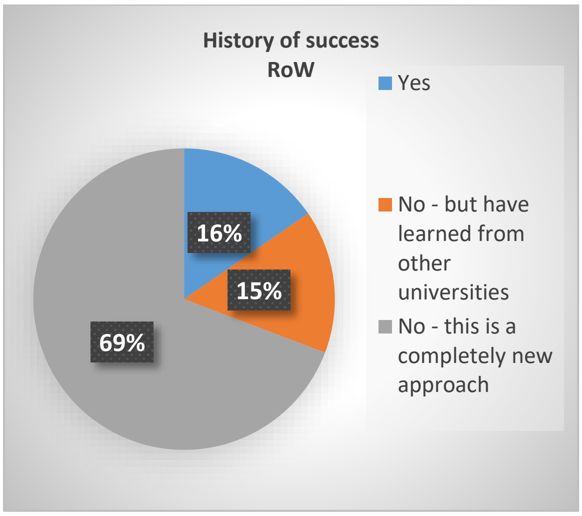






5.4.6 Question 6: Does the university have a history of successful continuous improvement programmes / change agendas using structured approaches such as Lean or Six Sigma?





Both the UK and the RoW, at around 65%, see continuous improvement as a new and innovative approach to delivering change. Only 6% of UK responders have looked at other academic institutions for guidance and assistance in implementing their continuous improvement programmes. All 9 industry Master Black Belts are based in organisations with a history of Lean, Six Sigma or other business improvement methodologies and often visit other sites to learn from other sectors and industries to try and improve their approach to delivering change.

Key learning outcomes gained by higher educational institutions in the UK from previous projects were:

- The need for staff to own the change
- The importance of cross departmental learning to reduce silo thinking
- The need to build Lean Reviews into all technical specifications and project initiation documents
- To benchmark the project using other techniques, for example using the European Foundations for Quality Management model
- The need to learn by visiting other universities further along the journey

Key learning outcomes gained by higher educational institutions from the ROW were:

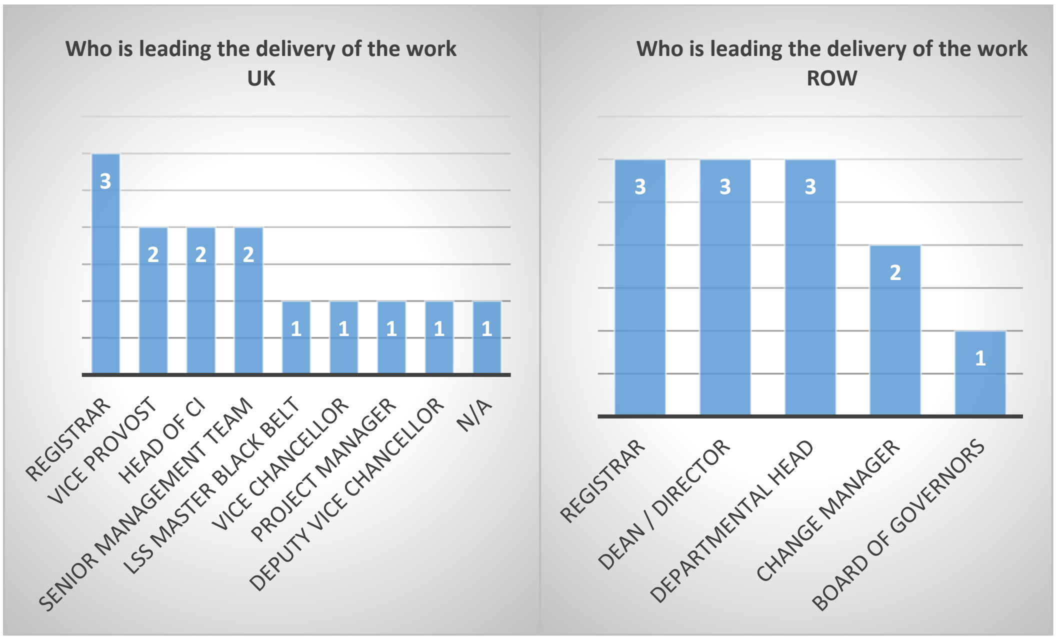
- The importance of data collection and key performance metrics in project success

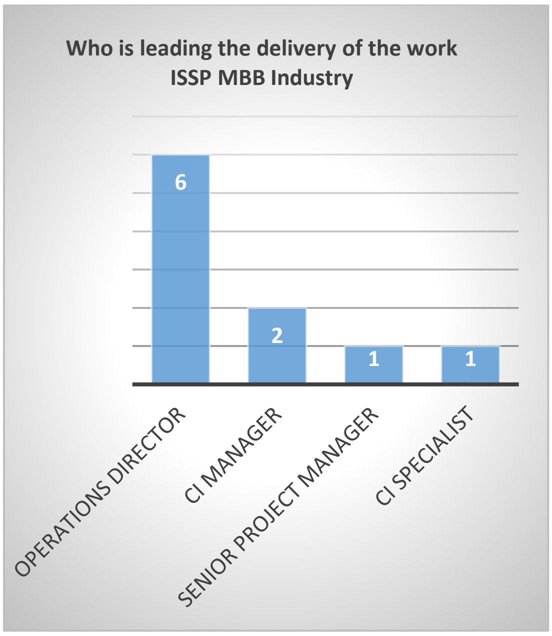
- The importance of learning and developing best practice approaches from other change programmes within the institution. For example learning from recent technology, systems construction and commissioning projects.
- The power of learning from other organisations to help facilitate change
- The use of internal experts, for example researchers, professors and administrative staff trained in Lean Six Sigma, to facilitate change rather than relying on expensive external expertise

Key learning outcomes from previous projects identified from the industry Master Black Belts were:

- Change needs to be led from the top
- People need to be empowered and allowed to deliver change
- Sustaining any initiative requires work and effort by the management team
- Teams need to be self-sufficient with respect to skills
- Correct project selection is critical for success
- Data driven project decision making is critical
- Companies need their own case studies to bring sceptics along and fight any resistance to change within the organisation

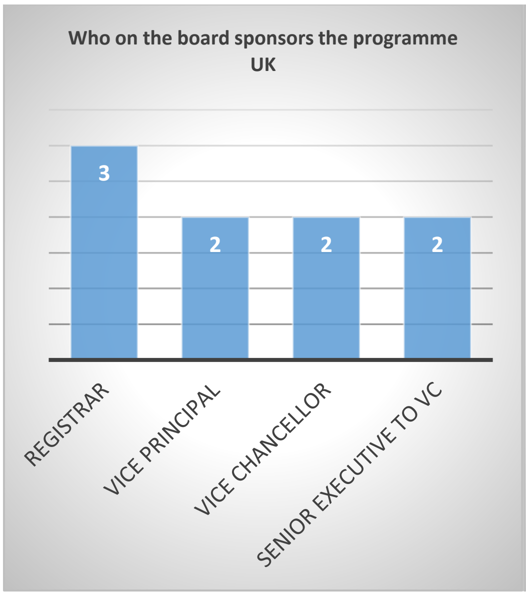
5.4.7 Question 7: Who is leading this continuous improvement programme / change agenda and where do they sit within the organisations' hierarchy?

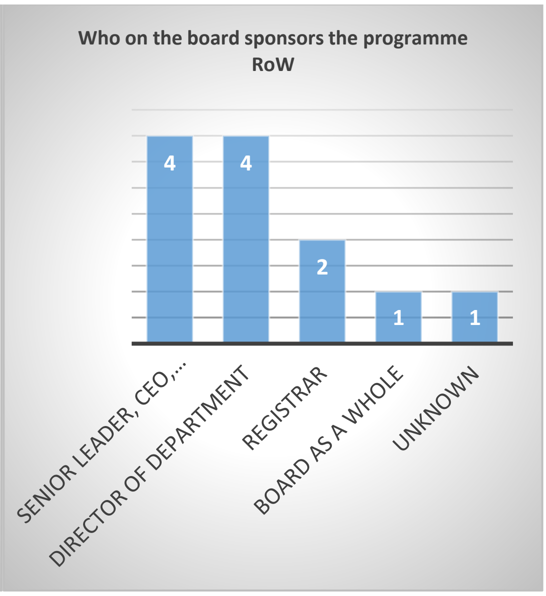


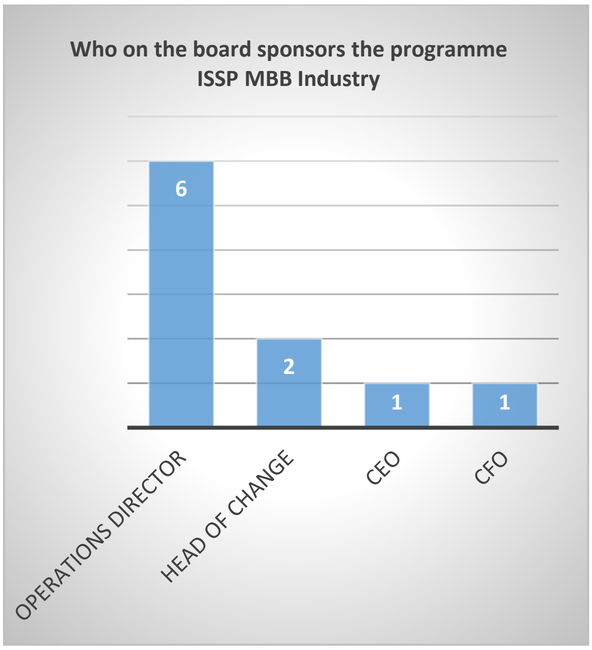


The leaders of the continuous improvement or change agenda are reasonably evenly spread across 4 headings in the UK accounting for nearly half of the responses, and 3 headings in the ROW, accounting for three quarters of the responses. However the registrar is top or joint top for both UK and RoW. The registrar is a position often regarded as an administrative driven one, with a potentially limited continuous improvement agenda. Within the 9 Master Black Belt responses, the Operations Director accounted for 66% of responses.

5.4.8 Question 8: Who is responsible at board or executive level for the strategy, vision and senior management oversight of the continuous improvement programme / change agenda?







The role of championing continuous improvement at board level in the UK is reasonably evenly split between the registrar, the vice principal and the vice chancellor. Within the responses from the RoW, the registrar only appears third, with the programme of change being represented and led by the CEO or senior leader of the higher educational institution. Within the 9 Master Black Belts, the operations manager, leading the potential change, appears to typically report into the operational director, who represents Lean Six Sigma continuous improvement at board level.

5.4.9 Question 9: What competencies, knowledge, skills and behaviours within the leadership team of this continuous improvement programme / change agenda were particularly required to guarantee success?

For the UK, 4 respondents identified 4 competencies, knowledge, skills, and behaviours they require from their continuous improvement managers or project leaders. There are:

- The need to have experience, qualifications and ability to manage change
- The ability and experience of running large scale university wide projects
- The ability to reviewing key administrative processes with a critical, non-subjective or biased view
- The ability to resource projects by utilising staff secondments

For the RoW, 5 respondents identified 6 competencies, knowledge, skills, and behaviours they require from their continuous improvement managers or project leaders. There are:

:

- The ability for individuals to facilitate team working and cross departmental working
- The ability to gather reliable data and be confident in data analysis techniques
- The ability to demonstrate Leadership within the context of continuous improvement
- The ability to gain commitment by all parties

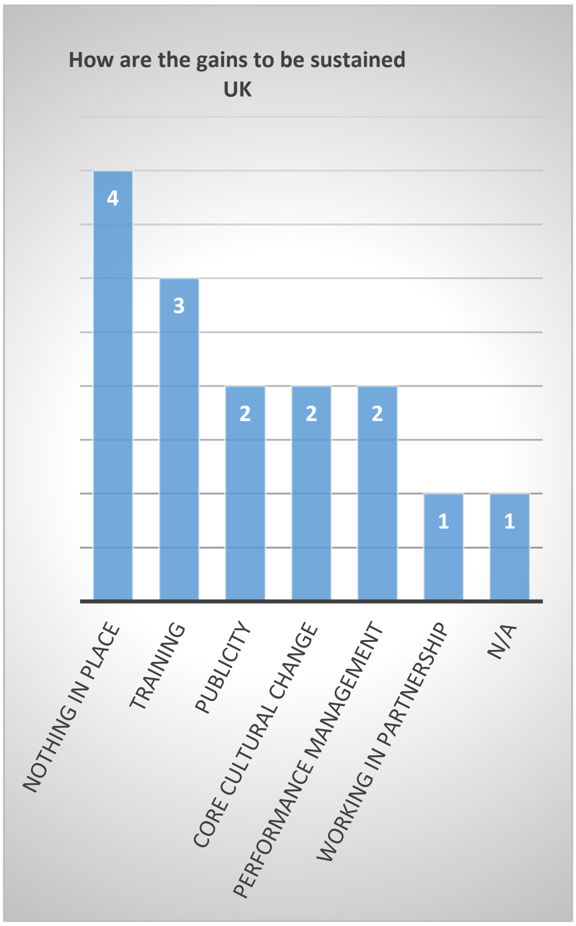
- The ability to involve and facilitate change at all levels within the organisational chart and to involve all members of staff, including researchers, professors and managers
- The ability, qualifications and experience to demonstrate continuous improvement expertise

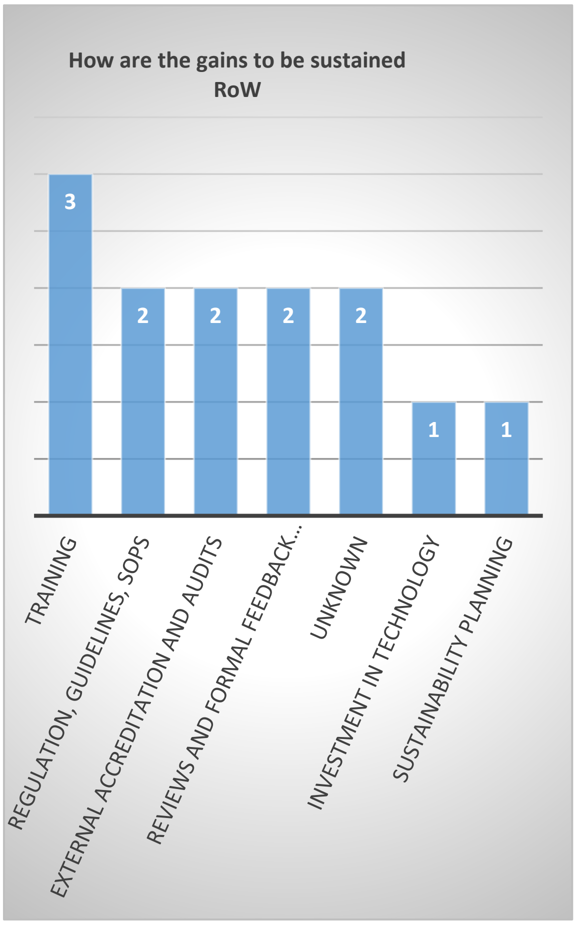
For the industry Master Black Belts all 9 responded with the following 11 competencies, knowledge, skills and behaviours:

- The ability to managing change
- Being able to set, articulate and communicate a vision
- To understanding the business, the sector and the environmental factors effecting performance
- The ability to develop, coach and mentor individuals
- The ability to solve technical and cultural problems in a structured manner
- To handle emotions and make decision based on data
- The ability to focus on the customer and wider stakeholders
- To display professional ethics and robust codes of conduct when dealing with others
- The ability to take responsibility and avoiding blaming others
- The ability to enhance the role of Lean Six Sigma, through the production of research articles, attendance at conferences, creation of case studies and becoming an internal ambassador for continuous improvement within their organisation
- Finally, to be able to demonstrate compassion to individuals adversely effected by change

5.4.10 Question 10: How will the institution sustain any gains and success made though this continuous improvement programme / change agenda?

No formal Lean Six Sigma tools or strategies were identified by the UK or the ROW with regards to sustaining their CI programmes. However the following was presented by the respondents as methods to maintain the gains achieved:


How are the gains to be sustained
UK
4
3
2
2
2
1
1
NOTHING IN PLACE
TRAINING
PUBLICITY
CORE CULTURAL CHANGE
PERFORMANCE MANAGEMENT
WORKING IN PARTNERSHIP
N/A


How are the gains to be sustained
RoW
3
2
2
2
2
1
1
TRAINING
REGULATION, GUIDELINES, SOPS
EXTERNAL ACCREDITATION AND AUDITS
REVIEWS AND FORMAL FEEDBACK...
UNKNOWN
INVESTMENT IN TECHNOLOGY
SUSTAINABILITY PLANNING

The 9 industry Master Black Belts identified the following areas for improving sustainability of Lean Six Sigma:

- Linking project selection to the business strategy
- Developing the companies' own "stories" and case studies
- Building the continuous improvement agenda into established systems and structures – for example ISO9000 quality management systems
- Regular audits by senior managers as they perform their daily walk arounds or Gembas
- Train a diverse audience of staff members across the organisation, not just deep within one department
- Measure not just financial benefits but cultural change, and benchmark the organisation against world class organisations.

5.5 Summary and concluding comments from the survey

Table 30 summarises the findings of chapter 5, linking the themes and trends identified by the author to the original question theme and the typical responses to the questions.

Question number	Aim of the question	The link back to the trends and themes identified in 5.3	Typical UK response	Typical RoW response
Q1	Has the higher educational institution started a change or continuous improvement programme?	5.3.1	86% have started or plan to start a change or continuous improvement	94% have started or plan to start a change or continuous improvement
Q2	Do the responders understand why they have undergone a change or continuous improvement programme?	5.3.1	To improve staff and student experience	To drive down costs and improve efficiencies
Q3	Has the higher educational institution identified potential key success factors for	5.3.2	Annual national student survey	Adherence to project plans and objectives

	measuring the impact of the change or continuum improvement programme?			
Q4	Is the higher educational institution using a recognised continuous improvement technique?	5.3.3	52% Yes - Lean	72% Yes - Lean
Q5	Is the higher educational institution using its own in-house expertise or relying on outside expertise to deliver the change programme?	5.3.4	67% Internal 16% External 17% Both	63% Internal 16% External 21% Both
Q6	Does the higher education institution have any history of delivering successful change and has it learnt from its mistakes and successes?	5.3.5	67% believes this to be a completely new type of activity	69% believes this to be a completely new type of activity
Q7	Who is leading the team or programme of change for the higher educational institution?	5.3.4	Registrar	Registrar, Dean or Dept. Head
Q8	Who is representing the strategy of change and continuous improvement at board level?	5.3.6	Registrar	Senior leader or Vice Chancellor
Q9	What knowledge, skills and behaviours are required to be either developed or enhanced to make sure the change programme has a chance of success?	5.3.7	4 new project based competencies identified	6 new project based competencies identified
Q10	How will the programme be sustained in the long term?	5.3.7 and 5.3.8	Nothing in place	Through ongoing training and development

Table 30 Summary of questionnaire responses, linking back to key themes and trends

This study of how universities in the UK and the RoW implement continuous improvement programmes and change agenda has highlighted several interesting trends. The main finding is that UK universities lack maturity in implementing Lean, Six Sigma or Lean Six Sigma philosophies, tools and techniques. This is born out in their understanding of methodologies such as Lean and Six Sigma, but also in the language used in answering the questions submitted by the author. This is typical of any new industry or sector embarking on a continuous improvement journey, and it is expected that the level of maturity within these institutions would be significantly less than those of manufacturing industries. However the implementation of Lean Six Sigma is not just about the "destination" but also the "journey" and it is expected that the higher educational institutions within the UK will mature as time progresses (Hines et al 2018.)

Although the trends identified above are interesting, the main aim of the questionnaire approach was to identify potential UK case study material for the development of LSS leadership maturity model in higher education. There are several universities in the RoW, which have successfully used Lean Six Sigma on their own internal administrative, teaching and research processes to improve the operational efficiency and effectiveness and they could be approached to test the model once it is complete, examples include (Sunder 2018):

1. Miami University, USA - The University is involved in regular Lean fairs and Six Sigma programs, which the management use to motivate individuals within the university to complete their own continuous improvement projects, for example to save energy and utility costs.

2. University of North Carolina, USA - The pharmacy department at the University of North Carolina has benefited significantly from applying LSS techniques to its inpatient pharmacy, since 2014.

3. National University of Singapore –The NUS, Singapore, introduced various LSS programs as part of the University offerings. The objective of these training programs is to provide the students with expert-level skills in analysing and improving processes using the integrated LSS approach. According to the

University, upon completion of the training, the participants can be expected to lead a project team to execute improvement project within a university process.

4. Valdosta State University, Georgia - One of the initiatives of the chancellor was starting the 2008 fiscal year with the implementation of LSS for higher education.

5. Gordon State College, USA - Gordon State College has recently introduced an LSS program to its planning process, implementing a language for change to be understood not only across the campus, but across the different institutions of the university system.

6. University of Central Florida, USA - A classic example of the application of LSS in the education institution is the University of Central Florida and its effort to expedite the admission process of qualified students through the use of LSS projects.

The author has chosen to focus the building of the model on UK institutions and published research; and the testing of the model using UK and RoW institutions, and industry Master Black Belts. There are some examples of UK universities trying to implement Lean Six Sigma beyond the administration processes; for example the author's own publication on using Taguchi techniques for systematic literature reviews and the use of Voice of the Customer techniques at Herriot Watt University and The University of Strathclyde to improve teaching quality and effectiveness. Outside of the author's own experience there are several UK institutions which are using Lean, Six Sigma, and Lean Six Sigma methodologies and it should be possible through detailed study to understand what makes leadership teams in academia successful in implementing Lean Six Sigma. This "maturity" model can then be used by UK academic leaders to assist in a better understanding of the critical success factors around implementing Lean Six Sigma and improve their chances of success, and close the gap on the RoW and industry.

There is clearly a need for this model since it appears that academic institutions in the UK have a long way to go before they can truly claim to have a continuous improvement philosophy in place. One of the main characteristics of Lean Six

Sigma is that any business process is open for scrutiny and improvement – teaching and research, not just administration, needs to be embraced before these institutions can claim to have a Lean Six Sigma culture. Finally, the only individuals within an institution who can make this cultural change happen are the leaders, not just of departments, but the ones at the very top of our academic institutions.

The following chapter demonstrates how the survey was used to identify potential case study universities for semi-structure interviews in order to develop a draft Lean Six Sigma maturity models for higher educational institutions. 4 UK institutions of varying size and history were selected, along with 3 others to act as test cases.

Chapter 6: The author’s own LSS Maturity Model

6.1 Conceptual model background

Over the past 5 years, the author has been researching Lean Six Sigma as an approach that higher educational institutions could use to drive continuous improvement and meet the challenges faced by the ever-changing academic sector. Building a culture of continuous improvement is not easy and for higher education institutions to succeed they will need to accept a philosophy of quality and continuous improvement across all levels of the organisation, provide efficient communication channels, reward and recognise outstanding achievements, and create networks based on strong values and standards, (Shoeibi and Zahmatdoost 2015.)

Previous authors have cited the challenges faced by academic institutions in the modern digital world and early chapters of this thesis have explored some of these challenges. Some authors believe that the quality of teaching has suffered in recent years because of the commercialisation of the academic sector in its pursuit to tackle these problems (Ramasubramanian 2012.) However many within the academic sector believe that universities can learn from manufacturing and service companies when it comes to delivering change, driving up quality and deploying a culture of continuous improvement, (Mazunder 2014.) Arguably the biggest challenge faced by these academic organisations as they try and develop a quality based, continuously improving culture has been identifying the true customer of the academic institutions processes and their understanding of what customers need. Within the world of Lean Six Sigma this is known as understanding the voice of the customer and it is important as it is at the heart of any Lean Six Sigma initiative (Prasad et el 2012.)

A potential customer of academic processes is the “student”, at some level both an internal and external customer of academic processes but Prasad et el (2012) argues that actually they start out as a raw material, an input, they are converted early on into an internal customer and then eventually become the product of the institution they have attended, eventually to be passed on to another external customer – for example an organisation recruiting graduates.

There are potentially many conflicts within academic institutions when it comes to identifying the true “customers” and their voices (Nadeau 2017.) For example is business a customer? Is government? Is society? etc. Because of the difficulty of identifying customers and their true needs, project selection has typically focussed on simple administrative processes where a customer of the administrative process can be more easily identified and a need established. These administrative projects are more easily defined than academic based projects, and often avoid major conflict between academics and managers; utilising simple tools and techniques such as process mapping, waste analysis and rapid improvement events to drive change (Nadeau 2017.)

A recent study by Nadeau (2017) identified 30 organisations using Lean, three using Six Sigma and three using Lean Six Sigma around the world but all of these institutions were deploying their approaches in administrative processes only and using very simple tools and techniques such as, in addition to those above, basic descriptive statistics, spaghetti diagrams and project charters. For example Nadeau (2017) identified there is no real evidence of institutions using statistical process control charts, process capability or advance statistical modelling to predict, for example, enrolment rates or exam success. These statistical tools have been widely used to great success in manufacturing for many years. This lack of maturity in Six Sigma and Lean Six Sigma within higher educational institutions has been one of the drivers for this research.

The aim of this chapter is to present a Lean Six Sigma maturity model for successful implementation of Lean Six Sigma in higher educational institutions. After detailed study of UK institutions, through literature review, direct questionnaires and case study approaches, it is clear that no UK higher educational institution is using pure Six Sigma or an advanced hybrid of Lean and Six Sigma (Lean Six Sigma) approach to deliver change – with most using a watered down version of Lean or Lean Six Sigma. In development of this model the author has visited four UK institutions, each at different stages of their continuous improvement journey, and discussed with the key change agents and their teams their approaches and methods of implementing continuous improvement. The author has been able to pull together learnings from all four institutions to develop a maturity model for implementing a culture of continuous improvement – with at its heart the original plan of a Lean Six Sigma approach to delivering change. The model presented in this chapter includes 5 Levels of maturity utilising a similar approach identified in chapter 2 – the capability maturity matrix. The reason for this is to demonstrate maturity of Lean Six Sigma over time; the assumption being that an organisation can move through the different stages or levels of maturity as they build more competency and experience with deploying Lean Six Sigma. There are several Lean Six Sigma maturity models already in existence, although none are specifically targeted at academic institutions. Table 31 below highlights a selection of recent Lean Six Sigma maturity models published in international recognised journals compiled and reviewed initially by Albliwi (2017) and updated by the author to include published models up to 2020. It is worth noting that many of these are based on the capability maturity framework.

Author:	Aim:	Research Approach:	Identified Limitations:
He (2009)	To assess and benchmark Six Sigma programme maturity in the Chinese software industry	Based on a mixture of the Baldrige criteria, Motorola's corporate quality system, reviews, guidelines, survey and interviews	Developed for software industry in China and not generalised for other industries -The model ignored product and process innovation. -The required Six Sigma infrastructure in each maturity level was not explained -Unsatisfactory supporting documentation
Lin et al. (2009)	To integrate Capability Maturity Matrix (CMMI) and Six Sigma in a framework to assess process maturity	Based on the integration of CMMI and Six Sigma	-Limited in the fact it was only developed for the automobile manufacturing industry -Limited focus on the current level of the process maturity and helping organisations to mature the relative processes of product development and manufacturing in its product lifecycle; therefore, it cannot be used to assess the maturity of LSS -Scoring system does not appear available in the model
Li and Lin (2011)	To integrate CMMI and Six Sigma in a framework to assess process maturity	Based on the integration of CMMI and Six Sigma	-Developed for the automobile manufacturing industry -Limited focus on the current level of the process maturity and helping organisations to mature the relative processes of product development and manufacturing in its product lifecycle therefore, it cannot be used to assess the maturity of LSS and scoring system is not available in the model
Watson-Hemphill and Bradley, (2012)	To measure the deployment of Lean Six Sigma	Based on many years of authors' practical experience in the field	-Based on the authors' practical experience: Lack of theoretical base, validity and generalisation -There is no clear definition for each maturity level -Limited to five categories and missed some important characteristics, such as organisational learning and scoring system -Not user friendly
Malmbrandt and Ahlstro (2013)	To create measures of Lean service	Based on Lean literature; it was then validated through workshops and semi-structured interviews with expert practitioners	Focus on service sector -Missing important components e.g. scoring system, time needed to move to next level, organisational learning practices and communication.
Kosieradzka (2016)	To develop a maturity model for production management incorporating all modern improvement techniques	Brief literature review of the capability maturity model and bringing together of approaches based on author's own view Tested on 16 companies	- Not relevant for small batch or jobbing environments - Not focused on one approach but tries to build a model utilising Lean, TQM, Six Sigma, Kaizen, Total Preventative Maintenance, Business Process Re-engineering, and Theory of Constraints – all of which can conflict, and confuse deployment
Uluskan and Erginel, (2017)	To develop a measurement system to measure the Six Sigma life cycle within a company	Based on a literature review of life cycles within Six Sigma companies and capability maturity models	- Few studies have mentioned life cycles within the world of Six Sigma, limiting the literature review element

		In addition, with a survey of Six Sigma impact across 97 organisations	- Experience from the surveys was not always positive and Six Sigma deployment can suffer and its life cycle diminished if other quality improvement approaches are adopted
Tavcar et al (2018)	The goal of this paper is to establish a maturity assessment model for engineering change management in the automotive supply chain, based on the Lean methodology	Model designed and built using the work of Khan et al (2013) developed for new product development applications in the automotive sector, and tested on 8 automotive suppliers	- Many of the building blocks identified in Khan et al (2013) have not been formally deployed or tested in industry and therefore are pure theory at this point - Tavcar et all (2018) model is specific for engineering change in product design and not widely adaptable to other applications or sectors - Cultural impact has not been considered, but was identified as important to future research in Khan et al (2013)
Moya et al., (2019)	To develop a Lean Six Sigma Global Index for small to medium enterprises	Based on a literature review on success factors for SMEs the authors developed the LSS index and then tested within a Chilean and French company	- No strategy or prioritisation plan offered to companies post assessment - No ranking of importance of factors - Limited test cases - Only focused on manufacturing companies not service or academic sectors

Table 31 Examples of LSS maturity models outside of academia

6.2 The development of a Lean Six Sigma maturity model for higher educational institutions

Since the Software Engineering Institute launched its Capability Maturity Matrix over 20 years ago, hundreds of maturity models have appeared and been proposed by researchers and practitioners across a variety of industries and applications, (Sun et al 2009.) At the centre of all of these models is the desire to think of the world as a process, with a purpose, inputs and outputs, and methods of measuring the outputs and inputs against the desired purpose (Sun et al 2009.) In the world of process improvement an array of maturity models have been presented by the author in this and previous chapters. Maturity models are based on the assumption of predictable patterns of evolution. These patterns within maturity models usually include a sequence of stages or steps through a series of levels that form a logical path from an initial starting state to a defined maturity (Poppelbulb and Roglinger 2011.) The author's final model will be based on the traditional capability maturity matrix framework and thus will need stages, steps and "levels" to define a higher educational Lean Six Sigma maturity model. In addition the model will follow the "5 characteristics of maturity models" outlined by the author in chapter 2. Table 31 below highlights the author's chosen approach against the 5 characteristics of maturity models:

Characteristic 1: The Type of Maturity Model

Process improvement and leadership maturity models are often designed around the original capability maturity model from the Software Engineering Institute at the Carnegie Mellon University. Capability maturity models are either Prescriptive or Descriptive, with a possible benchmarking or comparable element (Roeglinger et al 2012, He 2007, and Lockamy and McCormack 2004.) This ability to act as a benchmarking tool enables the reader to use the model to develop an action plan to progress and move through the levels of maturity.

Characteristic 2: The Scenarios of Maturity

Maturity models use design principles set around terms known as dimensions or factors, each with their own set of typically linear levels moving through time and maturity**.** The resulting scenarios (graphical areas of intercept between the factors and then levels) become the knowledge descriptors which are then used to benchmark performance against the maturity model (Poppelbulb and Roglinger 2011, Pesic 2009 and Fisher 2004.) For example a 5 level maturity model with 4 factors would have 20 possible combinations, or scenarios; each scenario representing a potential maturity point in space, and thus a potential description of the current or desired level of maturity.

Characteristic 3: The Target Audience of Maturity

Capability maturity models can be applied to almost any situation, entity or process. The approach to designing maturity models outlined in characteristic 2 is applicable to a wide variety of entities including abstract concepts such as leadership, or descriptive concepts such as processes, for example order fulfilment or the sales processes, and physical products and projects such as an organisation's products, capital construction projects or information technology based projects (Sun et al 2009, Cojocar 2009, Pee et al 2006, Kaner and Karni 2004, and Graeff 1997.) The application of maturity models is wide and varied, and therefore the idea can be applied to the author's desired aim of building a maturity model specifically for higher educational institutions trying to deliver a Lean Six Sigma agenda.

Characteristic 4: Challenging the Linearity of Maturity

Maturity models are often linear in their nature, often with an unspecified target audience, which can be a weakness in their simplicity. The best models are designed for specific entities, processes, industries or situations and can be circular, rather than linear in nature (Chen et al 2010, Pee et al 2006 Winston 2003, Earthy 1997.) A nonlinear model would require an element of "weighting" the scenarios, which could be done through the use of empirical quantitative research. For example, perhaps the reasons for successful implementation of Lean Six Sigma are wide and varied but not equally weighted – maybe leadership is more important that the tools used? Any weighting would need significant research to support the chosen prioritisation of factors or levels.

Characteristic 5: Testing the Maturity Model

Often new maturity models are designed through using existing models or concepts; building on previous findings, for example the success factors of successful project deployment. Factors and dimensions are the categorisation of subject matter knowledge into meaningful themes, and the levels are the representation and measurement of that knowledge, usually in a manner related to the reader. These categories (dimensions, factors ets) and representations (levels, stages etc) are confirmed through the use of questionnaires, interviews, and established thinking. The most respected maturity models are tested and refined using case studies, focusing on the target audience. The samples, members or elements of the case studies are not the same as those used to develop the original factors and levels, thus allowing the author the possibility of verifying the accuracy of the maturity model, (Hilton and Sohal 2012, He 2007, De Bruin and Rosemann 2005, Fisher 2004, and Kaner and Karni 2004.)

Characteristic:	**Authors Approach**
1) The type of maturity model	Using the Software Institute's Capability Maturity Model as a guide the author aims to develop a "descriptive" maturity model, which can be used by higher educational institutions to benchmark their current maturity against the model and potentially other higher educational institutions.
2) The scenarios of maturity	Using the current literature of success factors in higher education for Lean Six Sigma and the evidence collected from structured interviews within 4 case study institutions the author plans to create a series of "factors", each with several "characteristics", which can mature through several "levels".
3) The target audience	The target audience are the leadership teams, heads of departments and change agents within higher educational institutions, and fellow researchers wishing to investigate current trends in Lean Six Sigma in higher education
4) The challenge of linearity of maturity	The need for weighting of the factors, characteristic or levels of the author's maturity model is out of scope of this thesis. However future testing, research and work could refine the model to include a weighted score
5) The testing and redefining of the model	The model will be tested and refined (chapter 7) using a similar number of structured interviews and case studies from different higher educational institutions, both from the UK and abroad. In addition, Master Black Belts from outside the higher educational sector will be

	asked to comment on the model. It is expected that the testing and feedback from a variety of sources should enable the second version of the model to be significantly improved over the first and thus be ready for formal publication.

Table 32: Author's approach to designing the Lean Six Sigma maturity model for higher educational institutions

6.3 The structure of the Lean Six Sigma maturity model for higher educational institutions:

To meet the requirements of characteristic 2 "the scenarios of maturity," the model will require factors, characteristics and levels (Poppelbulb and Roglinger 2011, Pesic 2009 and Fisher 2004.) A review of capability maturity models in chapter 2 revealed that models typically had 5 or 6 levels of maturity, which potentially could be mapped against the belt structure within Lean Six Sigma. In addition most models have a similar number of success factors or themes. The number of characteristics within themes vary from model to model depending on the style and design of the maturity model. The author's own model will use the language of Lean Six Sigma to create the levels of the maturity model, and the evidence from literature, case studies and structured interviews within the higher educational institutions to identify the factors and characteristics within those factors. The author will start by first defining the levels, then the factors and finally the characteristics which make up the maturity model for deploying Lean Six Sigma in higher education institutions.

6.3.1 Level 1: Readiness Assessment for adopting LSS

The author has demonstrated in earlier chapters that the literature supports, through the use of case study evidence, that LSS acts as an effective management strategy for process improvements across a variety of industries (Kumar et al., 2006; Shah et al., 2008; Jeyaraman and Teo, 2010; Romdhane et al., 2017.) However these successes are not guaranteed, and a poorly deployed Lean Six Sigma programme will not yield the benefits expected and can turn into a negative cultural experience (Chakravorty 2009, Glasgow et al 2010, Albliwi et al 2014.) According to research published by Näslund (2008) and Antony (2014) organizational readiness is a key factor for any continuous improvement initiative, including Lean Six Sigma. Furthermore, Narayanamurphy et al (2019) identified the three reasons why almost 95% of Lean Six Sigma deployments in healthcare fail to meet their initial objectives:

1. The subjective nature of process boundaries, roles and responsibilities, customer expectations, demand, variation and strategy all hinder the DMAIC process
2. The lack of a systematic approach to change or experience in dealing with change beyond that of capital projects
3. Finally, the lack of readiness.

Narayanamurphy et al (2019) broke down this lack of readiness into:

a. lack of training,
b. lack of awareness of the need to change,
c. lack of a system to resolve employee issues,
d. lack of top management support,
e. lack of understanding of the current culture, and a
f. lack of understanding of the true resources required to deliver Lean Six Sigma

A lack of readiness and a lack of preparation before embarking on a Lean Six Sigma journey can lead to frustration among employees, resistance by the individual, or the wider organisational, and confusion due to the lack of direction for the CI journey (Antony 2014.) Anthony (2014) identified 14 attributes which need to be in place for an organisation to be ready for Lean Six Sigma journey:

1. Employees are motivated intrinsically to achieve the new vision, mission and goals of the new initiative,
2. Employees show a “can do attitude” and will be less defensive before the CI journey is properly kicked off,
3. The organisation is willing to take risks when it is appropriate, and try new ideas and approaches,

4. Leaders of the organisation create a positive environment for change. They do this by communicating to employees about the need for change and explaining explicitly about the challenges ahead of everyone in the organisation,
5. Leaders provide appropriate resources and recognise employees for both the small changes and the big strategic improvements,
6. Management decisions are made based on facts and data but not gut-feeling, emotions or intuition,
7. Leaders have in place a CI strategy, and are making LSS one of their top priorities as part of that strategy,
8. Key business processes are clearly documented and accountabilities are clearly defined and communicated,
9. The goals of LSS are measurable, relevant and aligned with corporate goals,
10. The organisation has relevant process performance metrics that all employees understand and use,
11. The senior executives in the business understand the critical business processes and the performance metrics associated with them,
12. The organisation has a culture of collecting relevant data which drives process management and performance,
13. The top talented people in the business will be/are assigned to strategic projects which deliver measurable and quantifiable bottom-line results; and
14. LSS deployment champions are assigned to review the progress of the projects and how well the projects are aligned with strategic goals of the business.

Recently, several other authors have emphasized the importance of organizational readiness for successful Lean Six Sigma deployment and this therefore should become the starting point of any descriptive and comparable Lean Six Sigma maturity model (2014; Sreedharan et al, 2018, Sreedharan et al 2019, Vaishnavi and Suresh 2020.)

The author's own maturity model for implementing Lean Six Sigma in higher education will include a level dedicated to readiness, level 1:

***Level 1: Readiness Assessment for adopting LSS** – Level 1 can be described as an initial diagnostic assessment of the organisation's readiness to adopt change and implement a culture of LSS. For example, does the organisation understand the reasons for change, what history of change exists within the organisation, has it ever successfully delivered structural, cultural or process change outside of its IT or capital projects programme? Here the organisation is beginning its journey towards becoming a true global leader in Lean Six Sigma. This mirrors the early stages of such models as those defined by, for example, Albliwi (2017), George (2002 and 2003) and Bessant (1997.)*

6.3.2 Levels 2 to 4 – LSS levels of maturity: using the classic LSS Yellow, Green and Black Belt analogies to show development over time:

Initially with Six Sigma, then with Lean Six Sigma, organisations began using a belt system to define an individual's training and project capability. This set it apart from other improvement approaches, by introducing a formal structure for differing roles within the host company's improvement strategy (Laurenai and Antony 2011.) Borrowed from the world of martial arts, the terminology, as well as defining hierarchy the belt system, also defined career paths for improvement professionals (Laurenai and Antony 2011.) Initially the belt system included only Green Belt and Black Belt, however this was expanded over the years to include Yellow and Master Black Belt – table 33 below highlights the differences between the different belt systems taken from a variety of sources (The American Society of Quality, Coronado and Antony (2002), Harry and Crawford (2004), Schroeder et al 2008, and Stankalla et al 2019.)

Belt:	Role	Typical individual within academia trained	Typical representation within total staffing levels	Typical investment required
Yellow Belt	• Typically members of a Green Belt or Black Belt project team are drawn from the Yellow Belt pool of employees • Often collect data for Green and Black Belt projects and contribute to solution generation • Trained to understand and apply the basic LSS tools and techniques to small localised problems	Administrators, Researchers	The more mature the organisation the larger the pool of Yellow Belts – up to 60-70% of workforce	8 hours of classroom instruction
Green Belt	• Lead projects within division or single location • Technical problem solvers • Support data collection for Black Belts • Building LSS into their existing roles and responsibilities – leading LSS projects becomes a part time role	Middle managers, Academics, Technical and administrative experts	5%	40 – 60 hours of classroom instruction
Black Belt	• Full time project management role • Delivering project savings in excess of $100k dollars per year in a large organisation or $40-45k per year in a small organisation • Coach and mentor Green or Yellow Belts	Head of department, Academic lead	1%-2%	160 hours of classroom instruction

	• Deliver large strategic projects across several departments or divisions			
Master Black Belt	• Typically deliver large, strategic high impact projects • Provide technical leadership • Heavily involved in project selection and definition • Develop in-house training, mentoring and coaching materials • Mentor lower levels, supporting them technically and culturally	Academic or technical specialist	0.1-0.2%	Highly experienced Black Belt

Table 33: Main differences and characteristics of the belts used in Lean Six Sigma

In addition the American Society of Quality, recommends that each project needs organizational support in the form of executives and champions. Typically executives and champions set the direction for selecting and deploying projects. They ensure, at a high level, that projects succeed, add value, and fit within the organizational plan.

- Champions: Translate the company's vision, mission, goals and metrics to create an organizational deployment plan and identify individual projects. Identify resources and remove roadblocks. Champions tend to be drawn from senior management and leadership positions and are often to key internal customer to a process or project and have a specific desire for the project to be a success.
- Executives: Provide overall alignment by establishing the strategic focus of the Six Sigma program within the context of the organization's culture and vision. Executives are often drawn from the senior leadership team

and utilising steering groups of key individuals make sure any programme of work fits into the larger strategic objectives of the institution.

The type of project undertaken by the Lean Six Sigma professional will depend on the level of training: the higher the training the more challenging and wide reaching the project's remit will be (Schroeder et al 2008, Stankalla et al 2019.) Table 34 below illustrates some examples of projects identified in literature which have been completed in higher education delivered by Yellow, Green, Black and Master Black Belt trained higher educational staff (Allen et al (2009), Niemeijer et al (2012), Hess and Benjamin (2015), Antony et al (2018) and O'Reilly et al (2019).

Projects	**Key Result**	**Project Type**
Reducing number of course changes within one school	Course changed reduced by 25% New electronic forms introduced Admin time reduced by 4hrs per week	Yellow Belt
Biometric residence permit distribution process during enrolment	Reduction in manning from 2 to 1 person £3k annual saving	Yellow Belt
Reduce the number of financial checks within finance – within payments process	Number of checks reduced from 8000 to 3500 per year £33k annual cost savings in staff time	Yellow Belt
Software procurement process	Purchasing time reduced from months to less than 5 days £2k annual cost savings achieved, a further £800 identified	Yellow Belt
Postgraduate research application process	Cycle time reduced by 60%	Green Belt
Grant applications process within the dental school	Process time reduced by 30%	Green Belt
Mailbox permissions process within the IT systems	Reduction in calls logged 40% Cycle time reduced by 71%	Green Belt

	94k euro annual savings	
Procurement email standardisation	Standard process 2k euro annual savings	Green Belt
Applying funding to students accounts	Time reduced to clear funds by 48 days	Green Belt
Energy usage in main library	15k euro annual saving in energy Lowest annual energy consumption on record for library	Green Belt
Non EU undergraduate accommodation process	Process steps reduced by 40% New office set up Standardisation of process	Green Belt
Improving the patient discharge times within a university hospital	Discharge time reduced from 3.3hrs to 2.8hrs Missing data was reduced by 68% 79% reduction in data errors on prescriptions	Black Belt
Delivery and sustaining the initial LSS programme across a university medical centre in the Netherlands	Over a 5 year period, 90 projects were completed, 82 employees trained (including 19 Black Belts) and over 15million euros in savings	Master Black Belt

Table 34: LSS project examples within higher educational institutions

Specifically the author has chosen the terms Yellow, Green and Black to represent the middle three layers of his maturity model. This links the author's maturity model with well documented Lean Six Sigma language helping to identify it with Lean Six Sigma. These three levels align very closely to George's (2003) service sector Lean Six Sigma maturity model of Engagement, Mobilisation, and Performance and Control, (level 1 is also included for completeness) – see table 35 below:

George's (2003) maturity model		Author's own LSS Maturity Model (levels 2 -4)
Phase 1 – Readiness Assessment	• *Select the champion* • *Establish a baseline snapshot* • *Interview the top management* • *Engage key influencers* • *Assess the potential impact*	*Level 1: Readiness for Lean Six Sigma*
Phase 2 - Engagement	• Engagement strategy • Education, communication and involvement • Rules of engagements • Starting off	Level 2: Yellow Belt Organisation – Beginning LSS
Phase 3 - Mobilization	• Commissioning an executive team • Creating the infrastructure • Developing training • Select and charter first wave of projects • Reach consensus on common metrics	Level 3: Green Belt Organisation – Developing LSS
Phase 4 – Performance and Control	• Planning for the future • Avoiding pitfalls in LSS deployment • Vigilance, warnings and decelerations • Achieving transformational change	Level 4: Black Belt Organisation – Sustaining LSS

Table 35 George's (2003) 4 stage maturity model vs authors own LSS maturity model

The author's own maturity model for implementing Lean Six Sigma in higher education – levels 2, 3 and 4:

***Level 2: Yellow Belt organisation – Beginning LSS** – The organisation has started to train individuals and is delivering simple process improvement projects across the organisation. Typically these are in the form of simple rapid improvement type events* *using cross functional teams, with simple tools such as process mapping, waste and variation identification, and quick turnaround improvements. Projects tend to be localised within small teams or departments and administrative based. Benefits may not be fully realised in financial terms, but can be expressed in other ways – for example time saved, or potential benefit to be achieved.*

Level 3: Green Belt organisation – Developing LSS – *The organisation has started to build the infrastructure to continue delivering projects beyond the first wave of training and initial excitement of the programme; possibly bringing academics into the process of continuous improvement as potential customers of any such improvements. Projects undertaken are more challenging, wider ranging and potentially cut across departments and teams. In addition projects begin to introduce basic statistical tools to aid in improving processes. Benefits should be measured in financial achievements and could reach £100k.*

Level 4: Black Belt organisation – Sustaining LSS *– the organisation has embedded LSS into all areas of the organisation and is delivering projects across a wide range of topics, beyond simple administrative processes, to include, for example teaching, student mentoring and research processes. For this level to be reached, organisations need to recognise that all activity within an organisation is viewed as a process (Snee 2010.) Projects will be using the full range of tools and techniques available to Lean Six Sigma professionals. Benefits should be measured in both cultural and financial, with financial benefits exceeding £100k per annual.*

6.3.3 Level 5: Master Black Belt – The learning organisation

As the higher educational environment changes and institutions adapt themselves to survive in an increasingly complex world, higher educational institutions influenced by these changes will need to make strategic choices (Tarakci 2016; Watkins and Kim 2018.) Such changes in workplace may encourage employees at all levels within the institution to think differently and learn new skills, practices, behaviours, and techniques. The systematic occurrence of such learning not only at an individual but also at team and organisational levels originated the term Learning Organisation (Marsick and

Watkins 2003.) A learning organisation has been denoted as an organisation where people continuously increase their ability to generate the desired results through the development of novel ways of collectively thinking, so that they learn to learn together (Senge 1990.) In this sense, a learning organisation's capabilities can be seen as a positive indicator of the organisational culture (Tortorella et al 2020.)

One of the main Lean Six Sigma principles is to 'seek for perfection' through continuous improvement. As Lean Six Sigma implementation becomes more mature within the organisation, these continuous improvement cycles may facilitate learning and knowledge sharing (Spear 2009; Bai, Satir, and Sarkis 2019), reinforcing the development of a learning organisation (Tortorella et al 2020.) Tortorella et al (2020) state that although research is limited in this area, there is clearly a link between the maturity of an organisation's improvement programme and its ability to be a learning organisation. Snee (2010) describes his key learnings from his 25 years deploying Lean Six Sigma in organisations as:

1. have a sense of urgency
2. Review progress on a regular basis
3. Understand human behaviour
4. Make it easy to see, understand and do
5. Always have an impact focus on process performance and bottom line
6. Use improvement as a leadership tool, do not be a victim of change but a driver of it

Galli and Kaviani (2018) go on to describe the risks to watch out for when trying to sustain a Lean Six Sigma programme:

1. Move away from excessive emphasis on the tools and move towards Lean Six Sigma "thinking" – the mind-set is more important than any individual tool
2. Make resource available
3. Do not limit people's ability to create solutions for themselves
4. Improve all aspects of communication across the organisation

5. Do not try to excessively manage Lean Six Sigma projects – allow people to improve processes daily
6. Make sure it is linked to long term strategy and management systems
7. Have top management participate in all activities

The final level in the author's own Lean Six Sigma maturity model for higher educational institutions tries to demonstrate a view of what a higher educational institution should aim for as it becomes a Lean Six Sigma learning organisation:

Level 5: Master Black Belt organisation – The learning organisation

The organisation has embedded LSS into all areas of the organisation and has fully understood the link between the creativity of its people and the ability to learn from both its mistakes and its successes. The organisation sustains the cultural approach to continuous improvement and the desire to find perfection, illuminate all waste and variation, and uses the concept of improvement as a leadership tool (Snee 2010.) Improvement projects touch all aspects of higher educational life, including the design of new products and services, such as new courses, new schools or new technologies. Benefits are measured using cultural change metrics, and the institution feels free to benchmark itself against other institutions inside and outside of the higher educational sector.

To build the theory within the maturity model further, the author wanted to learn from the limitations of previous models – see table 32 above, and from best practice observed within the UK higher educational sector. The aim was to develop themes - known as factors; and descriptors - known as characteristics - to allow organisation not to simply check where they are on the 5 level journey but accurately score themselves against the combinations of factors and levels. For example an institution could be at level 5 in one factor but only level 3 in another. Thus addressing some of the limitations identified in maturity models in chapter 3, specifically around the one dimension aspect of models and their lack of appropriateness for their target audience.

6.4 Using case studies and structured interviews to build the detail of the model

Chapter 4 reviewed the potential research approaches the author could undertake in developing his model. The chosen approach taken from the work of chapter 4 is to create a higher educational institution Lean Six Sigma maturity model using case studies and semi structured interviews. The ideal institutions for study would be delivering change and continuous improvement through the use of recognised improvement approaches such as Lean, Six Sigma, or Lean Six Sigma as this would allow the authors to link levels of success or failure within these institutions to themes identified in literature.

Case studies and semi-structured interviews combine well together (Yin 2009.) The case study approach is known as "qualitative research." The aim of this method is to research - through a mixture of observation, document review and interview - the drivers for change, the approaches taken, the results achieved, the challenges faced, and the leadership knowledge, skills and behaviours deployed and developed (Yin 2009.) At the centre of the process, driving the observations, document review and interviews would be the researcher's main research questions thus maintaining focus in what would be inevitably an interesting environment for the researcher (Yin 2009.) The output of this research is a "case study". It is essential to be able to define the unique characteristics of the case under study and different approaches can be undertaken (Stake 1995.)

An interview involves the researcher in a one to one discussion with the interviewee. The aim is to gain valuable depth of understanding. An interview can be structured, unstructured or both in its design, however the more unstructured the approach, the more difficult it will be for the researcher to analyse the findings later and create generalised theory which is transferable to other situations (O'Gorman and MacIntosh 2014.) The drawbacks of an unstructured interview are also the collection of irrelevant data or potentially the interviewee's answers being affected by the researcher's own bias (O'Gorman and MacIntosh 2014.) However, the semi-structured approach tries to bring the best of both unstructured and structured methods to the researcher, giving the researcher freedom to explore within the interview themes and trends as they appear, but still enable generalised theory to be developed (O'Gorman and MacIntosh 2014,Knox and Burkard 2009, and Kajornboon 2005.)

Seawright and Gerring (2008) argue that case studies should not be created randomly, but selected based on a criteria. In an earlier conference paper (Anthony and Antony 2017) the author identified several UK institutions which could be used for a basis of case study and semi-structured interview research; the aim being that the author could contact these organisations and complete a series of semi-structured observations and interviews to build up a story of how change is happening.   Eisenhardt and Graebner (2007) suggest that building theory from case study research requires one or more cases to create theoretical constructs, propositions and midrange theory from case based empirical evidence. Thus the author decided to identify at least four universities who were at different stages of their Lean Six Sigma journey. To identify the chosen UK institutions, a questionnaire was sent to over 100 academic institutions in the UK; although this was then widened to include universities across the world to improve the sample size and cross check the quality of responses – see chapter 5. This questionnaire was designed to test their current understanding and use of Lean Six Sigma. 47 staff members from these institutions responded. Table 36 below demonstrates the breakdown of these individuals:

Source	Leaders	Change Management lead	Change management team / practitioners	Academics	Administrative staff	**Total:**
UK Universities	5	2	2	12	0	**21**
International Universities	2	2	4	13	0	**21**
MBB / BB	0	0	5	0	0	**5**
Total:	**7**	**4**	**11**	**25**	**0**	**47**

Table 36: Academic responses to the author's initial questionnaire

From the 47 responders, four institutions were selected that appeared to demonstrate a varied understanding and approach to the use of LSS as a driver for continuous improvement. Table 37 below highlights the selection criteria used by the author in identifying the case studies from the initial questionnaire responses, adapted from Gerring and Seawright (2007) and Seawright and Gerring (2008.)

Selection Criteria:	Options / Notes:	4 chosen cases:
The feasibility of creating the case study:	1. Is the institution interested in hosting a case study? 2. Is the institution aligned with the goals of the researcher? 3. Are their internal champions willing to discuss success and failures within the institution? 4. Are they able to meet within the researcher's time frame?	All four chosen cases meet criteria 1 – feasibility of creating the case study
The way in which institutions vary:	1. Structure – College, school departments and governance etc 2. Size – staff, students, budget and turnover etc 3. Focus - UK focused or international focused 4. History – traditional, newly created, spin out etc	1 of the 4 cases using a college structure, the remaining 3 use a school based approach to managing the institution. 3 of the case studies are medium to large institutions, and one case study is a small institution compared to its peers – based on staff, turnover and student numbers. All 4 case studies are UK based, with 1 case study having 5 campuses around the world.

		2 of the case studies are historic universities, and 2 have been created within the last 100 years
Type of case:	1. Typical case: one or more cases with characteristics that are most common across the portfolio of higher educational institutions 2. Diverse case: two or more cases that illustrate the range of variation in one or more characteristics 3. Extreme case: one or more cases that exemplify an extreme or unusual manifestation of a characteristic or the outcome; for example, one or more cases with dramatic or very little change. 4. Deviant case: one or more cases that diverge from the portfolio in unexpected ways; a deviant case aims to better understand and develop a new model of how change takes place. 5. Influential case: one or more case with an influential configuration of factors that contribute to the outcome; an influential case aims to confirm the overall theory of change.	The author aims for his cases to come from a variety of types to aid in developing a maturity model: Case study 1 – Typical Case – most responders to the questionnaire answered this way Case study 2 – Extreme Case – this institution has the skills to implement LSS but has chosen not to Case study 3 – Influential Case – several responders quoted using case 3 as a guide to implementing LSS Case study 4 – Crucial case – this institution has developed best practices in the field of LSS in higher educational institutions

	6. Crucial case: one or more cases that are most or least likely to result in the expected outcome. 7. Pathway case: one or more cases where one factor but not another factor is likely to have caused the observed outcome.	

Table 37: Case study and semi structured interview criteria used by the author

Table 38 covers the titles of the individuals interviewed as part of the case study research. All interviews were conducted under a code of ethics and completed anonymously to give the interviewee the freedom to respond. A copy of the code of ethics document used by the author can be found in appendix one along with examples of interview notes taken during the case study investigation.

Case study	Leadership team	Change Management lead	Change management practitioners	Academics	Admin staff	**Total:**
1				2	2	**4**
2	1			5	1	**7**
3		1	1			**2**
4		1	1			**2**
Total:	**1**	**2**	**2**	**7**	**3**	**15**

Table 38: The positions of the case study interviewees

A description of the 4 institutions, taken from their respective websites, and why they were chosen is below:

Case study 1: Famous for its medical school, this institution split from its parental university in the 1960s to become an independent institution. It is ranked within the top 300 universities in the world and within the top 30 in the UK. This institution has around 16,000 students, 3,200 staff split evenly between academic and administrative functions, and is structured into 10 schools, each with its own Dean. The vision of the university is to: *“transform lives, locally and globally, through the creation, sharing and application of knowledge. Our Vision for the University is to become the UK’s leading University within 25 years.*” The university has an annual turnover of approximately £250 million. This institution was chosen as a “typical” university which has no formally recognised continuous improvement activity by the leadership or academic teams. This institution, like many others, has completed projects in the past, typically IT or capital based, using project management based approaches, for example PRINCE2, to manage project success.

Case study 2: Initially an engineering based university established in the 1800s, ranked in the top 500 by all three ranking agencies, and in the top 25% of UK institutions, its vision is to be: *“world-leading within all its specialist areas of science, technology, engineering and business.”* This institution has over 30,000 students, across 5 campuses, in the UK, Asia and the Middle East. Across these 5 campuses are 6 schools and one institute. It has over 1,700 staff and turns over £196million. . This institution was chosen since it is regarded by external measures as a centre of excellence for teaching and research in the field of continuous improvement (CI) and has tried in the past to roll out Lean Six Sigma training. Although there is no formal central CI team, small pockets of improvement exist within certain departments with a level of autonomy to improve their own processes.

Case study 3: Established in the 1400s this is one of the oldest universities in the English speaking world. It is one of the highest ranking institutions in the UK. This institutions has just under 10,000 students, 2,800 staff, and an annual turnover of £250million. The university is structured across 3 colleges, within which sit 4 faculties, under which are positioned 18 schools. One dean leads all the colleges. The vision of the university is simply to: *“attract and nurture the best staff and the most promising students from around the world.”* This institution was chosen because it has one of the longest establish CI team in the UK. This team is often quoted and used by other universities to help them get started on their Lean journey. They have published research on the success factors, of using specifically Lean, to drive change in an academic environment.

Case study 4: Established in the early 1900s, ranked around the top 100 in the world and in the top 20 for the UK, this city based university has just under 30,000 students, 6,500 staff across 5 faculties within the UK and an international faculty in Greece. The annual turnover of this university is over £680million. The vision and mission of the university is to: "*exceed our students' and customers' expectations adding value to the Sheffield experience, by:*

- *Valuing people through investment in our staff and their wellbeing, placing students and customers at the heart of every decision we make*
- *Building a community by continuing to develop an exceptional experience, through engagement and support*
- *Delivering success through improving value, ensuring quality, providing great service and developing partnerships*
- *Reinvesting any surpluses to maintain and improve facilities and services*
- *Working towards a sustainable future"*

This institution was chosen since it has one of the largest CI teams in the country and, in 2019, was proactively recruiting new members of the team. The team operates across the university and has strong links to the financial department which drives much of the project selection process. This team is adopting a wide range of Lean Six Sigma approaches to fix problems and processes.

The selection of case studies was deliberate to try and show the evolution of continuous improvement inside UK institutions and thus help build a better maturity model. (Eisenhardt, 1989.) The author has no financial ties or history with any of these institutions and they were selected due to their responses to the original questionnaire, and if they met the selection criteria above. Within each case study several members of the institution's leadership team and or continuous improvement team were interviewed using semi-structured based interview techniques. The basis of these interviews followed the form of a formal discussion, semi-structured around the original questionnaire issued and earlier research questions created from literature by the author; the aim being to “stimulate debate” between the interviewee and interviewer (Eisenhardt, 1989.) All interviews were expressed in confidence and individuals’ identity was always protected to enable freedom of discussion. Any online presence or any literature produced supporting the institution’s activity in this area was also recorded and reviewed, however for data protection reason not presented here.

6.5 Case study findings:

Before mapping the findings against any themes or factors, a summary of the key findings from the interviews completed at the four UK institutions is listed below:

Case study 1:

1. All departments develop independent processes and approaches making system change difficult and time consuming.
2. No formal continuous improvement programmes are publicised within the university. All continuous improvement activity is done locally within departments and is driven by low level management.
3. The Objective Setting and Review (OSaR) model is used within the HR function to manage individual performance and drive improvements – although individual objectives are not linked to a higher strategic model or business plan.
4. This university has published many articles promoting and researching continuous improvement in the NHS and medical sector – including articles on using data to drive improvement – however within the school itself no formal LSS programmes exist.

Case study 2:

5. There has been one formal LSS Green Belt programme within the organisation covering administrative departments within the business school.

6. No ongoing infrastructure or support post training is in place.
7. Projects were only selected if they are transactional, with volume and data.
8. Measures of success are disconnected from strategic aims of the institution or department and are arbitrary.
9. The organisation does not attribute value to continuous improvement and it is very difficult to justify activity outside of delivering the process – delegates struggled to be “allowed time” to work on their projects.
10. Projects exists within the institution outside of the training delivered but are not recognised as Lean, Lean Six Sigma or Six Sigma (LSS), or that LSS will deliver additional value - Only “Agile IT projects” are really continuous improvement projects in the mind of the institution.
11. The language of continuous improvement is not used, understood or valued.
12. The projects that have been initiated have used very simple tools and techniques, for example value stream mapping, waste identification and rapid improvement events - with no real understanding of the concept of voice of the customer or voice of the process.
13. No joined up continuous improvement strategy – individuals using the continuous improvement strategy and initiative to focus on developing their own knowledge skills and behaviours, rather than focussing on the needs of the institution.
14. All change is driven by the IT department and is system based – e.g. new student registration system.

Case study 3:

15. This institution was one of the first in the UK to have a dedicated Lean team and has had some form continuous improvement team in place since 2005. It has also published several articles on its experiences in implementing Lean and has since shared its rapid improvement approach with several universities around the world.

16. Currently the team sits outside the university structure as a “spin out” operation, although historically it was positioned under the Chief Information Officer portfolio – however this has changed recently due to the institution strategically “moving on from Lean.”
17. The rapid improvement events are modelled on the Kaizen approach to continuous improvement – using a fixed period of time, usually a week, to map the existing process, develop a future state, develop an intermediate state and create an action place to work towards the future state. These action plans are then monitored by the central team.
18. Tools utilised form many of the basic Lean tools including value stream mapping, idea generation affinity diagrams and prioritisation tools. At the heart of the programme is the classic Plan Do Check Act model and the tools and techniques linked to Womac and Jones’ work on the Toyota production system (Womac and Jones 2003.)
19. There is evidence of very simple analytical tools such as run charts, and demand records are also used to help support the action plans developed.
20. Most projects have been based in the administrative areas of the business. Although the team recognise the value and benefit available in the teaching and research fields of the institution, they have not been able to successfully delivery any project which is perceived to challenge the academics’ approach to teaching and research.
21. The team have been raising their profile through sharing best practice and producing literature and guides for other institutions as well as their own internal communications.
22. Some skills transfer is apparent with departments initiating their own projects off the back of the Lean team’s previous interventions.

Case study 4:

23. The continuous improvement team has been in place since 2011 under the title of Process Improvement Unit (PIU). Originally under the remit of the IT department – this led to projects only being considered that were “system” based. The team moved in 2015 to be under the Student

Services team – given them a wider remit to explore administrative processes across the schools within the institution.

24. Although it originally struggled to recruit and currently has four posts – with a 5^{th} starting in late 2018, this team is the biggest team in place compared to the other case studies presented in this paper.
25. The 5^{th} post will be a data collection position since it is believed that to maintain unbiased data in the projects, it must be collected independently.
26. The steering committee was chaired for the first 5 years by the Vice Chancellor (VC) and has only recently been handed over to the deputy VC as their role changed.
27. The VC was instrumental in setting up and launching the team and getting buy-in from senior managers and departmental heads – for example by entertaining them at his residence and insisting continuous improvement is here to stay.
28. The team has used a mix of Rapid Improvement Events and DMAIC projects to deliver over 40 change projects across the administrative functions. This has allowed the development of several internal case studies to support the "selling" of process improvement to a wider audience.
29. The team has some experience of working outside of the administrative fields, with two projects infiltrating the teaching and research fields – including capital equipment requests for PhD students and the part time PhD process. No pure teaching and research processes have been tackled yet.
30. From day one, the team was set three performance metrics by the VC. Specifically, these are: Staff/Student Satisfaction, Processing Time and Cash Savings. In addition, project specific KPIs can be added to these three strategic metrics.
31. Language has been key to the success of the team. For example the team is called the process improvement unit, the word standardisation has been replaced with Process Consistency, and language such as Lean and Six Sigma are avoided. They have also changed the classic DMAIC model. Control has been replaced with continuous improvement. This has prevented people reacting to language in ways they have in the past.

32. Formal training programmes exist for “doers” and “sponsors” on projects, and also general awareness sessions are delivered throughout the year.
33. There are examples of statistical tools being used – for example simple SPC charts to track administrative departmental performance.
34. The team is recognised as a useful resource by departments and is involved in several large university wide reviews of service in addition to delivering local projects for departments – there is a belief that all processes should be reviewed every 5 years to match the changing needs of the academic sector.

Combining the author’s earlier work, including literature reviews and questionnaires, with these findings, a conceptual maturity model was developed.

6.6 Development of the first conceptual model

There are many authors such as Norton and Kaplan (1996) and Martin (2000) from Harvard Business School who have written over the years about the importance of being able to translate ideas into a coherent business strategy through the use of a leadership model. Often these ideas are complex but need to be communicated simply and for decade’s business leaders have been using strategic roadmaps to make the difficult simple to understand. These roadmaps often include strategic themes and levels – such as those found in Norton and Kaplan’s (1996) Balance Score Card, to help categorise activity and measure success.

The author’s maturity model will follow a similar pattern and include levels, factors and characteristics, see figure 12 below. The levels, defined earlier in this chapter, are the progression through the maturity model and are based on the capability maturity matrix structure – see chapter 3. The author’s own maturity model starts at a basic “readiness” level and moves through to more advance levels of maturity until finishing at the “learning organisation” level.

The factors are the themes and headings relating to successful implementation of Lean Six Sigma in industry and higher educational institutions, and are derived from research. These are created by looking for patterns and collating the evidence into themes and common observations. Finally, the characteristics derived at each level and at each factor are designed to support and provide evidence for that part of the maturity model. These will be drawn from the case study evidence above, or, where gaps exist, from research. These levels, factors and characteristics will then be summarised in a matrix and called the Lean Six Sigma maturity model for academia – see figure 13.

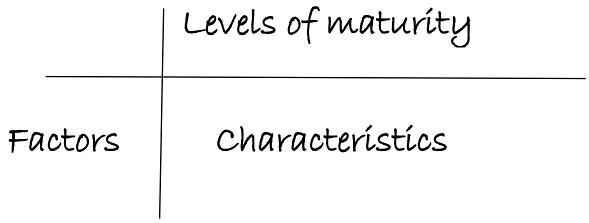


Figure 13: Linking levels, factors and characteristics

6.6.1 Defining the "critical" success factors

Boynton and Zmud (1984) defined the term 'critical success factors' as those few things that must go well in order to ensure the success of a specific program. For an institution, such as our higher educational institutions, they represent the vital areas that must have proper attention to yield a sustained or increasing level of performance (Sreedharam et al 2018.) Critical success factors are those critical areas where "things must go right" for the business to prosper and for managers to achieve their goals (Watson, 1993; García et al., 2013; Aquilani et al., 2017.) Table 39 below summarises the findings from five sources of literature on the critical success factors regarding implementing Lean Six Sigma. The first two are generic and the final three are specifically from higher educational research.

Source	Approach	Critical Success Factors identified:
Sreedharam et al (2018)	Taken from a literature review of 41 journal articles over 20 years up to 2016	Top management commitment Training and education Communication Customer focus Organisational culture

		Employee involvement Team work Supplier focus Knowledge of tools and techniques Organisational infrastructure to support LSS
Fernando and Oliveria (2017)	Taken from 7 journal articles up to 2015	Project management and selection Training and education Management commitment and leadership Business strategy Communication Customer focus Organisational culture Selection of staff Organisation infrastructure
Antony et al (2012)	Case study observations	Uncompromising top management support and commitment to the Lean Six Sigma programme Effective communication at all levels vertically and horizontally through the institution Strategic and visionary leadership from the board and those charged with delivering the change Develop organisational readiness for change Put in place the resources and skills to facilitate the implementation and change Project selection and prioritisation of activity within the Lean Six Sigma programme Preparing the organisation for cultural change
Antony and Cudney (2016)	Case study observations	Strategic and visionary leadership Developing organisational readiness Organisational culture Project selection and prioritisation Effective communication at all levels within the institutions
Haerizadeh and Sunder (2019)	DMAIC case study project within higher educational institution	Readiness, leadership and strategy by the senior team and commitment to the programme

		Training and project selection to give the institution the best chance of success Execution of pilot LSS projects using DMAIC methodology to build momentum and internal case studies demonstrating success

Table 39: Summary of critical success factors of Lean Six Sigma implementation

Reviewing the findings of the case studies – both good and bad - and linking them with the research behind successful LSS implementations, it becomes possible to identify five common themes within the findings and research. These themes can be summarised and renamed to become factors (a term often used in Six Sigma for key inputs into a process): Leadership and organisation structure, Project selection, resource and delivery, Training and development, Measuring cultural change, and Sustaining Lean Six Sigma.

Factor 1: Leadership and organisational structure

The factor most quoted in research as the one critical success factor which must be in place for Lean Six Sigma to work in any organisation is leadership, specifically top management support combined with: the right management structure for Lean Six Sigma, strong communication vertically and horizontally through the institution, and the right staff involvement at all levels (Snee and Hoerl 2002, Snee 2007, Antony et al 2012, Antony and Cudney 2016, Fernando and Oliveria 2017, Laureani and Antony 2018, Haerizadeh and Sunder 2019.)

The Lean Six Sigma transformation can be described as a journey that does not happen overnight (Laureani & Antony, 2015.) And according to Antony et al (2012) without the higher educational institution's senior management team on board from the outset of the programme, it is absolutely a waste of energy and time to launch a Lean Six Sigma initiative. The senior team should be trained in what is expected of them, and what they should expect from the programme (Antony et al 2012, Laureani and Antony 2018.) It is the role of leadership to identify Lean Six Sigma champions, create the right management structures and take responsibility for identifying, prioritising and overseeing projects, and, where needed, to inspire employees to keep going during difficult times (Jokinen 2005, Hilton & Sohal 2012; Suresh et al., 2012, Antony et al 2012.) In order to buy in senior management support and commitment, and avoid conflicts of resource allocation, it is also essential to select projects which are tied to strategic goals of the higher educational institution, (Antony et al 2012, Manville et al 2012.)

Effective communication at all levels vertically and horizontally is a key responsibility of leadership (Antony et al 2012, Manville et al 2012, Laureani & Antony, 2015.) Antony et al 2012 believes one of the problems faced by higher education institutions is that there is no shared understanding of the purpose of continuous improvement across the institution. Poor, or lack of, communication has been cited as a reason for implementation failure for continuous improvement initiatives across a number of public sector organisations (Antony et al 2012.) It is the role of leaders to communicate the link between Lean Six Sigma and the overall business strategy as well as to communicate this to employees in a clear manner and to create a compelling vision which the staff can buy into (Sumukadas, 2006; Suresh et al., 2012 Hilton & Sohal, 2012.) Only through effective communication will employees will be more engaged and work as a team for various problem-solving scenarios and through effective communication, organisations can establish a common language for change and improvement (Antony et al 2012.)

Factor 2: Project selection, resourcing and delivery

Arguably the most essential aspect of any Lean Six Sigma initiative is selecting the right improvement project (Antony et al 2012,) however it is also the most difficult to get right (Fernandes et al 2019.) The process in which organisations select projects, resource them, structure their delivery, and review the final result is a key critical success factor identified in several research articles and thus is a vital part of the author’s maturity model (Radnor and Walley 2008, Jenicke et al 2008, Antony et al 2012, Antony and Cudney2016, Fernando and Oliveria 2017, Haerizadeh and Sunder 2019.)

Project selection criteria enable organisations to prioritise large volumes of proposed projects, enable comparison to be made on the relative merits between different projects and allow the Master Black Belt to forecast which project will give the best financial or cultural impact (Harry et al., 2010.) According to Antony (2004), if Lean Six Sigma projects are to be successful and achieve long-term acceptance within higher educational institutions, then the right projects have to be selected. If institutions can select the right project then confidence in the management and employees towards Lean Six Sigma will grow, this in turn will make future efforts and investment into the initiative easier (Antony et al 2012.) If the wrong projects are selected, then the wrong processes will be improved, employees will become frustrated and demotivated and results will be delayed (Antony et al 2012.)

Antony et al (2012) identified the following potential considerations for project selection, resourcing and delivery within the higher educational institution:

1. Projects must be aligned with critical business and customer issues of the institution. This may be referred to as the voice of the business and the voice of the customer
2. Projects must be feasible to execute from a resource and data standpoint
3. Project objectives must be clear to everyone involved in the project
4. Projects should be selected in a manner which means they can be completed within four to six months
5. Project tollgate reviews must be performed at every stage of the Six Sigma DMAIC methodology, usually by the Lean Six Sigma deployment champion, to ensure a smooth running of the project
6. Projects should be selected if they have the ability to show measurable improvements in the delivery of quality associated with education, operational costs and timeliness parameters

There are different types of projects and approaches within the scope of the Master Black Belt when looking at how to manage a selected project (Jagdeep and Harwinder 2013.) The choices include structured approaches such as

DMAIC, and Plan Do Check Act projects, typically 3-6 months in length, and Rapid Improvement Events, or Kiaizen Events, which can be completed in days rather than months. Master Black Belts can use Daily Huddles of work teams, Gemba Walks through processes, Hoshin Kanri Breakthrough Projects, the standardisation of work or SMED (single minute exchange of die) to structure, resource and drive projects (Jagdeep and Harwinder 2013, Fernandes et al 2019.) Thus a key element in the author's own maturity model is not just how projects are selected but what form they will take.

Projects need to be resourced adequately for success, with the right project leader and support structures in place to assist the project leader with technical and cultural challenges (Fernando and Oliveria 2017, Sreedharam et al 2018.) Usually, the more training and experience a Lean Six Sigma professional has received, the more complex and significant the project can be, and it is the role of the leadership team, supported by the Master Black Belt, to make sure the right person is allocated the right project and given enough time and resource to complete the task in hand (Schroeder et al 2008, Stankalla et al 2019.) This final element of project selection, resource, and delivery leads onto the next factor – training and development.

Factor 3: Training and development

The importance of training and awareness is inevitable in any quality excellence program, and Lean Six Sigma is not an exception (Sreedharan et al 2019.) The famous quality guru Deming, in his 14 points for quality, clarified the need for instituting training on the job, education and self-improvement for everyone, because transformation or change is everyone's job in a firm (Sreedharan et al 2019.) A critical success factor for Lean Six Sigma specifically identified by several authors is the need to invest in its people through training and development of continuous improvement tools and techniques (Mayo and Nohria 2005, Antony et al 2012, Emiliani 2013, Antony and Cudney (2016) Fernando and Oliveria 2017, Sreedharam et al 2018, Haerizadeh and Sunder 2019.)

This investment, known as "building human capital" (Antony et al 2012,) should equip employees with project management tools, process improvement toolset and change management tools (Antony et al 2012.) Often the training is provided in a face to face classroom environment, with emphasis on the Lean Six Sigma tool kit, however the main focus should be to create a culture among students and staff to think about contributing for quality excellence rather than narrowly focusing on the technicalities behind the tools and techniques (Haerizadeh and Sunder 2019.) From an organizational behaviour perspective, well-trained personnel play a critical role in creating and establishing new forms of organizational culture, which is critical to total employee involvement - an essential success factor of quality excellence initiatives (Antony et al 2012, Sreedharan et al 2019.) Although training programmes within the world of Lean Six Sigma are well structured, Sreedharan et al (2019) argues that if an organisation is trying to create a conducive culture then a tailored programme needs to be developed. Training and development often follows the belt structure borrowed from the world of martial arts. The terminology, as well as defining hierarchy, also defined career paths for improvement professionals (Laurenai and Antony 2011.) As described earlier in this chapter, initially the belt system included only Green Belt and Black Belts, however this was expanded over the years to include White, Yellow and Master Black Belt, the higher the belt the more complex project can be undertaken.

To successfully implement a Lean Six Sigma project, organisations need to select their best performers; those who are capable of learning and implementing new methodologies (Fornari and Maszle 2004.) Within a higher educational setting these could be administrators, managers or academic leads – anyone with an interest and a desire to drive improvement within their school or department. When introducing Lean Six Sigma to an organization such as a higher educational institutions, coaching is widely recognized as a critical activity (Hagen, 2010.) Coaching in a Lean Six Sigma context has been defined as “the process of instructing, directing, prompting, modelling, and guiding others as they work towards the business’s desired outcomes” (Adams et al., 2003.) Occasionally projects will encounter a new set of challenges. These challenges can appear to be insurmountable to an inexperienced project manager, but for the experienced Master Black Belt they are often trivial and well understood (Svensson et al 2015.) The role of coaching is to transfer experience and instil confidence in the inexperienced project managers (Svensson et al 2015.) Finally, the Lean Six Sigma coaching is not limited to the project managers and team members. Often project champions are also unfamiliar with the methodology and their contribution, and thus need support from the experienced Master Black Belt, although this will also take leadership on behalf of the champion to admit they do not know what is expected of them as managers and champions (Svensson et al 2015.)

Factor 4: Measuring cultural change and reporting benefits

The organizational culture, and linking Lean Six Sigma to business success, have been widely identified as CSFs in the literature, specifically how language is used to drive change, how cultural change and financial benefits are measured and how change is reported within the organisation (Antony and Banuelas, 2002, Sakthivel 2007, Snee 2011, Siddique et al 2011, Manville et al 2012, Antony et al 2012, Antony and Cudney 2016, Fernando and Oliveria 2017, Sreedharam et al 2018, Haerizadeh and Sunder 2019.)

The language of Lean Six Sigma and the adoption of Lean Six Sigma as an institutional philosophy is not without it challenges and critics (Hess and Benjamin 2015.) For example, few institutions openly identify their students as "customers". The resistance to using the customer label is ubiquitous in the higher education world, primarily due to the fact that institutions perceive the relationship with students to be much more complicated and deeper (Hess and Benjamin 2015.) Thus using terms such as voice of the customer, or treating the concept of research as a process, although challenging, can be used as a way to define maturity in Lean Six Sigma for an institution (Hess and Benjamin 2015.)

Once viewed as an academic exercise of the faculty, the research function of the university has evolved into a business enterprise focused on revenue and idea production (Hess and Benjamin 2015.) Universities now consistently rely on research production as a means of producing revenue from the state and private sources, as well as to produce new technology for patenting and licensing. While some in the academic community might argue that research is conducted for the purist motive of exploration, most university administrators view research as a process and an opportunity to supplement a declining revenue stream (Hess and Benjamin 2015.)

Income streams for universities is critical and financial accountability is key within any Lean Six Sigma programme (Sakthivel 2007, Snee 2011) and it is necessary to keep the Lean Six Sigma efforts linked to the financial results of the organisation, making leaders accountable for the financial impacts of their initiatives and choices (Hess and Benjamin 2015.)

Measuring success only through financial metrics can be dangerous to the motivation of employees and managers and a perceived negative cultural towards Lean Six Sigma can develop (Antony et al 2012, Douglas et al 2017, Haerizadeh and Sunder 2019.) Thus it is important for organisations, such as higher education institutions, to measure the impact on their culture (Douglas et al 2017, Haerizadeh and Sunder 2019.) Johnson (1992) defined a “cultural web” for an organization. At its centre is its paradigm, a core set of beliefs and assumptions which fashion the organization's view of itself and its environment. This paradigm or world view is supported by: power structures, organizational structures, control systems, rituals and routines, stories and myths, and symbols. It becomes possible to benchmark an organisation against these cultural web elements, thus creating a qualitative measure of cultural performance over time. For example interviewing staff members on their experiences and “stories” of continuous improvement helps build a picture of the culture and attitudes towards continuous improvement.

To have success with Lean Six Sigma requires a company culture where everybody is proactively working to reduce waste and variation, and where everybody understands that their contribution is essential for the team in which they are a member and they can identify who their customer is and what their customers know as value (Dahlgaard and Mi-Dahlgaard Park 2006, Douglas et al 2017.)

Factor 5: Sustainability

A Lean Six Sigma initiative should not be viewed as a one off event or quick fix, as such attempts will be doomed to fail and eventually will be labelled as another passing management idea (Antony et al 2012.) Even in its infancy, Lean Six Sigma writers warned that that if continuous improvement approaches such as Lean and Six Sigma are viewed as a means of simply cutting costs to meet budget deficits, organisations will fail to achieve the real benefits and fail to understand what it really means to be a Lean Six Sigma organisation (Womack and Jones 2005.)

Sustaining any Lean Six Sigma initiative beyond the first intervention can be viewed at two levels. The first is sustaining the benefits achieved at the end of the DMAIC cycle for an individual project. Once a process has been improved, a plan to monitor and control the improved process must be established to sustain the change and ensure that the solution can continue to improve in the future (Murphy 2009.) The second, and the focus of this factor within the author’s Lean Six Sigma maturity model for higher education, is sustaining the ongoing Lean Six Sigma initiative within the organisation.

The culture of the higher education sector can be a big challenge in the introduction, development and sustainability of Lean Six Sigma within an organisation (Jenicke and Holmes 2008, Snee 2011, Antony et al 2012, Antony and Cudney 2016, Fernando and Oliveria 2017, Sreedharam et al 2018, Haerizadeh and Sunder 2019.) One of the key elements of Lean Six Sigma is staff involvement and in order for the staff to feel that they are part of the organisation and openly talk about their improvement suggestions, there needs to be culture of openness, trust and acceptance (Antony et al.) Staff need to be involved at all levels within the organisation to gain the full benefits of Lean Six Sigma. All staff, from all positions of power and hierarchy need to be involved; within higher education this includes the administrators, the managers, the researchers and the academic leaders. Once all staff are involved, projects can be selected from a much wider pool of potential ideas, including teaching and researching processes. Thus Lean Six Sigma will be seen as wider than just a cost cutting initiative within the administrative functions of a university. However, to get staff involved they need to feel there is something in it for them – they need a reason to change (Kotter 1990, Knoster 1991, Jenicke and Holmes 2008, Siddique et al 2011.)

Chapter 1 of this thesis discussed leadership, and specifically the motivation of academic staff in higher education. Academic staff motivation is not solely linked to salary, promotion or financial rewards (due to salary being linked to experience and salary sliding scales,) but when faculty staff have the opportunity to learn new skills, show helpfulness, feel a sense of being appreciated, and most importantly, have professional autonomy, they become motivated to change (Siddique et al 2011.) Siddique et al (2011) acknowledge if faculty staff have the freedom to make decisions and are given autonomy, then they feel more satisfied with their jobs and put more effort into accomplishing their goals. Thus to sustain any initiative within higher education, leaders need to prevent and eliminate academic "dis-satisfiers", whether internal or external, which will adversely affect the faculty members' autonomy. These dis-satisfiers could be used to introduce and be addressed by Lean Six Sigma techniques, bringing the academic staff into the Lean Six Sigma programme (Siddique et al 2011, Antony et al 2012, Montgomery 2017.) The reason for "satisfying" these "egos" is both good for the Lean Six Sigma agenda and good for the university's' financial balance sheet. Motivated faculty members can earn international recognition, a good image world-wide, and with this reputation - or 'brand' - institutions can attract the brightest students from all over the world, they can attract large amounts of funding for research and create a strong influencing culture in their field. This, in turn, maintains the pressure for autonomy, creating an almost perfect self-perpetuating process, which could be used to fuel Lean Six Sigma into the future.

6.6.2 Mapping the themes and factors against the observed case study and semi structured interview data:

Within each of these factors or themes are unique characteristics which change and develop as you move through the maturity model. The evidence collected during the case study interviews can be summarised next to these characteristics and factors – see table 40 below.

Factor:	Characteristics:	Case Study Covered	Case Study Evidence – see section 6.5 above
1. Leadership and Organisational Structure	1. Leader support 2. Structuring the team 3. Institutional involvement	4 1, 3 and 4 1, 3, and 4	26, 27 2, 15, 16, 23, 24 1, 20, 34, 29
2. Project selection, Resourcing and Delivery	4. Selection of projects and programmes 5. Resource allocation 6. Type of project delivered	2 2 2, 3 and 4	7 9 10, 17, 28
3. Training and Developing	7. Tools, techniques and methods used 8. Training and development programmes 9. Mentoring and coaching support	2 3 4	12, 18, 19, 33 5, 22, 32 6
4. Measuring Cultural Change and Reporting Benefits	10. The language of change 11. Measuring success 12. Reporting the benefits	2 and 4 1, 2 and 4 1 and 4	11, 31 4, 8, 30 3, 25
5. Sustainability	13. Sharing best practice 14. Wider staff involvement 15. Reward and recognition in a fragmented leadership model	3 2 2	21 14 13

Table 40: Linking case study evidence to the factors

It is worth noting that within the four case studies there was little evidence linked back to the factors – “project selection, resourcing and delivery” and “sustainability,” two areas well documented as key to the success or failure of any LSS deployment (Jenicke and Holmes 2008, Radnor and Walley 2008, Jenicke et al 2008, Antony et al 2012.)

6.6.3 Developing the scoring from the case study evidence

The completed LSS academic maturity model has 15 characteristics across 5 themes and 5 levels of maturity giving in total 75 potential data points to map an academic institution's current maturity. Table 41 below illustrates whether these 75 data points have been defined using case study or literature references. The semi structured interviews did not create enough unique data points to build a complete maturity model. Significant gaps remained between semi structured evidence collated which the author has filled using research from literature. For example the work completed by Anthony et al 2012 relating to critical success factors in Lean Six Sigma deployment in HEIs supports and fills in the gaps from the semi structured evidence collected relating to the theme – Leadership and Organisational Structure. The colour represents the level in the model for a given factor and characteristic – Red equates to level 1, Yellow, Green and Grey equates to levels 2 to 4 and Blue equates to level 5. The semi structured interviews assisted in gauging the extremes and often the mid points of a given characteristic. Literature research has been used to complete the picture where case study evidence is missing.

Theme	Characteristic within the Theme	The 5 levels within the characteristic	Case Study Evidence	Literature Reference
Leadership and Organisational Structure	Leadership Role and Support	1.1 No leadership support or commitment to LSS		Colins 2001, Snee and Hoerl 2002 Snee 2007, Loethen 2008, Bryman 2009, Antony et al 2012, Laureani & Antony, 2015
		2.1 Led by LSS or CI team lead		
		3.1 Led by Registrar / CIO	23	
		4.1 Led by Director / Deputy VC		
		5.1 Led by VC / Board	26 / 27	
	Central Team Structure	1.2 No team in place	2	Jokinen 2005, Hilton & Sohal 2012, Suresh et al 2012, Antony et al 2012
		2.2 Small team reporting to / sitting within IT department		
		3.2 Medium to Large Team reporting to non-academic	15 / 16 / 24	

		department such as student services department 4.2 Small team sitting outside of traditional structure reporting directly to VC / deputy VC office 5.2 Local LSS teams delivering change, coordinated by VC office central team		
	Institutional Involvement	1.3 LSS is not valued by the institution 2.3 LSS is only applied to student service and pure administrative process and problems 3.3 LSS is applied to administrative processes which interact with teaching and research processes 4.3 LSS is applied to administrative, teaching and research processes across all departments 5.3 All institutional activity benefits from LSS thinking	1 20 29 / 34	Temponi 2005, Sumukadas, 2006 Shahmandi et al 2011, Suresh et al 2012, Hilton & Sohal, 2012 , Mehmood et al 2012, Antony et al 2012, Manville et al 2012, Maleyeff 2014, Laureani & Antony, 2015.
Project Selection, Resource and Delivery	Selecting Projects and Programmes	1.4 No project selection criteria in place 2.4 Projects are based on system / IT project requirements 3.4 Project selection criteria devised by departmental heads 4.4 Project selection linked to institution's corporate strategy 5.4 Project Selection Criteria links back to long term vision and is developed by VC / Board	7	Antony 2004, Radnor and Walley 2008, Jenicke et al 2008, Harry et al 2010, Antony 2012
	Resourcing the Project	1.5 Resource not formally allocated	9	Fornari and Maszle 2004, Schroeder et

		2.5 Full time resource allocated to delivering LSS projects, held within the LSS team only		al 2008, Antony 2012, Fernando and Oliveria 2017, Sreedharam et al 2018, , Stankalla et al 2019
		3.5 Mix of central LSS team projects and department led LSS projects		
		4.5 Small central team dealing with large projects but primarily role is supporting departmental delivered projects		
		5.5 Resource is allocated as required for full time project leads in addition to an expectation that projects form part of the day job, supported by a small central team		
	Type of Project	1.6 Only projects delivered are capital projects	10	Jagdeep and Harwinder 2013, Fernandes et al 2019.
		2.6 Rapid Improvement Events only	17	
		3.6 Mix of Rapid Improvement Events and Lean Projects		
		4.6 Mix of Rapid Improvement Projects, Lean Projects and Six Sigma Projects	28	
		5.6 Rapid Improvement Events, Lean, Six Sigma and Design for Six Sigma are all options for projects		
Training & Development	Tool, Techniques and Methods Used	1.7 No understanding of the concepts of quality exist		Heuvel 2005, Hines and Lethbridge 2008, Jenike and Holmes 2008, Murphy 2009, Antony 2014, Haerizadeh and Sunder 2019
		2.7 Simple problem solving tools form the basis of the training and mentoring	12	
		3.7 Basic Lean based tools are used to drive change	18	
		4.7 Basic Six Sigma based tools and more advance Lean tools are used to drive change	19 / 33	

		5.7 Full spectrum of LSS tools - and other improvement philosophies are used to drive change		
	Training and Development Programmes	1.8 No formal training exists for LSS	4	Laurenai and Antony 2011, Antony 2012, Sreedharan et al 2019
		2.8 Training typically last 1-2 days and projects tackled require simple tools	22	
		3.8 Formal training programmes exist for Yellow Belt/Green Belt LSS practitioners	5 / 32	
		4.8 Formal training exists for Black Belts, Senior Leaders and Sponsors of projects		
		5.8 Fully integrated training strategy is in place e.g. 79% receive YB, 20% GB, 1% BB		
	Mentoring and Coaching Support Activity	1.9 No mentoring or support processes exist for LSS project leaders	6	Adams et al 2003, Mayo and Nohria 2005, Hagen, 2010, Emiliani 2013, Svensson et al 2015
		2.9 Mentoring and support is haphazard and inconsistent		
		3.9 A central team mentor and support the delegates as they develop their skills		
		4.9 A formal coaching model is deployed to support GB/YB in delivering projects		
		5.9 Local teams are empowered to coach, mentor, teach and train their peers		
Measuring Cultural Change and	The Language of Change	1.10 Individuals react badly to the language of LSS and change	11	Azis and Osada 2010, Antony et al 2012, Hess and Benjamin 2015
		2.10 Language of LSS is altered to avoid offence		

Reporting Benefits		3.10 Simple language of LSS is used to build trust and motivate individuals		
		4.10 Language is no longer a barrier to change and enhances project activity	31	
		5.10 Change is part of the DNA of the institution and the language of change is embraced not feared		
	Measuring Success - both Culturally and Financially	1.11 Performance of processes and systems are not measured		Dahlgaard and Mi-Dahlgaard Park 2006, Sakthivel 2007, Snee 2011, Siddique et al 2011, Manville et al 2012, Hess and Benjamin 2015
		2.11 Only academic metrics and student staff surveys are used to check progress	8	
		3.11 In addition to academic metrics, financial impact is measured	25 /30	
		4.11 In addition to measuring financial and academic metrics, cultural change is also measured		
		5.11 The institution benchmarks itself against both academic and non-academic institutions		
	Communicating and Reporting the Benefits of Change	1.12 Performance is not reported at any level		Johnson 1992, Dahlgaard and Mi-Dahlgaard Park 2006, Antony et al 2012, Douglas et al 2017, Haerizadeh and Sunder 2019
		2.12 Performance and project results are shared only locally	3	
		3.12 Benefits are reported at department / school level		
		4.12 Benefits are reported at board level		
		5.12 Visual management systems, virtual management systems and management reporting exist to share performance across the institution and with outside stakeholders		

Sustainability	Sharing Best Practice - Inside and Outside the Institution	1.13 No formal process exists for sharing results and best practice 2.13 The team feedback progress and best practice through an establish meeting such as a monthly quality meeting 3.13 Steering group is assembled to drive the initiative and share best practice 4.13 Forum for sharing LSS best practice and supporting members exists 5.13 The institution has fully integrated LSS into its existing systems and management processes	21	Kumi and Morrow 2006, Kurniawan and Puspitaningtyas 2013
	Wider Staff and Stakeholder Involvement	1.14 Staff view change as someone else's problem 2.14 Only administrative and IT staff are involved in projects 3.14 Academic staff act as advisors on project teams 4.14 Academic and administrative staff lead projects as and when required 5.14 All staff are involved in change	14	Womac and Jones 2005, Jenicke and Holmes 2008, Antony et al 2012, Jenicke and Holmes 2008, Snee 2011, Antony et al 2012, Antony and Cudney 2016, Fernando and Oliveria 2017, Sreedharam et al 2018, Haerizadeh and Sunder 2019.
	Reward and Recognition in a Complex Culture	1.15 No reward or recognition for improving one's processes 2.15 Financial incentives are used to improve motivation for change 3.15 Academic freedom is used as an incentive to improve motivation for chance	13	Kotter 1990 , Knoster 1991, Jenicke and Holmes 2008, Siddique et al 2011, Antony et al

		4.15 Individuals are able to see the value of change, and any reward or recognition system reflects their wider needs		**2012, Montgomery 2017**
		5.15 Staff feel self-motivated to change their own processes irrespective of reward or outside recognition. In addition, the organisation recognises the importance of succession planning for all staff involved in development		

Table 41: Linking the literature and case study evidence to the author's factors, characteristics and levels

Figure 14 below summaries these 75 data points in the form of the first *Lean Six Sigma Maturity Model for Higher Educational Institutions.* Now the first draft of the model is complete it becomes possible to go back and benchmark formally the four case studies against the maturity model, see table 42 below. Here all 4 case studies have been compared to the maturity model to identify which level corresponds closest to the institution's current performance. The results are best presented in a radar chart as shown in figure 15 below.

Unless the maturity model below is printed on A3 paper or larger it is somewhat difficult to read. Thus, although the author envisaged the model being used as a single sheet, it is also presented at the end of the chapter in a broken down format.

Academic LSS Maturity Model v1						
		1	2	3	4	5
Factors	Characteristic Name	*Not Prepared for LSS*	*Yellow*	*Green*	*Black*	*Mastering deployment*
Leadership and Organisational Structure	Leadership Role and Support	1.1 No leadership support or commitment to LSS	2.1 Led by LSS or CI team lead	3.1 Led by Registrar / CIO	4.1 led by Director / Deputy VC	5.1 Led by VC / Board
	Central Team Structure	1.2 No team in place	2.2 Small team reporting / sitting within IT	3.2 Medium to Large Team reporting to non academic department such as student services department	4.2 Small team sitting outside of traditional structure reporting directly to VC / deputy VC office	5.2 Local LSS teams delivering change, coordinated by VC office
	Institutional Involvement	1.3 LSS is not valued by the institution	2.3 LSS is only applied to student service and pure administrative process and problems	3.3 LSS is applied to administrative processes which interact with teaching and research processes	4.3 LSS is applied to administrative, teaching and research processes across all departments	5.3 All institutional activity benefits from LSS thinking
Project Selection, Resource and Delivery	Selecting Projects and Programmes	1.4 No project selection criteria in place	2.4 Projects are based on system / IT project requirements	3.4 Project selection criteria devised by departmental heads	4.4 Project selection linked to institutions corporate strategy	5.4 Project Selection Criteria links back to long term vision and is developed by VC / Board
	Resourcing The Project	1.5 Resource not formally allocated	2.5 Full time resource allocated to delivering LSS projects, held within the LSS team only	3.5 Mix of central LSS team projects and department led LSS projects	4.5 Small central team dealing with large projects but primarily role is supporting departmental delivered projects	5.5 Resource is allocated as required for full time project leads in addition to an expectation that projects form part of the day job, supported by a small central team
	Type of Project	1.6 Only projects delivered are capital projects	2.6 Rapid Improvement Events only	3.6 Mix of Rapid Improvement Events and Lean Projects	4.6 Mix of Rapid Improvement Projects, Lean Projects and Six Sigma Projects	5.6 Rapid Improvement Events, Lean, Six Sigma and Design for Six Sigma are all options for projects
Training & Development	Tool, Techniques and Methods Used	1.7 No understanding of the concepts of quality exist	2.7 Simple problem solving tools form the basis of the training and mentoring	3.7 Basic Lean based tools are used to drive change	4.7 Basic Six Sigma based tools and more advance Lean tools are used to drive change	5.7 Full spectrum of LSS tools - and other improvement philosophies are used to drive change
	Training and Development Programmes	1.8 No formal training exists for LSS	2.8 Training typically last 1-2 days and projects tackled require simple tools	3.8 Formal training programmes exist for Yellow Belt/Green Belt LSS practitioners	4.8 Formal training exists for Black Belts, Senior Leaders and Sponsors of projects	5.8 Fully integrated training strategy is in place i.e. 79% receive YB, 20% GB, 1% BB
	Mentoring and Coaching Support Activity	1.9 No mentoring or support processes exist for LSS project leaders	2.9 Mentoring and support is haphazard and inconsistent	3.9 A central team mentor and support the delegates as they develop their skills	4.9 A formal coaching model is deployed to support GB/YB in delivering projects	5.9 Local teams are empowered to coach, mentor, teach and train their peers
Measuring Cultural Change and Reporting Benefits	The Language of Change	1.10 Individuals react badly to the language of LSS and change	2.10 Language of LSS is altered to avoid offence	3.10 Simple language of LSS is used to build trust and motivate individuals	4.10 Language is no longer a barrier to change and enhances project activity	5.10 Change is part of the DNA of the institution and the language of change is embraced not feared
	Measuring Success - both Culturally and Financially	1.11 Performance of processes and systems are not measured	2.11 Only academic metrics and student staff surveys are used to check progress	3.11 In addition to academic metrics, financial impact is measured	4.11 In addition to measuring financial and academic metrics, cultural change is also measured	5.11 The institution benchmarks itself against both academic and non academic institutions
	Communicating and Reporting the Benefits of Change	1.12 Performance is not reported at any level	2.12 Performance and project results are shared only locally	3.12 Benefits are reported at department / school level	4.12 Benefits are reported at board level	5.12 Visual management systems, virtual management systems and management reporting exist to share performance across the institution and with outside stakeholders
Sustainability	Sharing Best Practice - Inside and Outside the Institution	1.13 No formal process exists for sharing results and best practice	2.13 The team feedback progress through an establish meeting such as the monthly quality meeting	3.13 Steering group is assembled to drive the initiative	4.13 Forum for sharing LSS best practice and supporting members exists	5.13 The institution has fully integrated LSS into its existing systems and management processes
	Wider Staff and Stakeholder Involvement	1.14 Staff view change as someone else's problem	2.14 Only administrative and IT staff are involved in projects	3.14 Academic staff act as advisors on project teams	4.14 Academic and administrative staff lead projects as and when required	5.14 All staff are involved in change
	Reward and Recognition in a Complex Culture	1.15 No reward or recognition for improving ones processes	2.15 Financial incentives are used to improve motivation for change	3.15 Academic freedom is used as an incentive to improve motivation for chance	4.15 Individuals are able to see the value of change, and any reward or recognition system reflects their wider needs	5.15 Staff feel self motivated to change their own processes irrespective of reward or outside recognition. In addition the organisation recognises the importance of succession planning for all staff involved in development

Figure 14: The draft Lean Six Sigma Maturity Model for academic institutions

Factor	Case Study 1	Case Study 2	Case Study 3	Case Study 4
Leadership and organisational structure	Mostly Level (L) 1	L1	L3	L4
Project selection, resource and delivery	L1	L2	L2	L3
Training and development	L1	L1	L2	L3
Measuring cultural change and reporting benefits	L1	L2	L3	L3
Sustainability	L1	L1	L3	L2

Table 42: Scoring the initial case studies

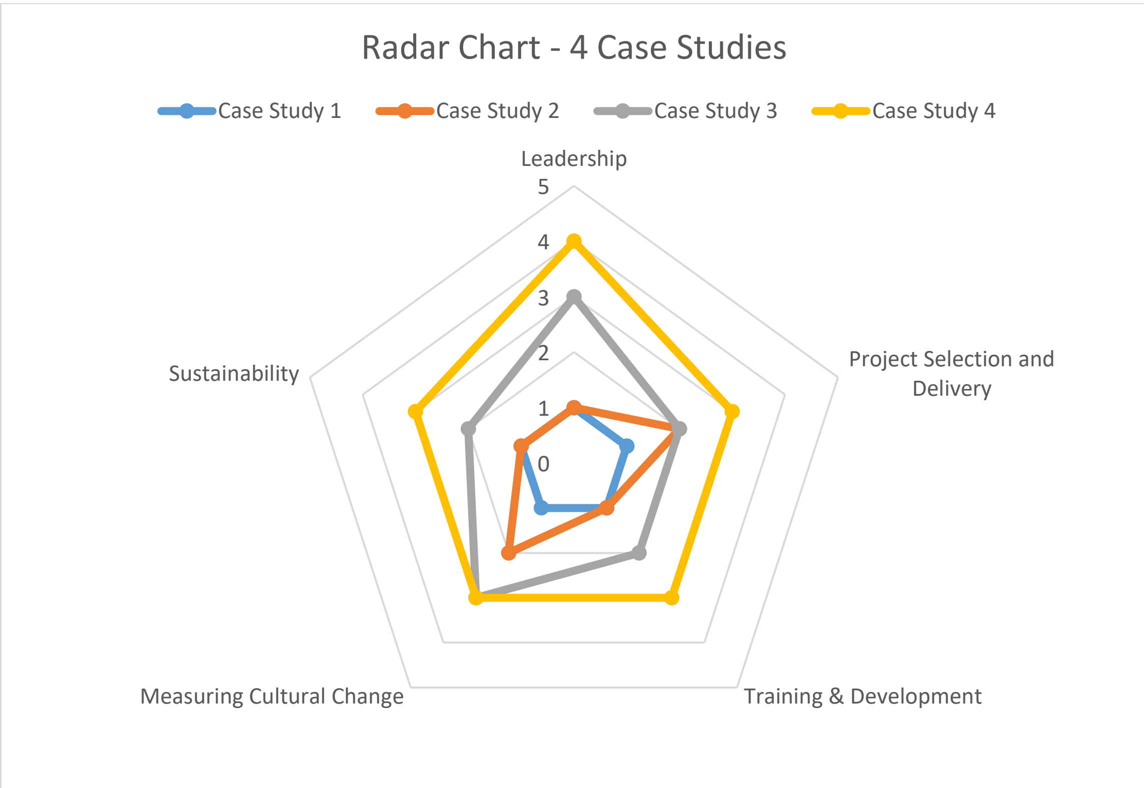


Figure 15: Example radar chart of case study performance against the draft model

For example: case study 1 has scored poorly on the maturity model, with evidence from semi-structured interviews and time spent at the institution, indicating that they are not yet ready to embark on Lean Six Sigma initiative. There is no appreciation by the leadership team, no team in place, no desire to improve, projects are not linked to corporate strategy, staff are not truly valued when it comes to leading change and are not allocated fully to an improvement programme. The higher education institution is right at the start of its journey, and the characteristics supporting the theme of Leadership would be a good place for the institution to start, specifically: Leadership role and support, Central team structure, and Institutional involvement.

Case study 4 presents close to the other extreme, with the best scores and evidence collected by the author against his maturity model. With mostly level 3 green scores to improve and mature in its Lean Six Sigma journey the institution should look into level 4 and 5 statements. For example: improving the mix of project types, expanding the range of tools and techniques used to include more advance approaches, developing a formal coaching model which works for their institution, and mixing the leadership of projects to include administrators, managers and academic staff.

The author's Lean Six Sigma maturity model for higher education is now ready for formal testing and refinement.

Lean Six Sigma Maturity Model – draft version 1:

Presented by factor, characteristic and level descriptor.

Academic LSS Maturity						
		1	2	3	4	5
Factors	Characteristic Name	*Not Prepared for LSS*	*Yellow*	*Green*	*Black*	*Mastering deployment*
Leadership and Organisational Structure	Leadership Role and Support	1.1 No leadership support or commitment to LSS	2.1 Led by LSS or CI team lead	3.1 Led by Registrar / CIO	4.1 Led by Director / Deputy VC	5.1 Led by VC / Board
	Central Team Structure	1.2 No team in place	2.2 Small team reporting to / sitting within IT	3.2 Medium to Large Team reporting to non-academic department such as student services department	4.2 Small team sitting outside of traditional structure reporting directly to VC / deputy VC office	5.2 Local LSS teams delivering change, coordinated by VC office
	Institutional Involvement	1.3 LSS is not valued by the institution	2.3 LSS is only applied to student service and pure administrative process and problems	3.3 LSS is applied to administrative processes which interact with teaching and research processes	4.3 LSS is applied to administrative, teaching and research processes across all departments	5.3 All institutional activity benefits from LSS thinking
Project Selection, Resource and Delivery	Selecting Projects and Programmes	1.4 No project selection criteria in place	2.4 Projects are based on system / IT project requirements	3.4 Project selection criteria devised by departmental heads	4.4 Project selection linked to institutions corporate strategy	5.4 Project Selection Criteria links back to long term vision and is developed by VC / Board
	Resourcing The Project	1.5 Resource not formally allocated	2.5 Full time resource allocated to delivering LSS projects, held within the LSS team only	3.5 Mix of central LSS team projects and department-led LSS projects	4.5 Small central team dealing with large projects but primarily role is supporting departmentally delivered projects	5.5 Resource is allocated as required for full time project leads in addition to an expectation that projects form part of the day job, supported by a small central team
	Type of Project	1.6 Only projects delivered are capital projects	2.6 Rapid Improvement Events only	3.6 Mix of Rapid Improvement Events and Lean Projects	4.6 Mix of Rapid Improvement Projects, Lean Projects and Six Sigma Projects	5.6 Rapid Improvement Events, Lean, Six Sigma and Design for Six Sigma are all options for projects

Training & Development	Tool, Techniques and Methods Used	1.7 No understanding of the concepts of quality exist	2.7 Simple problem solving tools form the basis of the training and mentoring	3.7 Basic Lean based tools are used to drive change	4.7 Basic Six Sigma based tools and more advance Lean tools are used to drive change	5.7 Full spectrum of LSS tools - and other improvement philosophies are used to drive change
	Training and Development Programmes	1.8 No formal training exists for LSS	2.8 Training typically last 1-2 days and projects tackled require simple tools	3.8 Formal training programmes exist for Yellow Belt/Green Belt LSS practitioners	4.8 Formal training exists for Black Belts, Senior Leaders and Sponsors of projects	5.8 Fully integrated training strategy is in place e.g. 79% receive YB, 20% GB, 1% BB
	Mentoring and Coaching Support Activity	1.9 No mentoring or support processes exist for LSS project leaders	2.9 Mentoring and support is haphazard and inconsistent	3.9 A central team mentor and support the delegates as they develop their skills	4.9 A formal coaching model is deployed to support GB/YB in delivering projects	5.9 Local teams are empowered to coach, mentor, teach and train their peers
Measuring Cultural Change and Reporting Benefits	The Language of Change	1.10 Individuals react badly to the language of LSS and change	2.10 Language of LSS is altered to avoid offence	3.10 Simple language of LSS is used to build trust and motivate individuals	4.10 Language is no longer a barrier to change and enhances project activity	5.10 Change is part of the DNA of the institution and the language of change is embraced not feared
	Measuring Success - both Culturally and Financially	1.11 Performance of processes and systems are not measured	2.11 Only academic metrics and student staff surveys are used to check progress	3.11 In addition to academic metrics, financial impact is measured	4.11 In addition to measuring financial and academic metrics, cultural change is also measured	5.11 The institution benchmarks itself against both academic and non academic institutions
	Communicating and Reporting the Benefits of Change	1.12 Performance is not reported at any level	2.12 Performance and project results are shared only locally	3.12 Benefits are reported at department / school level	4.12 Benefits are reported at board level	5.12 Visual management systems, virtual management systems and management reporting exist to share performance across the institution and with outside stakeholders

Sustainability	Sharing Best Practice - Inside and Outside the Institution	1.13 No formal process exists for sharing results and best practice	2.13 The team feedback progress through an establish meeting such as a monthly quality meeting	3.13 Steering group is assembled to drive the initiative	4.13 Forum for sharing LSS best practice and supporting members exists	5.13 The institution has fully integrated LSS into its existing systems and management processes
	Wider Staff and Stakeholder Involvement	1.14 Staff view change as someone else's problem	2.14 Only administrative and IT staff are involved in projects	3.14 Academic staff act as advisors on project teams	4.14 Academic and administrative staff lead projects as and when required	5.14 All staff are involved in change
	Reward and Recognition in a Complex Culture	1.15 No reward or recognition for improving one's processes	2.15 Financial incentives are used to improve motivation for change	3.15 Academic freedom is used as an incentive to improve motivation for chance	4.15 Individuals are able to see the value of change, and any reward or recognition system reflects their wider needs	5.15 Staff feel self-motivated to change their own processes irrespective of reward or outside recognition. In addition the organisation recognises the importance of succession planning for all staff involved in development

Figure 16 Lean Six Sigma maturity model for higher educational institutions, presented by factor, characteristic and level descriptor.

Chapter 7: Testing and validating the conceptual Lean Six Sigma Maturity Model for Higher Education Institutions

7.1 Developing the test strategy

To finish the process of building a robust Lean Six Sigma maturity model for higher educational institutions, the author wished to test and validate the draft model with other higher educational institutions not used in the original development of the model, and with Master Black Belts and academics in the field of Lean Six Sigma. By testing the model, the author aims to create a more robust, user friendly maturity model for higher educational institutions, (Hadid and Mansouri 2014, Lu et al 2017, and Sunder and Antony 2018.) The author wanted to identify a new population of Lean Six Sigma professionals who were not involved in the original case studies used in the draft model development. This new population would need to be respected in the field of Lean Six Sigma or be involved in delivering Lean Six Sigma projects in their respective institutions. Thus the author could utilise their experiences and knowledge to expand and develop the draft maturity model into a more robust tool for academic leaders.

Initially three academic institutions within the UK and one international university from the USA with established continuous improvement units were chosen, along with five Master Black Belts from UK industry. They were approached using the links and networks the author gained from the original four case study interviews and earlier research. The selection criteria for these test cases and Master Black Belts is demonstrated in table 43 below:

Sample:	Selection Criteria
3 UK Test Cases:	• Different organisations from the four test cases used to build the draft maturity model – creating a new data set • Established LSS or continuous improvement programme active within the organisation – demonstrating experience of deploying LSS in higher educational institutions • Using LSS as the core approach to delivering some form of operational excellence – creating a link with the author's own research

	• Published or plan to publish results of LSS activity – demonstrating potentially peer reviewed research
1 USA Test Case:	• Different organisation and country perspective from the original four test cases used to build the draft maturity model – creating a new data set from a potentially further advanced LSS deployment • Established LSS or continuous improvement programme active within the organisation – demonstrating experience of deploying LSS in higher educational institutions • Using LSS as the core approach to delivering some form of operational excellence – creating a link with the author's own research • Published or plan to publish results of LSS activity – demonstrating potentially peer reviewed research
5 Master Black Belts	• Master Black Belts with a minimum of 5 years' experience at Master Black Belt level – providing significant experience in deploying LSS • Not from higher educational institutions but different organisational sectors – provide a broader view of the model and potentially other avenues of future research • Leading LSS deployment within their own organisations – demonstrating an understanding of the importance of structure, governance and leadership within LSS deployment • Developed a culture of improvement within their organisations – creating a link between LSS and cultural change within an organisation

Table 43: Selection criteria for test cases and Master Black Belts

In addition the author held a workshop at a Lean Six Sigma conference in the spring of 2019 where 10 delegates working within higher educational institutions and from three countries (USA, UK and Ireland) were encouraged to score their higher educational organisations against the model and give feedback on how the model could be improved and deployed. Finally there were four individual interviews with academics who are leading researchers in the field of Lean Six Sigma and come from the USA (3) and Ireland (1.) These additional interviews were completed to bolster the number of individuals testing and validating the draft model. These four leading academic researchers have published a variety of articles supporting their own Lean Six Sigma deployment in higher educational institutions; examples include improving course design through the use of Lean Six Sigma, deploying Lean Six Sigma into enrolment processes, and improving and measuring student satisfaction using Lean Six Sigma voice of the customer tools and techniques. The main advantage for the author is that these academics are at the front of Lean Six Sigma research and could help identify any gaps in the current Lean Six Sigma Maturity Model. Table 44 below highlights the breakdown and positions the test cases and reviewers held within their respective institution and their geographical location:

Testing and Validation Subjects	**Leadership team**	**Change Management lead**	**Change management team / practitioners**	**Academics**	**Admin staff**	**Total:**
3 UK universities	1	2	8		1	**12**
1 international university (USA)		1		1		**2**
MBB and BB (UK)			5			**5**
Conference workshop		2 (USA / Ireland)	3 (UK)	5 (3 x USA, UK and Ireland)		**10**
Individual international academic interviews (3 USA, 1 Ireland)				4		**4**
Total:	**1**	**5**	**16**	**10**	**1**	**33**

Table 44: Draft maturity model reviewers, validators and test cases

A total of 33 individuals have been involved in the testing, validating, commenting and giving constructive feedback on the draft Lean Six Sigma Maturity Model. This, combined with the original 18 interviews at the four case study institutions, has given the author 51 sources of primary research material in which to build, test, validate and refine a Lean Six Sigma Maturity Model for academic institutions. All the feedback was collected anonymously, similar to the original 4 case studies, with the aim that as much of it as possible would be used to improve the draft maturity model. Any feedback not incorporated into the model would be kept for potential future research and further development of the model, and falls outside the scope of this thesis. Examples of original data collected from the test cases are presented in the appendix of this thesis.

7.2 Background to the test cases

The three UK universities visited in early 2018 to test the model were:

Test Case 1: This University is ranked in the top 20 in the UK, having been established as a technical college in 1920. It currently has around 16,000 students and its main campus is based in the East Midlands. The university has an annual budget of approximately £300million and is structured around 3 colleges – the college of life sciences, the college of science and engineering and the college of social science, arts and humanities. There is an established continuous improvement team, which has been in place for approximately 3 years, reporting to the head of IT. The team is tasked to deliver Lean Six Sigma projects across the 3 colleges using LSS approaches to stream line and improve processes. The testing of the model took the form of:

- A 90 minute interview with the head of the continuous improvement unit,
- A 3 hour workshop with the continuous improvement unit. The full team of four was invited to score and comment on the maturity model. The team contained 3 practitioners and the head of the continuous improvement unit. Specifically the team were asked to comment on the strengths and weaknesses of the model and their findings are summarised below in table 44.

Test Case 2: this university based in the north of England was established in 1824 and gain university status in 1992 when the then polytechnics were upgraded to full university status. Currently 24,000 students are based on the campus. The university has a budget of approximately £220million and is structured into 14 schools, split across three campuses. The CI team has been established for 4 years, and is part of the strategic planning support service working within the registrar's office. The testing of the model took the form of:

- A 60 minute telephone meeting was held with the project support officer, who is a member of their continuous improvement team. During the interview the university was benchmarked against the model and comments made on its appropriateness.
- The model was then shared electronically with the wider CI team, which includes three practitioners and one administrator, for comments and feedback on its strengths and weaknesses. The feedback was received within 48 hours of issuing the request. The responses from the interview and the wider CI team are summarised in table 44 below.

Test Case 3: this London based university was established in 1878 and gained full university status in 1992. It current has around 20,000 students. Its current budget is £210million, and is structured across three faculties: the faculties of arts, social sciences and technology, and is split across 4 campuses, 3 of which are outside the UK. The CI team is the largest the author has dealt with in the UK, and reported directly to the vice chancellor's office. The team had been in place for 3 years and have delivered LSS projects across all the faculties within the UK campus. The testing of the model took the form of:

- A series of 60-90 minute interviews were conducted with the head of the CI team and two practitioners from the continuous improvement unit. The maturity model was reviewed, the university scored, and comments made on the strengths and weaknesses of the model as a tool for helping deploy LSS in each of the interviews. The responses from the interviews are summarised in table 44 below.

The one international university approached in 2018 was:

Test case 4: this USA based institution, founded in the 1860s, has over 40,000 students, with over 200 based educational programmes. Originally established to train farmers and engineers, it has become one of the most successful public research universities in the USA. It has an annual budget of over $2.5billion and is recruits the 4th largest student pool each year, the majority of which are located on one purpose built large campus. The testing of the model took the form of:

- 60 minutes interviews were conducted with two of the practitioners within their business process improvement unit
- The two lead interviewees then shared the model with their remaining team and gave feedback on its usefulness. The responses from the interviews are summarised in table 45 below:

Test Case	**Feedback Received**
Generic feedback from all 4 test cases:	All four test cases appreciated the opportunity to test the maturity model with their staff and institution. All four test cases made positive comments regarding the need for a maturity model, the realisation of the complexity of deploying LSS and the depth and breadth of the model presented. All four test cases could understand and relate to the language of the model. All four test cases stressed the importance of leadership having access to such a tool to help with strategic decision making and better cultural support of the central continuous improvement teams
Test Case 1	Within the model there was significant overlap between characteristic 2 – structuring the team and characteristic 5 – resource allocation. A suggestion for improvement is to rename characteristic 2 to reflect the structure of the central team to distinguish it from characteristic 5 the project team.

	Characteristic 11 – measuring success and characteristic 12 – reporting benefits could be combined freeing up a data point for another characteristic – perhaps relating to visual management When shared with the wider team and departmental practitioners there was some misinterpretation of the meaning of some of the statements. A suggestion for improvement is that when the model is deployed within a leadership or management team then the group is professionally facilitated using a LSS expert who understands the model and can help facilitate any language challenges.
Test case 2	There is no recognition in the model for succession planning for both central continuous improvement unit staff and departmental teaching and administrative staff. Their experience has highlighted the difficulty in maintaining highly competent and qualified staff after they have trained them in Lean Six Sigma. A suggested improvement is to change the language of characteristic 2 or 15 to include succession planning of central and developed staff. 'Stage 1 – not prepared for six sigma' contained strong emotive language which could distract a leadership team during a strategic review and would need to be adjusted for the target audience
Test case 3	The model would be easier to read and score if the 15 characteristic headings are in place and space is provided to allocate a tick, score or comment. The maturity model is best read when printed in colour on an A3 paper size. The maturity model could easily be converted into a questionnaire to annually survey the staff and measure cultural change within the organisation maturity of implementing continuous improvement through Lean Six Sigma.
Test case 4: The USA based test case	The model could be better presented in sections – with one page per factor, thus breaking up the model into easier to read and use sections

	Once completed the final report should highlight the next step in maturity under each of the 15 characteristics, thus providing a way of identifying the next steps for the institution to take Language within the model was very UK centric and sometimes difficult to translate – for example positions of senior academic staff having different terms in the USA and the UK.

Table 45: Feedback from Four test cases, three UK and one USA test case

7.3 Test Case Findings:

The model held up well under testing, especially since two of the three heads of the continuous improvements teams within the four test cases interviewed were external Lean or Six Sigma professionals and had a strong understanding of what good should look like in their respective institutions. The three UK test case institutions were all in a similar position from a maturity perspective, utilising a central team to deliver projects in an administrative role. However they all recognised that they were underutilised and not focused on specific board led objectives – something the model highlighted to them. Linked to this and another strong output from the test cases is the lack of robust project selection criteria. This lack of robust project selection was in all seven UK institutions interviewed for this research, highlighting a real lack of maturity in UK higher educational institutions today in linking the importance of strategic thinking to the selection of LSS projects. Good project selection is derived from the strategic objectives – Motorola in the 1980s would link all its Six Sigma projects back to 5 strategic criteria – Importance to customer, Cost to implement, Feasibility of success, Cost reduction expected, and Cross departmental synergy, (Mikel 1988, Yang and Hsieh 2009, Rathi et al 2016, Kovach and Ingle 2020.) Academic leadership teams in the UK clearly need to develop their own criteria for project selection if they are going to genuinely mature in the use of LSS.

7.4 Individual Interview Findings:

Along with the four test cases, several industry Master Black Belts and Lean Six Sigma academics were approached to validate and give feedback on the model. The industry Master Black Belts were selected from the Institute of Six Sigma's list of members, of which all 10 current Fellows of the institution were chosen from their membership and five responded to the request for feedback. Fellows of the Institute of Six Sigma are established Master Black Belts with significant years of experience in deploying Lean Six Sigma solutions, usually in excess of 10 years. In addition, four international academics were interviewed during a Lean Six Sigma conference in 2019. Three of these academics came from the USA, the 4th came from the Republic of Ireland.

The five Master Black Belts positive feedback is summarised below – these are direct quotes lifted from the validation interviews:

1. "Critical and pleasing to see that project selection is linked to organisational objectives and strategy"
2. "The Leadership and Organisational structure has dependencies linked to the Board"
3. "The measurement of cultural change – that it is part of the DNA of the organisation"
4. "The metrics are easily understood and could facilitate a self-assessment"
5. "The language was simple and "somewhat old fashioned", but did mean it was easy to understand and traverse the model"
6. "Initially thought having 5 levels would be hard to clearly distinguish each level from another but it works well and very clear to see the difference in levels"
7. "It gives a very clear indication to how far an organisation is progressing on the Lean Six Sigma path and highlighted to me why higher educational institutions have possibly not been able to fully embrace Lean Six Sigma. For example, leadership not coming from the top and how projects are selected etc"

8. “The model’s real strength is its clear layout & format, providing a good snapshot and overview of levels of maturity. The real value for change leaders is that the model chunks down a large subject, such as Lean six sigma, into a manageable section which is very user-friendly”

The five Master Black Belts improvement ideas for the model are summarised below:

1. Two of the Master Black Belts felt that a Green Belt level organisation would have in place some form of visual management of performance, possible on the academic intranet or on screens around campus.
2. There appears to be a heavy reliance on IT projects as examples of non-Lean Six Sigma type projects. All the Master Black Belts suggest that other project types could be referenced in the model.
3. As part of the sustainability factor, two of the Master Black Belts believed that an organisation would have in place some form of cross departmental, staff member idea generation scheme or platform in which ideas can be generated from outside the leadership team.
4. One of the Master Black Belts suggested that the metric scoring system could be refined so that there is a minimum score in each category that an institution must achieve if they were to score highly in another category. For example someone cannot score 5 in leadership but also score 1 in project selection.
5. One Master Black Belt suggested that within the Training and Development factor a mature institution would want to measure the impact of its training and development investment.
6. In regards to scoring a characteristic when doing an initial assessment several master black bets felt that if the assessor is having difficulty choosing between two levels (for example a 1 or 2) then maybe they should have an additional scoring guidance sheet that goes hand in hand with the model and provides a list of practical examples/minimum requirements for each level.
7. Finally one Master Black Belt suggested that an output from the model could be some form of visual representation of a Lean Six Sigma roadmap with timescales for an academic institution to follow.

The four international academics presented similar benefits of the model as per their Master Black Belt colleagues and these are summarised below. However the three USA academics did suggest something different form the usual improvement ideas – specifically around the scoring.

The benefits of the model suggested by the academics were:

1. The importance of leadership is clear to see in the model and its link with the institution's objectives and mission.
2. The importance of sustaining any initiative by measuring not just financial benefits but also the measurement of cultural change.
3. The idea that it is a self-assessment exercise, and although it allows the institution to be both over and under critical, it is not possible to be extremely over optimistic since the guidance for the levels is very clear.
4. The 15 levels within the 5 factors give a clear framework for strategic deployment of LSS in HEIs.

The main areas for improvement for the model were centred on the scoring system. Currently the 15 levels within the 5 factors each have five potential responses, giving a total score of 75 maturity points. Two potential improvements to this were identified. The first was to apply a weighting system to the individual levels within the factors. For example, the academics believed that a clear critical success factor in all Lean Six Sigma projects was "leadership", and this factor would clearly be more important than the "language used" or the "tools and techniques used". That is not to say these are not important factors and themes but that they are less so than leadership commitment. Clearly, if this is the case, and more research would be needed, then the potential of weighting the factors and themes would require careful consideration, since any weighting would clearly skew the scoring system against certain areas and improve others. Table 46 below demonstrates an example of this approach. The scoring for the weighting system in this example has been developed in discussions with the 3 academics during their interview and is purely based on their opinions. In this example scenario the institution ends up with a higher score due to its leadership commitment and the way it selects and resource projects, whereas the type of project and the tools used in the project have become less important.

Characteristic Name	Example Weighting Factor	Inititial Score	After weighting is applied
Leadership Role and Support	2	3	6
Central Team Structure	0.9	1	0.9
Institutional Involvement	1.5	3	4.5
Selecting Projects and Programmes	1.5	3	4.5
Resourcing The Project	1.2	3	3.6
Type of Project	0.8	2	1.6
Tool, Techniques and Methods Used	0.6	1	0.6
Training and Development Programmes	1	2	2
Mentoring and Coaching Support Activity	0.8	2	1.6
The Language of Change	1.2	3	3.6
Measuring Success - both Culturally and Financially	0.8	1	0.8
Communicating and Reporting the Benefits of Change	0.9	2	1.8
Sharing Best Practice - Inside and Outside the Institution	0.9	2	1.8
Wider Staff and Stakeholder Involvement	1.2	3	3.6
Reward and Recognition in a Complex Culture	1.1	3	3.3
	Total	34	40

Table 46 Example of weighting the model scores

Some research has already been completed on areas of ranking critical success factors (Bakås et al 2011, Laureani & Antony 2012, Mezza and Jeong 2013, Witt and Baker 2018.) For example Witt and Baker (2018) published a review of literature supporting seven key elements which to some extent appear in the author's own maturity model – see table 47 below. Witt and Baker (2018) were illustrating that although these seven areas are important some appear in research more than others.

Leadership engagement Positively related to SSTP (Six Sigma Team Performance)	Aboelmaged, 2010; Antony, Douglas and Jiju Antony, 2007; Antony, Jiju Antony, Kumar and Rae Cho, 2007; Antony et al., 2005; Banuelas Coronado and Antony, 2002; Basu, 2004; Brady and Allen, 2006; Brun, 2011; Byrne, 2003; Caulcutt, 2001; Cho et al., 2011; Choo et al., 2007a; DeFeo, 2000; Gijo and Rao, 2005; Hahn, 2005; Henderson and Evans, 2000; Hilton and Sohal, 2012; Hilton et al., 2008; Ismyrlis and Moschidis, 2013; Johannsen et al., 2011; Kwak and Anbari, 2006; Laosirihongthong et al., 2006; Linderman et al., 2003; McAdam and Lafferty, 2004; Moorman and Rosemann, 2010; Montgomery and Woodall, 2008; Nair et al., 2011; Nakhai and Neves, 2009; Ray et al., 2013; Sabry, 2014; Schroeder et al., 2008; Shanmugam, 2007; Shokri et al., 2014; Swami and Prasad, 2010, Timans et al., 2012; Zu et al., 2008
Strategic project selection Positively related to SSTP	Aboelmaged, 2010; Antony, Douglas and Jiju Antony, 2007; Antony, Jiju Antony, Kumar and Rae Cho, 2007; Antony et al., 2005; Banuelas Coronado and Antony, 2002; Banuelas et al., 2006; Bhatnagar and Pandey, 2005; Brady and Allen, 2006; Brun, 2011; Caulcutt, 2001; Cho et al., 2011; Choo et al., 2007a; DeFeo, 2000; Griffin and Hesketh, 2004; Hahn, 2005; Ismyrlis and Moschidis, 2013; Johannsen et al., 2011; Kleasen, 2007; Kwak and Anbari, 2006; Laosirihongthong et al., 2006; Linderman et al., 2003; McAdam and Lafferty, 2004; Montgomery and Woodall, 2008; Nair et al., 2011; Ray et al., 2013; Revere et al., 2006; Schroeder et al., 2008; Shanmugam, 2007; Timans et al., 2012; Zu et al., 2008
Psychological safety Positively related to SSTP	Choo et al., 2007a; Linderman et al., 2003; McAdam and Lafferty, 2004; Nair et al., 2011; Schroeder et al., 2008; Zu et al., 2008 Arumugam et al., 2013; Choo et al., 2007b Edmondson, 1999

Use of improvement specialists in the SSTP	Aboelmaged, 2010; Banuelas Coronado and Antony, 2002; Basu, 2004; Brady and Allen, 2006; Byrne, 2003; Caulcutt, 2001; Cho et al., 2011; Choo et al., 2007a; DeFeo, 2000; Hahn, 2005; Henderson and Evans, 2000; Hilton and Sohal, 2012; Ismyrlis and Moschidis, 2013; Johannsen et al., 2011; Kwak and Anbari, 2006; Lanyon, 2003; Laosirihongthong et al., 2006; Linderman et al., 2003; McAdam and Lafferty, 2004; Moorman and Rosemann, 2010; Montgomery and Woodall, 2008; Nair et al., 2011; Nakhai and Neves, 2009; Schroeder et al., 2008; Shanmugam, 2007; Wyper and Harrison, 2000; Zu et al., 2008
Structured methods used by the SSTP	Banuelas Coronado and Antony, 2002; Basu, 2004; Brady and Allen, 2006; Choo et al., 2007a; Cronemyr, 2007; Easton and RosenZweig, 2012; Fuller, 2000; Henderson and Evans, 2000; Ismyrlis and Moschidis, 2013; Kwak and Anbari, 2006; Linderman et al., 2003, 2006; McAdam and Lafferty, 2004; Montgomery and Woodall, 2008; Nair et al., 2011; Schroeder et al., 2008; Wyper and Harrison, 2000; Zu et al., 2008 Choo et al., 2007b Nair et al., 2011
Experience (leader, organizational, individual)	Easton and RosenZweig, 2012; Hensley and Dobie, 2005; Hilton and Sohal, 2012; Huq, 2006 Swink and Jacobs, 2012
Culture change Positively related to SSTP when mediated by key Six Sigma contextual elements	Zu et al., 2010 American Productivity and Quality Center, 2001; Brewer, 2004; Choo et al., 2007a; Craven et al., 2006; Dahlgaard and Dahlgaard-Park, 2006; Davison and Al-Shaghana, 2007; Setijono et al., 2012; Eckes, 2001; Immaneni et al., 2007; Ismyrlis and Moschidis, 2013; Johnson, 2006; Kumar et al., 2008; Lertwattanapongchai and William Swierczek, 2014; McAdam and Evans, 2004; M Adam and Lafferty, 2004; Mi Dahlgaard Park and Näslund, 2013; Motwani et al., 2004; Rajamanoharan and Collier, 2006; Yeung, 2007

Table 47: Research supporting different weightings of Lean Six Sigma characteristics

The idea of weighting the five factors and 15 characteristics is of interest to the author but outside of the scope of this thesis.

The second area of improvement identified by the academics interviewed linked back to the current research of one of the academics in the group. They were currently investigating the link between the effort and experience an organisation had with Six Sigma and the quality and results of the intervention. The idea being that each of the 15 characteristics within the author's own maturity model would be scored not on 1 but 2 axes; the first axis describing how far along the journey of maturity they had travelled, the second axis being how successful had they been at that level. For example, taking the characteristic 6 "type of project" from the model, axis one would include the current level of maturity scoring system:

1. *Only projects delivered are capital projects*
2. *Rapid Improvement Events only*
3. *Mix of Rapid Improvement Events and Lean Projects*
4. *Mix of Rapid Improvement Projects, Lean Projects and Six Sigma Projects*
5. *Rapid Improvement Events, Lean, Six Sigma and Design for Six Sigma are all options for projects*

These levels of maturity would then be mapped against how successful the institution had been at delivering these projects. An example of such a scoring system could be:

1. *The institution has never undertaken this type of activity before prior to entering this level of maturity*
2. *The institution has no recent history of successfully implementing this type of project prior to entering this level of maturity*
3. *The institution has a history of successfully implementing this level of project*
4. *The institution has qualitative and quantitative evidence that these types of projects have been a success*
5. *The institution has evidence of sharing best practice, case studies and research on its ability to deliver this type of project across the institution*

The final score for this characteristic would be the two axes multiplied together. For example, each of the 15 characteristics now would have a potential score of

1 to 25, giving an overall maturity score of 15 x 25 (rather than 5), resulting in a final potential score up to 375 descriptor points.

Figure 17 below demonstrates graphically the way in which an institution could show the scoring of each of the 15 characteristics using this alternative method.

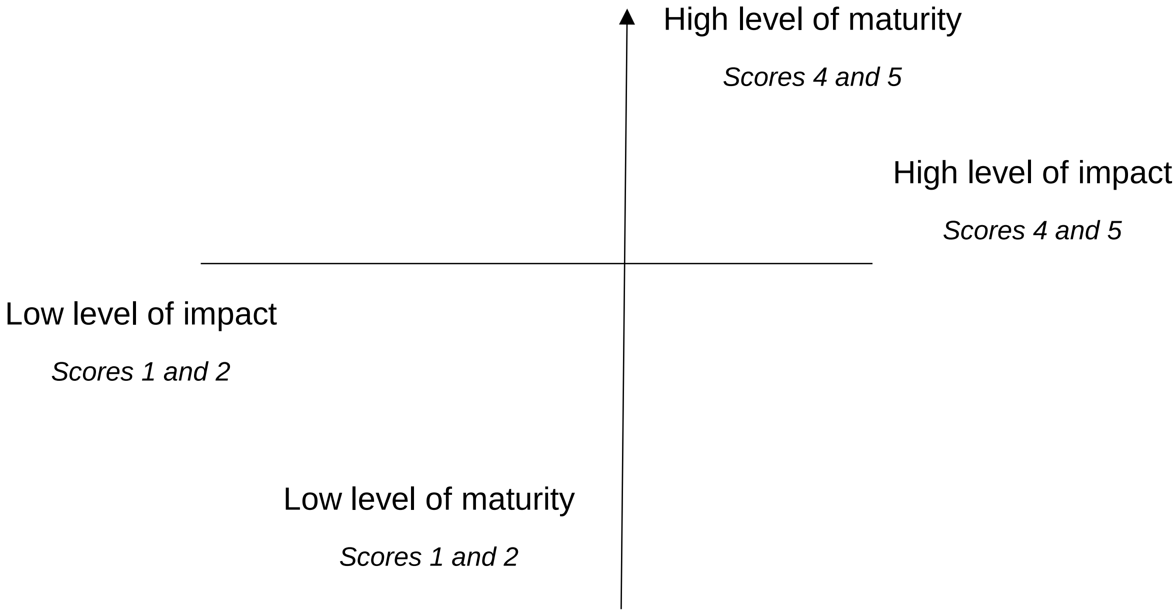


Figure 17 Example of a matrix scoring system

Some research has already been started in this area, (Mezz and Jeong 2013.) Mezz and Jeong (2013,) using surveys and case studies, ranked Lean Six Sigma performance projects against critical success factors and financial results of projects. They created a method of measuring the impact of Lean Six Sigma projects and the critical success factors in use at that time. This work, although linked to science and manufacturing companies only, could be transferable to the author’s own models maturity model for higher educational institutions.

There has been significant research over the years in manufacturing companies on how best to measure the success and effectiveness of a Lean Six Sigma project: examples of this research and research relating to measuring success in general are presented below in table 48. It should be possible through further research to develop another set of 75 effectiveness measures to combine with the author's maturity model.

Saraph et al. (1989)	Identified 10 critical success factors (CSFs) including: The role of management leadership and quality policy, role of quality department, training, product/service design, supplier quality management, process management, quality data and reporting and employee relation
Wali et al. (2000)	Identified the following CSFs: Top management (impact on society, speed of change, level of commitment, quality of leadership, market change, business result, rapid innovation rate), middle management (speed of learning, speed of training, team format, level of process and function design, speed of communication between top and operational management), operational management (extent of adopting seven QC tools, speed to solve problems, productivity growth, inventory turnover, customer deliveries, timeliness and response to new technology) and shop floor management (no. of defects, rate of output, rework/scrap, total cycle time and absentees) and outside organisation performance measures includes supplier (quality of incoming material, lead time, vendor rating, quality standards, inventory turnover, timeliness),customers (service level/after sale service, customer satisfaction)
Rahman (2001)	Assessed the impact of quality management factors on organisational performance for SMEs in Western Australia with and without ISO 9000 certification, quality improvement efforts and increases in customer metrics. The result showed that there was no significant difference between SMEs with and without ISO 9000 certification with respect to quality based improvement implementations and organisational performance
Terziovski and Samson (1999)	Identified 15 CSFs including: Customer satisfaction, employee morale, cost of quality, delivery in full, defect rates, warranty cost, productivity, cash flow, employee growth, market share growth, sale growth, export growth, innovation (new product) and organisational performance
Anderson and Sohal (1999)	Identified six areas where quality management improvement techniques could improve areas of the business including: overall competitiveness, sales, market share, employment levels, cash flow and exports. The results show that the practices and principles of quality management have had the highest impact on the overall competitiveness of business and least impact on exports

Coronado, BR and Antony, J (2002)	Identified 12 CSFs relating to deploying Six Sigma in organisations. In addition the authors compared the roles, the profiles, the training requirements and the numbers required of Green Belts, Black Belts and champions to ensure successfully deployment
Antony, J and Banuelas, R (2002)	Identified 11 CSFs - Management commitment and involvement; understanding of Six Sigma methodology, tools and techniques; linking Six Sigma to business strategy; linking Six Sigma to customers; project selection, reviews and tracking; organisational infrastructure; cultural change; project management skills; linking Six Sigma to suppliers; training; linking Six Sigma to employees (human resources)
Brun (2011)	Identified 12 CSFs and performance measures as follows: management involvement and commitment; cultural change; communication; organisational infrastructure and culture; education and training; linking Six Sigma to business strategy; linking Six Sigma to customer; linking Six Sigma to human resources; linking Six Sigma to suppliers; understanding tools and techniques within Six Sigma: project management skills; project prioritisation and selection
Lavy et al. (2010)	Identified four types of effectiveness indicators: Financial, physical, functional, and survey-based. Indicators are arranged from general to the most specific indicators.

Table 48: Sample of research looking at measuring the success of Lean Six Sigma deployment

Again, this potential improvement idea will require significant further research to develop another set of 75 descriptors and the USA academic who provided the feedback and is leading this approach is currently only looking himself at applying this to 4 success factors, not the 15 identified by the author's LSS maturity model.

However the author is excited to think that potentially a future model could include multi dimensions and a weighting system.

7.5 Conference workshop findings

During the spring of 2019 at the 5th International Conference of LSS in Higher Education held in Edinburgh, the author had the opportunity to run a workshop with international academics and change agents to benchmark and use the model with an international rather than just a UK audience. The duration of the workshop was 2 hours and 30 minutes. 14 delegates attended the event from seven universities, 10 of these delegates were completely new to the model, and four had been interviewed separately and formed the academic feedback presented above.

The version of the Lean Six Sigma Maturity Model for HEIs used in this workshop incorporated some of the earlier feedback from the test cases and validation interviews, including the language used, and the way the model was presented. Specifically, the model was broken down into a series of A4 handouts, split by the five main factors.

The workshop was run as a series of facilitated discussions and group exercises and included:

- What are the challenges faced by academic institutions that wish to implement LSS? – A 4 group exercise, with each group having 3-5 delegates with the results compared and discussed.
- Using the author's Lean Six Sigma Maturity Model, score your own institution against the model's 15 characteristics for successfully deploying LSS– an individual or team exercise, with the results shared with other members of the workshop
- Give feedback on the usefulness and ease of use of the model – a facilitated group discussion

This workshop was the final stage of the testing process and the results of the workshop are presented below:

Discussion point 1: Challenges and barriers faced by academia in implementing LSS

Table 49 below summarises the findings of the first part of the workshop, where delegates in groups were asked to identify the top challenges they have faced when trying to implement Lean Six Sigma in their respective institutions. Once they had listed their findings, a wider discussion with a facilitator identified more potential challenges.

Group 1	Group 2	Group 3	Facilitators suggestions
Lack of commitment from top management	Pay not linked with performance	Not using in-house talent	Staff engagement
Lack of funds	Lack of clear vision from the top	Not using individual metrics to measure performance	Lack of opportunity
Poor awareness	Lack of accountability	SMT struggle to see fit with LSS	Not willing to invest
Lack of motivation	Not making LSS a priority	Lack of visibility of LSS	No idea of actual number of active projects
Misalignment with corporate strategy	Lack of stamina for long term change	Fixed term leadership – merry go round of management	The need to do something different from the last CEO
Lack of expertise	Too busy	Hearts and minds not in it	Who are the customers?
No clear benefits	It's only relevant to IT	Silo structures and bunker mentality	Silo barriers
Not looking for a "customer"	Not sure who the customers are in HE context	Lack of focus on the customers	Project selection non existent
		Scared of the statistics	Don't understand process or DMAIC
		Lean equals cutting down costs	

Table 49 Challenges facing academics involved in the implementation of Lean six sigma

These challenges helped set the scene for the second part of the workshop – benchmarking their own institutions' performance against the author's Lean Six Sigma Maturity Model.

Part 2: Benchmarking of institutions using the LSS maturity model

The group then split into either individuals or small groups to assess their institution. A total of seven benchmarks were completed covering the seven universities represented within the workshop. Table 50 below highlights the results, including the average score of the assessments conducted for an institution and any variation that existed if more than one individual scored an institution. The results were then shared and discussed by the delegates.

Institution	Average Score of the assessments	Variation within assessments – Range (Max – Min)	Number of assessments
1	40	4 (42-38)	3
2	41	1 (41 – 40)	3
3	26	2 (27 – 25)	2
4	23	0 (23 - 23)	2
5	27	0 (27 - 27)	1
6	51	0 (51 - 51)	1
7	37	0 (37 - 37)	1

Table 50 Workshop benchmarking results

The key findings from this group discussion were:

1. Although all delegates from the same institutions initially believed they were in a similar place from a maturity point of view their scores varied tremendously. On further investigation and discussion, a combination of

confusing language and certain delegates being over optimistic means that the group concluded that this exercise is best completed with the use of a continuous improvement facilitator to help moderate scores and translate any confusing text.

2. All seven institutions commented on the value it gave them to see not just where their organisation was positioned but also where potentially they could focus their next steps to improve their Lean Six Sigma journey.
3. Two of the groups commented on the desire to repeat the exercise with a wider group of their peers back at their university; the aim being to see if, as a larger sample group within an academic institution, they could agree on the current performance or mimic the wide variation seen already within the workshop.

Part 3: the positives and areas for improvement of the model:

The final part of the workshop was to gain feedback from the delegates on the maturity model and its usefulness.

The key benefits of the maturity model were clear to the delegates of the workshop and included:

1. The ability to give a score of their current level of maturity and demonstrate how much further they have to go under each of the 15 characteristics of the maturity model
2. The usefulness to allow comparison within an institution and across institutions, in the form of a 360 degree type appraisal. It thus becomes possible for a department or a whole institution to understand and score their perceptions towards any LSS initiative, and potentially learn from any best practice within the institution.
3. The 75 descriptors followed a logical path and were easy to navigate.
4. Breaking the model down into sections, and printing each section on a different sheet of paper made it easier to see and use.

The major improvement opportunity raised was that of potentially pairing off characteristics or factors and mapping them against each other. Each factor in the author's Lean Six Sigma Maturity Model scores the factor from 1 to 5, where 1 is readiness to deploy Lean Six Sigma and 5 is a LSS learning organisation. The delegates recommended that a score of 1 to 2 would indicate a low level of maturity and a score of 4 to 5 would indicate a high level of maturity. For example figure 18 below combines leadership scores with project selection scores. This combination of factors creates four new regions of maturity:

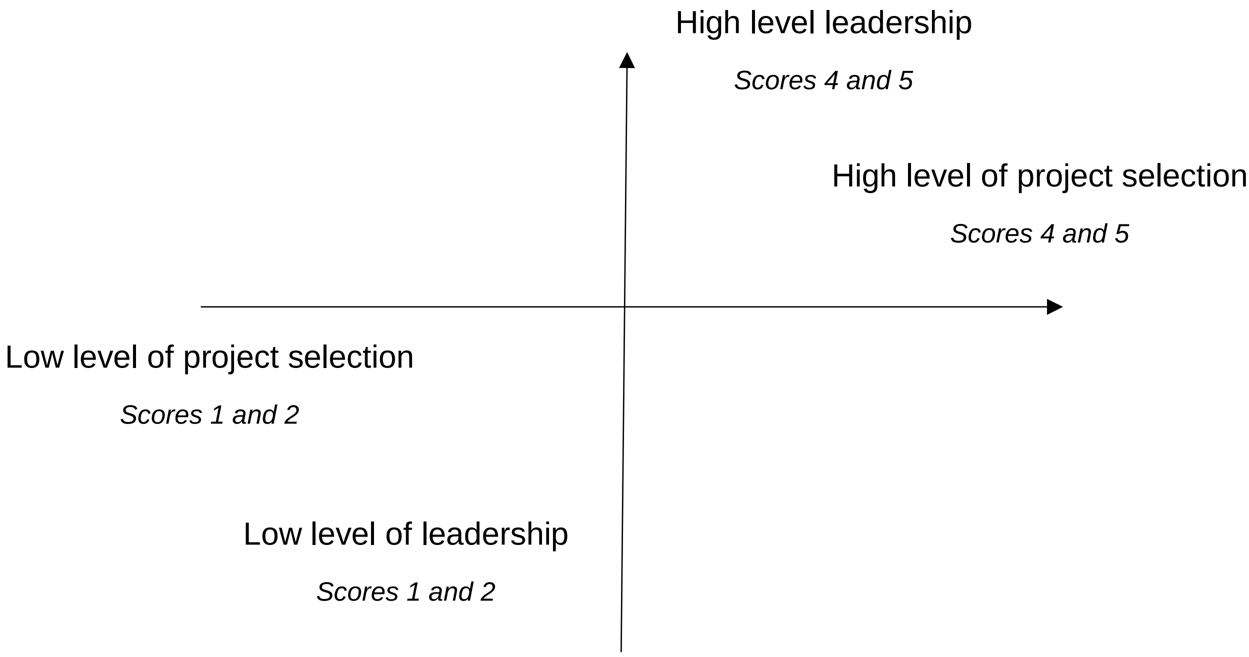


Figure 18: Pairing off factors or characteristics to create regions of maturity

For example, if leadership is combined with project selection, the 4 potential "maturity regions" are:

- Region 1: the institution has a high level of leadership and project selection – potentially the target region for best in class maturity
- Region 2: the institution has a high level of leadership but has not yet linked this with project selection – leading to the follow up action of needing to link project selection with the vision of the institution

- Region 3: the institution has a poor level of leadership commitment, but has a high project selection score because it follows a robust project selection criteria – leading to the follow up action of needing to link project selection with the vision of the institution
- Region 4: the institution has poor leadership commitment and no formal project selection criteria - leading to the follow up action of needing to link project selection with the vision of the institution

This gives an institution potentially one improvement action which could cover 3 maturity scenarios.

Again this potential improvement idea will require significant research to develop the correct pairings and combinations of factors and characteristics. However the author is excited to think that potentially a future model could not just include multi dimensions and a weighting system but develop robust actions plans which meet a variety of scenarios presented to the academic leadership team. This is explored further in the final chapter.

7.6 The final LSS maturity model for HEIs

Figure 19 below brings together all the feedback from the test cases, Master Black Belt and international academic validation interviews and conference workshops to present a final refined Lean Six Sigma Maturity Model for higher educational institutions. Where possible, the author has used all the feedback presented in this chapter, except for the three ideas which require significantly more research and model development: weighting the scores, measuring impact as well as maturity, and pairing off key factors and characteristics. Due to the size and complexity of the model it is difficult to read and best printed in A3 or larger, unless broken down into sections, as demonstrated below:

Academic LSS Maturity Model v2

Factors	Characteristic Name	Score 1- 5	1 *Not Prepared for LSS*	2 *Yellow*	3 *Green*	4 *Black*	5 *Mastering deployment*
Leadership and Organisational Structure	Leadership Role and Support		1.1 No leadership support or commitment to LSS	2.1 Led by LSS or CI team lead	3.1 Led by Registrar / CIO	4.1 led by Director / Deputy VC	5.1 Led by VC / Board
	Central Team Structure		1.2 No team in place	2.2 Small team reporting / sitting within IT	3.2 Medium to Large Team reporting to non academic department such as student services department	4.2 Small team sitting outside of traditional structure reporting directly to VC / deputy VC office	5.2 Local LSS teams delivering change, coordinated by VC office
	Institutional Involvement		1.3 LSS is not valued by the institution	2.3 LSS is only applied to student service and pure administrative process and problems	3.3 LSS is applied to administrative processes which interact with teaching and research processes	4.3 LSS is applied to administrative, teaching and research processes across all departments	5.3 All institutional activity benefits from LSS thinking
Project Selection, Resource and Delivery	Selecting Projects and Programmes		1.4 No project selection criteria in place	2.4 Projects are based on system / IT project requirements	3.4 Project selection criteria devised by departmental heads	4.4 Project selection linked to institution's corporate strategy	5.4 Project Selection Criteria links back to long term vision and is developed by VC / Board
	Resourcing The Project		1.5 Resource not formally allocated	2.5 Full time resource allocated to delivering LSS projects, held within the LSS team only	3.5 Mix of central LSS team projects and department led LSS projects	4.5 Small central team dealing with large projects but primarily role is supporting departmental delivered projects	5.5 Resource is allocated as required for full time project leads in addition to an expectation that projects form part of the day job, supported by a small central team
	Type of Project		1.6 Only projects delivered are capital projects	2.6 Rapid Improvement Events only	3.6 Mix of Rapid Improvement Events and Lean Projects	4.6 Mix of Rapid Improvement Projects, Lean Projects and Six Sigma Projects	5.6 Rapid Improvement Events, Lean, Six Sigma and Design for Six Sigma are all options for projects
Training & Development	Tool, Techniques and Methods Used		1.7 No understanding of the concepts of quality exist	2.7 Simple problem solving tools form the basis of the training and mentoring	3.7 Basic Lean based tools are used to drive change	4.7 Basic Six Sigma based tools and more advanced Lean tools are used to drive change	5.7 Full spectrum of LSS tools - and other improvement philosophies are used to drive change
	Training and Development Programmes		1.8 No formal training exists for LSS	2.8 Training typically last 1-2 days and projects tackled require simple tools	3.8 Formal training programmes exist for Yellow Belt/Green Belt LSS practitioners	4.8 Formal training exists for Black Belts, Senior Leaders and Sponsors of projects	5.8 Fully integrated training strategy is in place i.e. 79% receive YB, 20% GB, 1% BB
	Mentoring and Coaching Support Activity		1.9 No mentoring or support processes exist for LSS project leaders	2.9 Mentoring and support is haphazard and inconsistent	3.9 A central team mentor and support the delegates as they develop their skills	4.9 A formal coaching model is deployed to support GB/YB in delivering projects	5.9 Local teams are empowered to coach, mentor, teach and train their peers
Measuring Cultural Change and Reporting Benefits	The Language of Change		1.10 Individuals react badly to the language of LSS and change	2.10 Language of LSS is altered to avoid offence	3.10 Simple language of LSS is used to build trust and motivate individuals	4.10 Language is no longer a barrier to change, and enhances project activity	5.10 Change is part of the DNA of the institution and the language of change is embraced not feared
	Measuring Success - both Culturally and Financially		1.11 Performance of processes and systems are not measured	2.11 Only academic metrics and student staff surveys are used to check progress	3.11 In addition to academic metrics, financial impact is measured	4.11 In addition to measuring financial and academic metrics, cultural change is also measured	5.11 The institution benchmarks itself against both academic and non academic institutions
	Communicating and Reporting the Benefits of Change		1.12 Performance is not reported at any level	2.12 Performance and project results are shared only locally	3.12 Benefits are reported at department / school level	4.12 Benefits are reported at board level	5.12 Visual management systems, virtual management systems and management reporting exist to share performance across the institution and with outside stakeholders
Sustainability	Sharing Best Practice - Inside and Outside the Institution		1.13 No formal process exists for sharing results and best practice	2.13 The team feedback progress through an establish meeting such as the monthly quality meeting	3.13 Steering group is assembled to drive the initiative	4.13 Forum for sharing LSS best practice and supporting members exists	5.13 The institution has fully integrated LSS into its existing systems and management processes
	Wider Staff and Stakeholder Involvement		1.14 Staff view change as someone else's problem	2.14 Only administrative and IT staff are involved in projects	3.14 Academic staff act as advisors on project teams	4.14 Academic and administrative staff lead projects as and when required	5.14 All staff are involved in change
	Reward and Recognition in a Complex Culture		1.15 No reward or recognition for improving one's processes	2.15 Financial incentives are used to improve motivation for change	3.15 Academic freedom is used as an incentive to improve motivation for chance	4.15 Individuals are able to see the value of change, and any reward or recognition system reflects their wider needs	5.15 Staff feel self motivated to change their own processes irrespective of reward or outside recognition. In addition the organisation recognises the importance of succession planning for all staff involved in development

Figure 19 Final refined LSS model for academic institutions

7.7 Developing the model into a benchmarking tool

Through testing, validating and developing the model, it became clear that although pictorially it looks good as a one page A3 capability maturity model, the practical use requires the model to be presented in a slightly different format.

During the workshop described in section 7.5, the model was presented in the form of a group exercise handout. The format was designed to aid the attendees in scoring their institution and appeared to be a more user friendly version of the capability matrix shown in figure 19. Figures 20 to 24 below demonstrate the new benchmarking format: Here the model is broken down into five parts. Each part represents one of the five key factors and their respective three characteristics.

Part 1: Leadership and organisational structure

Factor	Characteristic	Your Score: 1 -5 (1 is low, 5 is high)	Level Score	Level Descriptor
Leadership and Organisational Structure	Leadership Role and Support		1	1.1 No leadership support or commitment to LSS
			2	2.1 Led by a LSS or CI team lead, champion or manager
			3	3.1 Led by the Registrar or CIO
			4	4.1 led by a Director or Deputy VC
			5	5.1 Led by the VC or Board
	Central Team Structure		1	1.2 No team in place
			2	2.2 Small team reporting and sitting within IT
			3	3.2 Medium to Large Team reporting to non academic department such as student services department
			4	4.2 Small team sitting outside of traditional structure reporting directly to VC or deputy VC office
			5	5.2 Local LSS teams delivering change, coordinated by the VC office
	Institutional Involvement		1	1.3 LSS is not valued by the institution
			2	2.3 LSS is only applied to student service and pure administrative process and problems
			3	3.3 LSS is applied to administrative processes which interact with teaching and research processes
			4	4.3 LSS is applied to administrative, teaching and research processes across all departments
			5	5.3 All institutional activity benefits from LSS thinking

Figure 20. The Lean Six Sigma Maturity Model benchmarking tool - Part 1 - Leadership and organisational structure

Part 2: Project Selection resource and delivery

Factor	Characteristic	Your Score: 1 -5 (1 is low, 5 is high)	Level Score	Level Descriptor
Project Selection, Resource and Delivery	Selecting Projects and Programmes		1	1.4 No project selection criteria in place
			2	2.4 Projects are based on academic systems or IT project requirements
			3	3.4 Project selection criteria devised by departmental heads
			4	4.4 Project selection linked to institution's corporate strategy
			5	5.4 Project Selection Criteria links back to long term vision and is developed by VC, the Board and other relevant stakeholders
	Resourcing The Project		1	1.5 Resource not formally allocated to CI activity
			2	2.5 Full time resource allocated to delivering LSS projects, held within the LSS team only
			3	3.5 Mix of central LSS team projects and department led LSS projects - resourced accordingly
			4	4.5 Small central team dealing with large projects but primarily role is supporting departmental delivered projects
			5	5.5 Resource is allocated as required for full time project leads in addition to an expectation that projects form part of the day job, supported by a small central team of facilitators and mentors
	Type of Project		1	1.6 Only projects delivered are capital projects
			2	2.6 Rapid Improvement Events only
			3	3.6 Mix of Rapid Improvement Events and Lean Projects
			4	4.6 Mix of Rapid Improvement Projects, Lean Projects and Six Sigma Projects
			5	5.6 Rapid Improvement Events, Lean, Six Sigma, Operational Excellence, and Design for Six Sigma are all options for projects

Figure 21 The Lean Six Sigma Maturity Model benchmarking tool - Part 2 - Project selection, resource and delivery

Part 3: Training and development

Characteristic	Your Score: 1 -5 (1 is low, 5 is high)	Level Score	Level Descriptor
Tool, Techniques and Methods Used		1	1.7 No understanding of the concepts of quality, or the tools that support it, exist
		2	2.7 Simple problem solving tools form the basis of the training and mentoring
		3	3.7 Basic Lean based tools are used to drive change
		4	4.7 Basic Six Sigma based tools and more advanced Lean tools are used to drive change
		5	5.7 Full spectrum of LSS tools and other improvement philosophies are used to drive change
Training and Development Programmes		1	1.8 No formal training exists for LSS
		2	2.8 Training typically last 1-2 days and projects tackled require simple tools
		3	3.8 Formal training programmes exist for Yellow Belt/Green Belt LSS practitioners
		4	4.8 Formal training exists for Black Belts, Senior Leaders and Sponsors of projects
		5	5.8 Fully integrated training strategy is in place i.e. 79% receive YB, 20% GB, 1% BB
Mentoring and Coaching Support Activity		1	1.9 No mentoring or support processes exist for LSS project leaders
		2	2.9 Mentoring and support is haphazard and inconsistent
		3	3.9 A central team mentor and support the delegates as they develop their skills
		4	4.9 A formal coaching model is deployed to support GB/YB in delivering projects, such as OSCAR
		5	5.9 Local teams are empowered to coach, mentor, teach and train their peers

Figure 22 The Lean Six Sigma Maturity Model benchmarking tool - Part 3 – Training and development

Part 4: Measuring cultural change and reporting benefits

Factor	Characteristic	Your Score: 1 -5 (1 is low, 5 is high)	Level Score	Level Descriptor
Measuring Cultural Change and Reporting Benefits	The Language of Change		1	1.10 Individuals react badly to the language of LSS and change
			2	2.10 Language of LSS is altered to avoid offence
			3	3.10 Simple language of LSS is used to build trust and motivate individuals
			4	4.10 Language is no longer a barrier to change and enhances project activity
			5	5.10 Change is part of the DNA of the institution and the language of change is embraced not feared
	Measuring Success - both Culturally and Financially		1	1.11 Performance of processes and systems are not measured
			2	2.11 Only academic metrics and student staff surveys are used to check progress
			3	3.11 In addition to academic metrics, financial impact is measured
			4	4.11 In addition to measuring financial and academic metrics, cultural change is also measured
			5	5.11 The institution benchmarks itself against both academic and non academic institutions
	Communicating and Reporting the Benefits of Change		1	1.12 Performance is not reported at any level
			2	2.12 Performance and project results are shared only locally
			3	3.12 Benefits are reported at department / school level
			4	4.12 Benefits are reported at board level
			5	5.12 Visual management systems, virtual management systems and management reporting exist to share performance across the institution and with outside stakeholders

Figure 23 The Lean Six Sigma Maturity Model benchmarking tool - Part 4 – Measuring cultural change and reporting benefit

Part 5: Sustainability

Factor	Characteristic	Your Score: 1 -5 (1 is low, 5 is high)	Level Score	Level Descriptor
Sustainability	Sharing Best Practice - Inside and Outside the Institution		1	1.13 No formal process exists for sharing results and best practice
			2	2.13 The team feedback progress through an establish meeting such as the monthly quality meeting
			3	3.13 Steering groups and CI forums are assembled to drive the initiative
			4	4.13 Forums for sharing LSS best practice and supporting members exists
			5	5.13 The institution has fully integrated LSS into its existing systems and management processes
	Wider Staff and Stakeholder Involvement		1	1.14 Staff view change as someone else's problem
			2	2.14 Only administrative and IT staff are involved in projects
			3	3.14 Academic staff act as advisors on project teams
			4	4.14 Academic and administrative staff lead projects as and when required
			5	5.14 All staff are involved in change
	Reward and Recognition in a Complex Culture		1	1.15 No reward or recognition for improving one's processes exists
			2	2.15 Financial incentives are used to improve motivation for change
			3	3.15 Academic freedom is used as an incentive to improve motivation for chance
			4	4.15 Individuals are able to see the value of change, and any reward or recognition system reflects their wider needs
			5	5.15 Staff feel self motivated to change their own processes irrespective of reward or outside recognition. In addition the organisation recognises the importance of succession planning for all staff involved in development

Figure 24 The Lean Six Sigma Maturity Model benchmarking tool - Part 5 - Sustainability

7.8 Testing the model - concluding comments

The final *Lean Six Sigma Maturity Model for Higher Educational Institutions* has been built using a mixture of literature review and surveys, but mainly the four case studies, four test cases, key academic and practitioner interviews, and conference workshops presented here. The model provides a framework to map how institutions are maturing in their Lean Six Sigma journey and to provide a framework of next steps to drive maturity.

The model is presented in two formats, the first as an A3 one page capability maturity matrix, the second as a benchmarking tool split across five parts. The model has been revised and developed over time and the author cannot stress enough the benefit that was gained through this phase of his research. The final refined *Lean Six Sigma Maturity Model for Higher Educational Institutions* has become both a measurement and benchmarking tool, as well as a method of identifying the next steps in an institution's LSS journey. However the maturity model is a dynamic concept which, following feedback form academics and Master Black Belts, has the potential to be refined and developed further in the coming years – something which the author explores in the following final chapter.

Chapter 8: Discussion of key findings

It is a shame that through the author's empirical research no academic examples have been discovered in higher educational institutions where they are using advanced Lean Six Sigma approaches to address the challenges of the 21st century. Specifically there are no examples or published case studies of Lean Six Sigma being used to address: the survival of the institutions, the quality of teaching, and the value of research. The author has identified nine key discussion points from both his empirical research and his literature reviews, all linked back to a lack of maturity observed in using Lean Six Sigma to address these challenges. These nine discussion points are therefore potential areas HEIs leaders could invest in and develop further, thus helping to improve their , knowledge, skills and maturity with Lean Six Sigma and address the challenges faced by their institutions in a structured and controlled manner.

8.1 Lack of maturity in academic leadership of LSS

There is no denying that academic institutions are facing many challenges in today's globalised educational world, with public funding cuts, commercially driven credit based curriculums, accountability, quality assurance, the student as customer, and performance based management, (Laing and Laing 2011, Kurniawan and Puspitaningtyas 2013.) There is a significant body of research that has been written on the importance of leadership in dealing with these challenges and specifically with respect to deployment of LSS in industry, and higher educational institutions are no exception, (Zare 2011, Antony et al 2012, Laing and Laing 2011, Kurniawan and Puspitaningtyas 2013, Antony 2014, Balzar 2015, Sadeh and Garkaz (2015), Waterbury 2015. and Laureani and Antony 2018.) In addition to LSS, traditional management language such as "excellent academic performance", "organise effectively", "efficiently", "sustainably", and "accountability" have sneaked into the vocabulary of academic leaders, (Kurniawan and Puspitaningtyas 2013.) However, although leadership is raised as a readiness factor and critical success factor in LSS deployment (Antony 2014,) examples of LSS leadership have been missing in nearly all the literature, questionnaires and case studies researched by the author; with only one case study identified by the author where the Vice President of the university championed and valued the LSS initiative within their organisation. Without strong leadership LSS will fail to meet its long term objectives of delivering value and reducing waste and variation. Literature is awash with one off success stories within higher educational institutions but very few examples exist where LSS has gone beyond the first initial projects, (Antony et al 2016, Montgomery 2017, Antony et al 2018 and O'Reilly et al 2019.) LSS is a journey not a destination, and it is important that higher educational institutional leadership teams realise that the real benefit of LSS is in changing the culture of an institution, not just fixing broken administrative processes, (Snee 2010, Antony 2014, Laureani and Antony 2018 and Arcidiacono and Pieroni 2018.) It is the author's view that this lack of leadership is the most important aspect in developing higher educational institutional maturity with respect to LSS.

8.2 Lack of maturity in understanding the term customer within the world of LSS and higher educational institutions

Within the higher educational institutions researched by the author, there appears a real struggle to understand who the customers of academic processes are. This lack of customer definition can result in projects being deployed in areas which, although give benefit to the institution, miss more important improvement opportunities. Literature supports that lack of understanding of the customer and not understanding the voice of the customer will always results in sub-optimum project delivery, (Snee and Hoerl 2002, Zhao 2005, Hines and Lethbridge 2008, Simmon and Young 2014, and Cudney et al 2020.) However there are some examples, although few in number, where LSS methodology along with tools and techniques have been deployed into academic student administrative based processes such as enrolment, library services and counselling services (Emiliani 2004, Kumar and Morrow 2006, Nelson 2015, Cudney et al 2020, Gupta et al 2020.) These projects are student centred, and the authors define the student as a customer in their research. It is encouraging to see how some individuals within academia understand the concept of voice of the customer and view the students as one of many customers within the higher educational institution. In whatever manner the institution defines what students are, they are critical and central to a higher educational institution's LSS journey and should not be simply viewed as a resource, a cost or, worse, a burden.

8.3 Lack of maturity in linking project selection with the higher educational institution's strategy

Although there are pockets of excellence around the UK where institutions are using Lean Six Sigma to drive down costs and improve student experiences, within certain administrative processes, there appears to be major fundamental weaknesses in their approach to delivering Lean Six Sigma in areas of project selection, resourcing, team working, type of Lean Six Sigma project deployed and sustaining cultural change (Cudney et al 2020.) Specifically, project selection appears not to be linked to any strategic long term plan, rather it appears these tools are being deployed to fix short term immediate administrative problems. Projects are selected locally by managers working in their own silos, with no appreciation of the knock on effects to other processes or stakeholders as they change processes and procedures within their silo. These personal "pet" projects are not aligned with any strategic plan outside the department's own needs and there is no evidence in the UK of a Motorola or GE type project selection criteria being used to select, resource and manage LSS programmes, (Box 2006, Kumi and Murrow 2006, Yang and Hsieh 2009. Antony et al 2012, Hess and Benjamin 2015 and Cudney et al 2020.) A key fundamental of LSS is the ability to link project selection to organisational strategy. If this link is not there, projects will never be a priority and never fully deployed or implemented.

8.4 Lack of maturity in project ideas and style of project

The types of projects identified in 8.2 and the lack of project selection criteria identified in 8.3 above have led to the majority of continuous improvement activity within higher educational institutions being focused on student related support processes, resulting in other stakeholders, such as teachers, professors, researchers, managers and leaders, being ignored. It may be some time before our higher educational institutions can break down the cultural barriers which are preventing them from moving beyond the relatively simple transactional student administrative, infrastructure and IT based projects, since these barriers to change are fundamentally built into the very fabric of our institutions, (Box 2006, Kumi and Murrow 2006, Antony et al 2012 and Hess and Benjamin 2015, Gupta et al 2020.) Potential project ideas need to be generated throughout the institution, by all stakeholders and at all levels. These ideas can then be rationalised against a strategic project selection criteria and resourced and managed accordingly. Projects do not have to be just administrative or transactional. For example LSS can be used to improve teaching methods and offer alternatives to research approaches. In this thesis, the author has used Taguchi methods to run an efficient structured literature review. There are a few examples where professors have used voice of the customer techniques to gauge students' opinion but these are rare and infrequent, and have tended to be one-off events (Emiliani 2004, Garkaz et al 2011, Antony et al 2012, and Gupta et al 2020.)

The form of projects delivered is also sadly limited, with typically rapid improvement events being the desired approach by most institutions (Robinson and Yorkstone 2014.) These rapid improvement events typically take a week, then are followed up by the central LSS team over a 2-3 month time frame while quick win changes are implemented. Although this approach will have its benefits, long term structural issues within a higher educational institution cannot be solved through these rapid improvement events. However, there are more options available to mature organisations. In addition to rapid improvement events, institutions could be taking advantage of more traditional Green Belt or Black Belt style DMAIC projects, Kaizen events, Triz events, systems thinking projects, and new product and process introduction through the use of Design for Six Sigma – the latter could be used by academics to design better courses for students and executive programmes (Yang et al 2003, Park and Antony 2008, Thomas et al 2017, Jenab et al 2018.)

8.5 Lack of maturity in the tools and techniques used

The variety tools and techniques within the domain of a LSS specialist is vast and range from simple voice of the customer techniques such as value statements to more advanced techniques such as non-normal significance testing through non-parametric approaches, for example such as the Moods Median Test. However the author has discovered, through his formal questionnaire, semi-structured interview programme and conference workshop discussions, no institution using advance statistical LSS techniques such as: Design of Experiments, Significance Testing, Correlation and Regression, Control Charts, Process Capability Studies and Probability theory. All the tools witnessed as part of this research would be defined by the author as simple Lean tools, such as Process Mapping, Critical to Quality, Action Planning, Idea Prioritisation, Visual Management and Control Plans. The more advanced Lean tools of Rapid Change Overs, Total Productive Maintenance, Just in Time, Poka Yoke, Overall Equipment Effectiveness and Kanban do not appear in any of the solutions used by the institutions to address their problems. It may be that these institutions are unsure how to adapt these tools to fit their projects or problems (Carvalho et al 2013, Antony et al 2012, Douglas et al 2015.)   In table 51 below the author gives some of his own examples of how such tools could be used in HEI context:

Tool and Techniques	Potential Examples
Design of Experiments	• Delivering structured systematic literature reviews • Modelling student movements and traffic flows around campus
Correlation and Regression	• Supporting the creation of timetables to minimise the travel time to and from lessons • Developing a link between quality of teaching and quality of grades
Process Capability and Process Control	• Managing student enrolment • Measuring lecturer performance
Probability Theory	• Predicting student dropout rates • Predicting student grades based on non-academic factors

Rapid change overs	• Improving the readiness of classrooms by better setting up of classrooms between lessons • Improving the mentoring of students through better change overs between meetings
Total productive maintenance	• Improving IT server availability through preventative maintenance activity • Improving the reliability of the facility's campus vehicle fleet
Just in time	• Improving assignment marking time • Improving time in responding to grant applications
Overall equipment effectiveness	• Measuring the impact of around campus of visual management monitors and boards • Improving the laboratory equipment availability and use

Table 51: The authors' view of where advanced LSS techniques could be used in HEIs

Applying the right tool to the right problem or project requires a mix and complexity of the LSS tool kit which is currently not evident in the higher educational institutions studied by the author.

8.6 Lack of maturity in the structuring of project teams and central support functions

Central teams of Lean Six Sigma professionals are often working from project to project without having adequate project review time with the host department they are supporting. In addition, these central teams are not giving any thought to how these departments will continue to change and improve after the Lean Six Sigma team moves on or the delegates' project finishes. This lack of sustainability means they will never reach their full potential, or reap the full rewards Lean six sigma, and other improvement techniques such as system thinking, operational excellence and theory of constraints have to offer. These central teams are being managed usually within a departmental silo, typically linked to the IT or facilities senior manager, (Pryor et al 2012, Antony et al 2012, Antony 2014, and Cudney 2020.) Since they are branded as part of IT or facilities, it becomes difficult for the CI team to operate with any respect outside of these types of projects. This often leads to the members of the central team becoming frustrated and ultimately leaving the institution; resulting in a high turnover of staff within these central teams, (Pryor et al 2012, Antony et al 2012, Antony 2014, and Cudney 2020.) These individuals are often recruited from outside the university sector where LSS is valued, leadership teams support the LSS team, and although they are held accountable to deliver benefit, they are also given the resource to achieve their objectives, (Fornari and Maszle 2004, Bandyopadhyoy 2014, Laureani and Antony 2018 and Cudney et al 2020.) These Lean Six Sigma professionals from outside of higher educational institution become frustrated and angry with the higher educational institutions management, culture and ways of working which appear to the professional as opposite to what they experience outside of higher educational institutions, (Fornari and Maszle 2004, Bandyopadhyoy 2014, Laureani and Antony 2018 and Cudney et al 2020.) Retaining competent individuals is key to sustaining any change, especially LSS initiatives, (Buck and Watson 2002, Selesho and Naile 2014.)

8.7 Lack of maturity in how staff resources are developed, mentored and motivated

Following on from the importance of structure and retaining competent LSS individuals, resources for leading and participating in higher educational institutional projects are often limited to administrative and managerial positions. In addition, institutions are struggling to gain a “critical mass” of trained Lean Six Sigma professionals who are able to deliver projects on their own with minimum support from a central coordination office. There is a significant body of research which supports the fact that for LSS to be a success, the widest number of people need to be involved, with LSS trained individuals performing better on complex tasks than those who are not LSS trained, (Linderman et al 2003, Zare 2011, Easton and Rosenzweig 2012, Cudney et al 2014. Cudney et al 2020).

LSS training is an expensive investment for most organisations, (Karbasian and Aghadaee 2006, Zare 2011, Pulakanam 2012, Madhavan and Gurumurthy

2019). However the main costs are associated with the trainer, the venue and the time lost by delegates attending. This should be offset by higher educational institutions since many will have the skills and facilitates in house to deliver LSS training, and thus the main challenge faced by these institutions becomes releasing individuals to attend the required courses. The academic calendar potentially could create time in the year when releasing certain individuals to be trained has less of an impact on their role and colleagues around them. Whatever the individual institution's challenge in gaining a critical mass of individuals across all positions and structures, training and development is essential to build the infrastructure needed to be successful, (Linderman et al 2003, Zare 2011, Easton and Rosenzweig 2012, Antony 2014, Cudney et al 2014. Antony and Cudney 2016, Cudney et al 2020).

Projects need project leaders: individuals who are trained in project management skills, can prioritise activity, manage resources, and deliver results. In addition, these individuals need to be able to sell the project to other stakeholders and bring people along with them on their journey, (Hach 2009, Timans et al 2017, Cudney et al 2020, Patel and Chudgar 2020). Project leaders need teams of people who understand the importance of the DMAIC process, and can assist the project lead in delivering results, (Hach 2009, Timans et al 2017, Cudney et al 2020, Patel and Chudgar 2020). These teams need the time and space to define the problem, collect base line data, analyse the sources of the variation, create new ideas and solutions, and implement control plans (DMAIC). Experience teaches us that the first round of projects, although hard and require leadership commitment to free up resource, will deliver improved capacity and create more opportunity for training and projects in the future (George 2003, Antony 2014, Laureani and Antony 2018 and Gupta et al 2020).

8.8 Lack of maturity in how success is measured and communicated

Many organizations, and higher educational institutions are no different, feel extreme pressure to become more efficient and to attain more with the same or less resource (Antony et al., 2016). Any organization can accomplish significant results by bringing together quality improvement, reducing complexity and processing waste elimination within their processes (Ravel et al 2019). However how this success is measured and communicated is critical in any LSS journey (Pearson 2001, Antony et al 2014, Patel and Desai 2018, and Ravel 2019). Sadly, organisations often select the wrong measures of performance; rather than developing the most appropriate measurement system, they select the easiest, the fastest or the cheapest, (Pearson 2001.)

Measuring success requires investment and thought, especially in complex organisational cultures such as higher educational institutions, (Pearson 2001, Antony and Cudney 2016, and Cudney et al 2020). Mature LSS programs combine the most effective statistical and non-statistical methods to measure and communicate overall business improvements. The results generated from these methods are the final measures for all improvement efforts and are often strategic and widely shared; whereas a collection of independent local improvements could not achieve the goal of measuring and communicating the wider LSS journey, (Pearson 2001, and Antony 2014).

Savings per annum is by far the most popular approach to measuring LSS success (Patel and Desai 2018). However LSS is more than just about saving money. LSS should always be considered as a journey, rather than just a destination; and therefore it is imperative to be able to identify and measure the journey an organisation is required to undertake in its quest to be regarded as a legitimate LSS organisation, (Bhasin 2011). To demonstrate movement along the journey measurement at this point moves from end point financial metrics to maturity metrics, (Bhasin 2011). To demonstrate maturity, there is a need to expand financial measures to include organisational culture, and benchmarking against other institutions and sectors, (Bhasin 2011). Organisational culture forms the glue that holds the organisation together and stimulates employees to commit to the organisation and to perform. Literature on how to operationalise this “glue” is fairly rare, although widely acknowledged by literature of its importance (Van Den Berg and Wilderon 2004, Tata and Jones 2011, Antony 2012, and Kh 2018). This focus on cultural change leads to the last discussion observation:

8.9 Lack of maturity in understanding that LSS can be used to address the challenges in HEI and through that build sustainability for LSS

To sustain LSS in any organisation the unique challenges faced by that sector need to be addressed and the organisational culture changed, (Snee 2010, Antony et al 2012, Singh and Rathi 2019, and Cudney et al 2020). Singh and Rathi (2019) summarised the main challenges for higher educational institutions from research. Table 52 below is adapted from their work:

Challenges:	References:
Misunderstanding of concepts, tools and vocabulary	Waterbury (2015); Radnor and Bucci (2011)
Lack of commitment and leadership from top management	Waterbury (2015); Radnor and Bucci (2011); Comm and Mathaisel (2005)
Lack of individuals taking responsibility for the training of staff and students	Francis, (2014); Radnor and Bucci (2011); Comm and Mathaisel (2005)
Lack of clarity and receptiveness in communications	Waterbury (2015); Radnor and Bucci (2011)
Little resources assigned to the interventions	Radnor and Bucci (2011)
Poor arrangement and coordination of interventions with the strategic arrangement of the organization	Waterbury (2015), Nadeau (2017)
Deficiency of ability to define problems to be solved	Balzer (2010), Hu et al. (2008)
Lack of planning, coordination and soundness of key project management activities	Thirkell and Ashman (2014), Nadeau (2017)
Protection from change, lacking support, culture of fault, poor administration of contentions inside the organization	Balzer (2010), Nadeau (2017)
Rapidly changing external environment	Balzer (2010), Hess and Benjamin (2015)

Difficulties that are particular to the university group mainly arise from the multifaceted nature of the group and its procedures	Laureani and Antony, (2012); Svensson et al. (2015); Radnor and Bucci (2011)
Dearth of documented experience in this sector	Antony et al., 2012; Hines and Lethbridge (2008)
Challenges of contextualizing certain tools in the sector	Albliwi et al. (2014)
Challenges of characterizing who the customer is and what added value is for the customer	Radnor and Bucci (2011); Steinlicht et al. (2010), Tenali et al. (2015)
At times, insufficient links between teaching activities and research	Svensson et al. (2015)
A negative culture observed around faculty, who feel that academic opportunity and freedom is compromised	Emiliani (2005), Thirkell and Ashman (2014)
Failure of institution in identifying and targeting customer	Cudney et al. (2018)
Inability to cope with process change	Cudney et al. (2018)
Lack of interest in and commitment from the stakeholders	Albliwi et al. (2014)
Lack of understanding of LSS methodology in the educational context	Cudney et al. (2018)

Table 52: List of challenges faced by higher educational institutions when sustaining LSS

Singh and Rathi's (2019) table above was part of a larger review into LSS across all sectors, including education. They found that approximately 58% of all articles published represented the implementation of LSS in service sector, leaving 42% for manufacturing. Within this 58% service sector band LSS has been mostly implemented in financial sector, accounting for almost half the publications. The other sectors such as health care and education are trailing approximately 36% and 24%, respectively (Singh and Rathi 2019).

Thus if higher educational institutions' leadership teams can address these identified challenges, and start to change the culture of their institution then LSS as a method to drive change will be a success, (Hess and Benjamin 2015, and Antony 2015). The type of projects, the way projects are resourced and ultimately the way projects are selected are three areas where higher educational institutions could improve their maturity and drive cultural change in LSS. This would lay the foundations and allow them to move on to more challenging factors and characteristics identified in the author's own LSS maturity model, such as measuring cultural impact and wider stakeholder involvement. It is the hope of the author that academic institutions will think more strategically about their approach to Lean Six Sigma as a method of addressing the challenges faced by academia and that the Lean Six Sigma Maturity Model presented in chapter 7 becomes a vital tool in their strategic deliberations.

Chapter 9: Conclusions, Implications, Further Research Opportunities and Limitations of Research

9.1 Conclusions and recommendations.

The author's main aim of this thesis was to develop a LSS Maturity Model for Higher educational Institutions, allowing them to calculate their maturity against key LSS critical success factors, benchmark themselves against best practice and develop a strategy and action plan for moving the institution forward. On the way to creating the maturity model the author has also been able to make several other conclusions and observations regarding the role LSS has to play in higher education. To help structure the research the author specifically set himself the following research question and objectives:

Research Question: *If academic leaders need to change their institutions to remain relevant in the modern world how can they use tools and techniques from other industries such as Lean Six Sigma to deliver successful change?*

Objective 1: What is the role of academic leadership in delivering change in HEIs and is their context and approach similar to that of or industries and Is there a need for a separate definition for academic leadership?

Objective 2: What is the current situation within UK HEIs with respect to implementing Lean Six Sigma to delivery change? Is this approach different from HEIs from around the world and is it different from the manufacturing sector – the traditional home of Lean Six Sigma? For example: how is Lean Six Sigma (or similar) continuous improvement programme success measured, monitored and sustained in a higher educational institutions and how does this differ from non-academic applications? What type of Lean Six Sigma (or similar) continuous improvement programmes exist within higher educational, how do they translate across to a typical Lean Six Sigma programme in industry, and do they vary depending on whether it is being applied institutionally wide, localised within a department, or within an administrative, research or teaching process?

Objective 3. Does a hierarchy of successful academic leadership exist, like the Collins maturity model, for implementing Lean Six Sigma (or similar) continuous improvement programmes in higher educational institutions – and if so how is that hierarchy constructed, what language does it use, is it similar to the Collins maturity model, and how could higher educational institutions benchmark themselves against this hierarchy or model?

Table 53 below links the following conclusions to the research objectives and thus ultimately answer the author's research questions:

Objective Number:	**Objective (abridged version)**	**Relevant Conclusions**
1	What is the role of academic leadership in delivering change in HEIs and is their context and approach similar to that of or industries?	• C1 • C2 • C3
2	What is the current situation within UK HEIs with respect to implementing Lean Six Sigma to delivery change?	• C5 • C6 • C8
3	Does a hierarchy of successful academic leadership exist, like the Collins maturity model, for implementing Lean Six Sigma (or similar) continuous improvement programmes in higher educational institutions?	• C4 • C7 • Final LSS Maturity Model for HEI

Table 53: Linking the authors research objectives to his conclusions

The main objectives for chapter 1 were to understand the current context and culture of higher educational institutions, understand the changing environment these institutions find themselves operating within, and understand the importance of leadership within a higher educational environment. The author's approach to meeting these objectives was through a detailed literature review centred on the term academic leadership. Through this research the author has been able to make the following conclusions:

C1) Whichever business improvement or change management model universities strive to adopt, at the heart of any university is its reason for existence, and its need to maintain its social contract with society. As society changes, a university needs to change with it, and its ability to successfully manage its own change is something within its own power – the role of today's academic leaders has never been more important, and the role of academic leadership never more crucial.

C2) It is evident that academia has unique challenges when it comes to leadership and that Academic Leadership is a wide term reflecting both institutional and departmental leadership. Academic leaders can come from, and be translated into, leaders with positional power, leaders with expertise power, leaders with networking power and leaders with personality power, but this is no different from any other industry.

C3) The final working definition used by the author to define and describe an academic leader is *"…someone in a position to identify the need to change, to allocate resources to change, to actively manage and facilitate the change, to monitor and motivate during the change, and finally deliver change within higher education, both at the institutional level and the departmental/college level."*

These conclusions led the author to consider how change could be managed, through the use of maturity models. The main objectives for chapter 2 were to understand if the concept of change could be managed through the use of a capability maturity model and if so what characteristics the author will need to consider when he was to develop his own maturity model for managing change within higher educational institution. The author's approach was again through detailed literature review of maturity models and change management. Through this research the author has been able to identify five common characteristics in capability maturity models.

C4) The five common characteristics in capability maturity models.

Characteristic 1: Process improvement and leadership maturity models are often designed around the original capability maturity model from the Software Engineering Institute at the Carnegie Mellon University. Capability maturity models are either Prescriptive or Descriptive, with a possible benchmarking or comparable element.

Characteristic 2: Maturity models use design principles set around terms known as dimensions or factors, each with their own set of typically linear levels moving through time and maturity**.** The resulting scenarios (graphical areas of intercept between the factors and the levels) become the knowledge descriptors which are then used to benchmark performance against the maturity model.

Characteristic 3: Capability maturity models can be applied to almost any situation, entity or process. The approach to designing maturity models outlined in characteristic 2 is applicable to a wide variety of entities including abstract concepts such as leadership, or descriptive concepts such as processes.

Characteristic 4: Maturity models are often linear in their nature, often with an unspecified target audience, which can however be a weakness in its simplicity. The best models are designed for specific entities, processes, industries or situations and can be circular, rather than linear in nature.

Characteristic 5: Often new maturity models are designed through using existing models or concepts, building on previous findings, for example the success factors of successful project deployment. Factors and dimensions are the categorisation of subject matter knowledge into meaningful themes, and the levels are the representation and measurement of that knowledge, usually in a manner related to the reader.

It becomes clear to the author that, to develop a maturity model for higher education, specific factors, dimensions, characteristics and levels would be required to be researched, defined and potentially created from other sources. The main objectives for chapter 3 were to complete a systematic literature review of LSS in higher education, to identify the need for a LSS Maturity Model to manage change within the higher educational sector, and to start to identify potential questions that will need to be asked to help identify the factors, characteristics and descriptors required to build a maturity model. In addition the author wished to demonstrate the use of LSS tools within a research environment, by using one such tool, Taguchi Design of Experiments, to plan, develop and deploy a systematic literature review. Through this research the author has been able to identify that:

C5) No LSS Maturity Model for higher educational institutions currently exists in published research. Any current deployment methods for LSS in higher education are simplistic, and based on copies taken from other sectors, rather than uniquely developed for a higher educational perspective.

C6) Design of Experiments (DoE) is a powerful technique for process understanding and has been rarely used outside of manufacturing. This thesis has demonstrated the use of DoE as an approach to structure a systematic literature review; and through the verification exercise, demonstrated the robustness of this approach, even when not all combinations of search strings are used. DoE also can add additional analysis tools, such as the Main Effects plots, to assist the researchers in understanding which key search strings matter.

Having established that no dedicated LSS maturity model exists for higher educational institutions, the author decided to pursue a programme of research to build the missing maturity model. The main objectives for chapter 4 were to review different research paradigms to identify which best suited the author's own approach to answering his research questions, and to complete a self-assessment against these research philosophies, methodologies and approaches.

C7) The author’s chosen position:

1. Continuum	Basic	**Applied**
2. Ontology	**Objective**	Subjective
3. Epistemology	**Positivism**	Interpretivism
	Direct Realism	**Critical Realism**
4. Approach	Deductive	**Inductive**
	Exploratory	
	Descriptive	
	Explanatory	
5. Research Method	**Mixed**	**Surveys, Case Studies, Triangulation**

Having identified the preferred research position of the author, the first stage of the primary research was to gauge the current situation relating to LSS implementation within higher educational institutions through the use of a questionnaire initially targeting UK higher educational institutions. The main objectives for chapter 5 were to: develop a questionnaire to identify the current state of LSS deployment in UK higher educational institutions, and expand the survey to include several international institutions with a reputation of LSS deployment. The questionnaire was developed from the research gleaned in chapters 1 through to 3.

C8) The following conclusions were drawn from the survey developed in chapter 5:

C8.1) The main reason for institutions embarking on a programme of continuous improvement or change agenda within a UK university was to improve the staff and student experience within the institution. However this is not born out in the detail since many of the improvement programmes are focused on administrative rather than teaching, research or pastoral based processes.

C8.2) Where measures of change programme success do exist in the UK, the national student survey forms the main measure of success. However this appears to be a very simplistic approach to measuring success. Any survey suffers from the bias of the most recent history skewing the results.

C8.3) Virtually all improvement activity in UK institutions is Lean Thinking based, rather than Six Sigma, Lean Six Sigma, Systems Thinking, or other business improvement approaches. These Lean Thinking approaches are almost universally applied to administrative based processes.

C8.4) Typically UK universities are using a team based approach, led by a CI champion or project manager to implement the continuous improvement programme / change agenda.

C8.5) Over 60% of the initial questionnaire respondents have never embarked on a continuous improvement programme / change agenda before starting this one, with only one institution in the UK contacting another university for assistance and guidance in implementing Lean.

C8.6) Within the UK the institution Registrar appears to both lead the programme at operational level and at board level in most circumstances. Again this re-enforces the role played by Lean Six Sigma to be one centred within the administrative rather than teaching or research fields.

C8.7) There is no real evidence in the UK to support ongoing sustainability strategies or tools beyond additional training and current performance management.

C8.8) Within the UK a lack of continuous improvement maturity exists, demonstrated by the answers to some of the questions given to the initial survey, with several answers relating to simple continuous improvement activity, such as process mapping, and the main knowledge, skills and behaviours recorded were “basic project management skills”, rather than, for example, leadership, root cause analysis, design of experiments, and data analysis skills.

Having identified the current situation within UK higher educational institutions, and compared them with international institutions and Master Black Belts from industry, the author decided to identify potentially strong LSS UK institutions based on their responses to the questionnaire. These institutions would form the basis of the new LSS maturity model the author was trying to develop. The main objectives for chapters 6 and 7 were to: develop, and then subsequently test, a LSS maturity model for higher educational institutions. The conclusions and final maturity model drawn from this chapter are based on a total of 47 survey responses and 51 semi structured interviews, which in turn have been used to design, develop and test the LSS maturity model. The model provides a framework to map how institutions are maturing in their Lean Six Sigma journey and provides a framework of next steps to help drive and improve maturity. Following on from chapter 7, the author raised 9 discussion points relating to the maturity of higher educational institutions as they undergo their own LSS journey; finally identifying the importance of leadership and cultural change if LSS is going to be successful for higher educational institutions.

9.3 Future research ideas of interest to the author

The author has identified four areas of interest for future research; three come from feedback from the testing phase of this report and one from the author's own deliberations.

The first area to potentially explore in the future is the weighting of the 15 individual characteristics by their importance. All 15 characteristics have been identified through case study and literature research as important to deliver Lean Six Sigma in academia but perhaps not all 15 are equally weighted.

By weighting a factor or characteristic, the author would need to understand the effect this would have on any scoring or benchmarking output from the model. In addition any resulting action plan to move the institution forward in maturity would be potentially affected or skewed by the weightings – therefore the author would need to fully understand how a characteristic should be weighted, and also the consequences of that weighting: a problem to be tackled by future research.

A second area of future research covers the feedback from one of the leading academics in the field of Lean Six Sigma when they suggested that it is not just where you are in the journey but how effective you have been, (maturity verses effectiveness.) The concept being that, for example, although a project is using a wide and varied number of tools (demonstrating significantly maturity of LSS,) most are not relevant, or, although a wide variety of project types are being deployed the wrong project type is being deployed to a particular problem, (demonstrating poor effectiveness of the use of these tools.) Figure 25 below demonstrates graphically the way in which an institution could show the scoring of each of the 15 characteristics against both the maturity and effectiveness. However, this approach requires the author to create an additional 75 descriptors to support the original 75 which relate to the maturity of the organisation. Thus the author has decided that this would be an interesting future research goal.

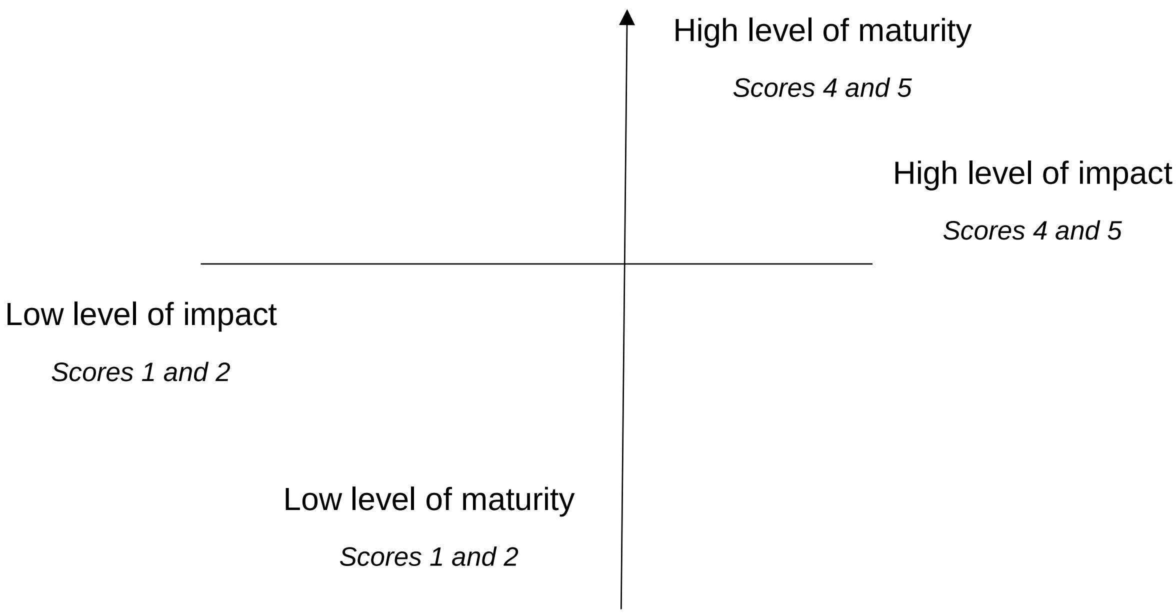


Figure 25 Example of a matrix scoring system

The third potential future area of research is through developing action plans by pairing off factors or characteristics. For example figure 26 below combines leadership scores with project selection scores.

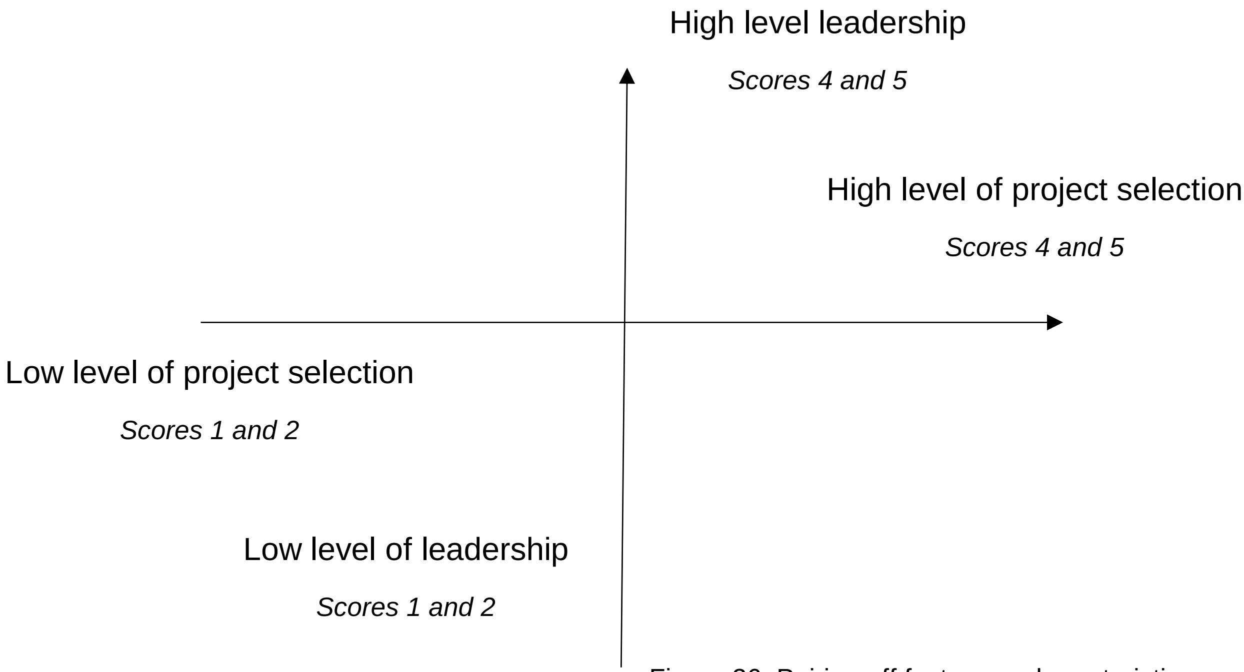


Figure 26: Pairing off factors or characteristics

For example, if leadership is combined with project selection, four potential "maturity regions" are created:

- Region 1: the institution has a high level of leadership and project selection – the target region for good maturity. For example: the higher educational institution has identified individuals within the senior management team to lead and sponsor LSS; and the wider leadership team of the institution have linked their business and academic objectives with the selection criteria for LSS projects and how they are resourced.
- Region 2: the institution has a high level of leadership but has not yet linked this with project selection – leading to the follow up action of needing to link project selection with the vision and strategy of the company. For example, although the higher educational institution leadership has identified key personnel to lead the LSS initiative, it is still seen as separate from the vision and mission of the university thus and project selection is not directly linked to the institution's strategy.

- Region 3: the institution has a poor level of leadership commitment, but has a high project selection score because it follows a robust project selection criteria – leading to the follow up action of needing to link project selection with the vision and strategy of the company. For example, no one in the leadership team is leading the LSS initiative, due to a lack understanding of its value or contribution to strategic delivery, and historically projects have been selected using a civil, capital or IT project selection criteria potentially driven by the institution's relevant civil, capital or IT strategy document.
- Region 4: the institution has poor leadership commitment and no formal project selection criteria - – leading to the follow up action of needing to link project selection with the vision and strategy of the institution. For example the institution has no-one at board level championing or valuing the contribution of LSS and projects are selected based on local needs of departments and schools. However these projects never get completed or fully supported due to the lack of senior management involvement or any link to the wider institutions objectives.

In the above example one improvement action, "linking LSS deployment with the institutions overall organisational strategy" could cover three of the four maturity regions, and thus if completed would improve both the axis of leadership and the axis of project selection. The large number of potential combinations of pairing of each of the 15 characteristics means that further research would be needed to identify real "dependencies": Those characteristics which truly depend on another and which, when combined, will create action plans which are both effective and efficient

The 4th and final area of potential future research comes from the ongoing study and observation of academic institutions delivering strategic change through the use of manufacturing based improvement techniques. There are many other improvement strategies that the author has not investigated: system thinking, theory of constraints, quality management systems, such as ISO9001, operational excellence and IT based improvement strategies such as agile and scrum. It may be that UK universities have progressed and are delivering change outside of the Lean Six Sigma community.

These four potential future areas of research offer the author many possibilities in taking his work further and it is motivating him to continue developing and working in this field in the future.

9.4 Limitations of Research:

Within any project a project manager should identify what he has in and out of scope. The moment boundaries and areas fall out of scope, the project manager is applying limitations to his work. There are many good reasons for this, although predominately being to ensure progress and an eventually sense of completion. This thesis, like any other project, has its limitations and the three main ones have been summarised below:

Limitation 1: The main limitation applied by the author to his research was from the use of the feedback received from the test cases. Any feedback which refined the existing draft model was utilised. However there were three specific pieces of feedback centred on weighting the 15 characteristics, developing a multidimensional scoring system of both maturity and impact, and finally pairing off characteristics to develop robust action plans and next steps, which have not been applied. These three pieces of feedback have been positioned outside the scope of this thesis but will potentially be developed by the author in the future.

Limitation 2: The research has focused robustly on UK institutions; however it has not explored in detail international academic Lean Six Sigma centres of excellence. Although international academics and universities have supported the development and testing of the maturity model, their selection was made based on availability and willingness to speak to the author, rather than a systematic selection criteria when compared to the UK institutions used in the research.

Limitation 3: Another limitation of this work is in the fact that the sample sizes have always been small. Due to this being a new field of discovery and research. 47 individuals eventually responded to the initial questionnaire, 15 individuals were interviewed across the four case studies to help build the first draft model and 33 individuals contributed to the testing and refining of that model giving a total of 95 data samples.

Limitation 4: The infrastructure required to complete a LSS journey within higher education institutions has not been developed in detail. Specifically, a tool kit for higher educational institutions has not been developed; the belt system used with LSS has not been tailored to fit the organisational structure of higher education institutions; and no framework for project selection has been recommended.

9.4 The implications to practice and policy making within HEI and final thoughts from the author:

The author has demonstrated several areas where practice and policy making within HEI can be impacted by his research:

1. The importance and value of Design of Experiments (DoE) as a manufacturing tool used in a non-manufacturing setting to aid researchers and academic's across a variety of disciplines. Although typically used to optimise manufacturing processes the author has demonstrated the practical value of using DoE to conduct systematic literature reviews in an efficient and practical manner. Often academics question the value of Lean Six Sigma tools outside of administrative processes, and in this thesis the author has been able to demonstrate an alternative approach to systematic literature reviews which brings real value and benefit to the researcher.
2. The authors' findings from surveys and semi structured interviews have set the foundation for the use of continuous improvement methodologies in the higher educational sector. These findings are useful to senior leaders in HEI

since they illustrate how low generally the UK HEI maturity is within the Lean Six Sigma approach, and thus there is significantly more benefit to be gained from developing HEIs maturity with Lean Six Sigma in the future. The author's research has illustrated many of the challenges faced by HEI leaders as they deliver change, but has also showed how HEIs can potentially overcome many of these challenges by continually investing in building a culture of continuous improvement and change

3. The authors' final maturity model for Lean Six Sigma in HEI can be used as a benchmark for many HEI to measure their own maturity and by using the authors' self-assessment tool, HEIs can understand the strengths and weaknesses of their CI implementation. The maturity model helps organisations develop action plans showing what needs to be achieved to research the next level of maturity in their Lean Six Sigma deployment.
4. Finally, policy making implications are identified by the author as potentially benefiting two different levels – the school level and the university level. The benefit of developing a culture of process improvement using the authors' model at school level could be to improve transparency across schools, generate greater empowerment of staff within schools and increase engagement of all staff in dealing with challenges and issues faced by the school. Schools could become centres of best practice developing their own approaches and tools to deliver change within a larger university framework. The benefit of developing a culture of process improvement using the authors model at the university level could be to develop a cultural transformation of the university, moving away from a blame or command and control culture which exists in many UK HEIs to one which is positive towards change, strives for continuous improvement and is genuinely leading the world at adapting to the needs society places upon it.

Whichever business improvement or change management model higher education institutions strive to adopt, at the heart of any university is its reason for existence, and its need to maintain its social contract with society. As society changes, a university needs to change with it, and its ability to successfully manage its own change is something within its own power – the role of today's academic leaders has never been more important, and the role of academic leadership never more crucial. Change can be managed and delivered successfully if academic leaders realise that they can manage change. Therefore the author wishes to finish this report by thanking all its contributors and repeat his definition of what true academic leadership is…………*"someone in a position to identify the need to change, to allocate resources to change, to actively manage and facilitate the change, to monitor and motivate during the change, and finally deliver change within higher education, both at the institutional level and the departmental/college level."*

References:

Abu Sultan, Y.S., Al Shobaki, M.J., Abu-Naser, S.S. and El Talla, S.A., 2018. The Style of Leadership and Its Role in Determining the Pattern of Administrative Communication in Universities-Islamic University of Gaza as a Model, International Journal of Academic Management Science Research Vol. 2 Issue 6, June – 2018, Pages: 26-42

Adams, C.W. Gupta, P. and Wilson, C.E. 2003. Six Sigma Deployment, Vol. 4, Routledge, London

Adler, P. and P. Adler 2012. ‘Expert voice’. In S. E. Baker and R. Edwards, How Many Qualitative Interviews are Enough? National Centre for Research Methods Review Discussion Paper, pp. 8–11. Retrieved from http://eprints.ncrm.ac.uk/2273/(accessed 9 May 2015)

Ahern, D. M., Clouse, A., & Turner, R. 2004. CMMI Distilled. Boston: Pearson Education.

Ahmed, S., Abd Manaf, N.H. and Islam, R., 2018. Effect of Lean Six Sigma on quality performance in Malaysian hospitals. International journal of health care quality assurance.

Akhter Ireen, Mahmudul Haque Sharif 2012. In search of academic excellence by becoming an effective leader: a study of academic leadership in higher education, global journal of management and business research, Vol 12, No10, June 2012

Albliwi, S.A., 2017. Lean Six Sigma maturity model within Saudi Arabian organisations: an empirical study (Doctoral dissertation, Social Sciences).

Allen, T.T., Tseng, S.H., Swanson, K. and McClay, M.A., 2009. Improving the hospital discharge process with Six Sigma methods. Quality Engineering, 22(1), pp.13-20.

Altbach, P., 2010. Why branch campuses may be unsustainable. International Higher Education, (58).

Alzhrani K., Alotibie, B., Abdulaziz, A., 2016. Total quality management in Saudi higher education, International Journal of Computer Applications, Vol 135 No4, February

American Productivity and Quality Center 2001, “Deploying Six Sigma to bolster business processes and the bottom line”, final report, Knowledge Transfer Session, Houston.

Anacona D., Malone, T., Orlikowski W, Senge P., 2007. “In praise of the incomplete leader.” Harvard Business Review. Vol. 85(2), pp. 92-100, 2007

Anand, G., Ward, P.T. and Tatikonda, M.V., 2010, “Role of explicit and tacit knowledge in Six Sigma projects: an empirical examination of differential project success”, Journal of Operations Management, Vol. 28 No. 4, pp. 303-315.

Anderson, M. and Sohal, A.S., 1999. A study of the relationship between quality management practices and performance in small businesses. International Journal of quality & Reliability management.

Anthony S., Antony J., 2017. Lean Six Sigma in Academic Institutions—UK vs. Rest of the World, Proceedings of the 4th International Conference on Lean Six SIGMA for Higher Education Paperback – 4 May 2017

Antman EM, Lau J, Kupelnick B, Mosteller F, Chalmers TC, 1992. A comparison of results of meta analyses of randomized control trials and recommendations of clinical experts: Treatments for myocardial infarction: JAMA 1992;268:240-248.

Antony J and Cudney, 2016. Lean Six Sigma journey in a UK higher education institute: Challenges, projects, and key lessons learned. International Journal of Quality and Reliability Management

Antony J, Coleman S, Montgomery D C, Anderson M J, Silvestrini R T, 2010. Design of experiments for non-manufacturing processes: benefits, challenges and some examples: Proceedings of the Institution of Mechanical Manufacture Engineers, Part B: Journal of Engineering 7 December 2010. DOI: 10.1177/0954405411395857

Antony J., 2003. Design of Experiments for Engineers and Scientists, 2003, Butterworth-Heinemann ISBN: 0750647094

Antony J., 2004. Some pros and cons of six sigma: an academic perspective, The TQM magazine, vol 16, No4, 2004, pp 303-306

Antony J., 2014. Readiness factors for the Lean Six Sigma journey in the higher education sector International Journal of Productivity and Performance Management, Volume: 63 Issue: 2, 2014

Antony J., Ghadge A., Ashby S., Cudney E., 2018. Lean Six Sigma journey in a UK higher education institute: a case study. International Journal of Quality & Reliability Management, 35(2), pp.510–526

Antony J., Krishan N., Cullen D., Kumar M., 2012. Lean Six Sigma for higher education institutions (HEIs): Challenges, barriers, success factors, tools/techniques International Journal of Productivity and Performance Management, Volume: 61 Issue: 8, 2012

Antony, J and Banuelas, R., 2002. Key ingredients for the effective implementation of Six Sigma program’, Measuring business excellence. Bradford: Emerald, 6(4), pp. 20–27. doi: 10.1108/13683040210451679.

Antony, J. 2007,“Is Six Sigma a management fad or fact?”, Assembly Automation, Vol. 27 No. 1, pp. 17-19.

Antony, J. 2014. Readiness factors for the Lean Six Sigma journey in the higher education sector. International Journal of Productivity and Performance Management, 63(2), 257–264.

Antony, J. 2015. Challenges in the deployment of LSS in the higher education sector: Viewpoints from leading academics and practitioners. International Journal of Productivity and Performance Management, 64(6), 893–899.

Antony, J. and Banuelas, R., 2002. Key ingredients for the effective implementation of Six Sigma program. Measuring business excellence.

Antony, J., 2017. Lean Six Sigma for higher education. International Journal of Productivity and Performance Management, 66(5), pp.574–576.

Antony, J., Douglas, A. and Jiju Antony, F., 2007, “Determining the essential characteristics of Six Sigma black belts”, The TQM Magazine, Vol. 19 No. 3, pp. 274-281.

Antony, J., F., Kumar, M. and Rae Cho, B., 2007, “Six sigma in service organisations”, International Journal of Quality & Reliability Management, Vol. 24 No. 3, pp. 294-311.754 IJQRM 35,3 Downloaded by University of Nebraska at Omaha, Doctor Phillip Witt At 13:42 05 March 2018 (PT)

Antony, J., Krishan, N., Cullen, D., & Kumar, M., 2012. Lean Six Sigma for higher education institutions (HEIs): Challenges, barriers, success factors, tools/techniques. International Journal of Productivity and Performance Management, 61(8), 940–948.

Antony, J., Kumar, M. and Madu, C.N., 2005, “Six sigma in small- and medium-sized UK manufacturing enterprises”, International Journal of Quality & Reliability Management, Vol. 22 No. 8, pp. 860-874.

Antony, J., Sivanathan, L. and Gijo, E.V., 2014. Design of Experiments in a higher education setting. International Journal of Productivity and Performance Management.

Antony, J., Sony, M., Dempsey, M., Brennan, A., Farrington, T. and Cudney, E.A., 2019. An evaluation into the limitations and emerging trends of Six Sigma: an empirical study. The TQM Journal.

Antony, J.; Ghadge, A.; Ashby, A; Cudney, E., 2018. Lean Six Sigma journey in a UK higher education institute: a case study. International Journal of Quality & Reliability Management, 35(2), pp.510–526.

Aquilani, B., Silvestri, C., Ruggieri, A. and Gatti, C., 2017. “A systematic literature review on total quality management critical success factors and the identification of new avenues of research”, The TQM Journal, Vol. 29 No. 1, pp. 184-213.

Arcidiacono, G. and Pieroni, A., 2018. The revolution Lean Six Sigma 4.0. International Journal on Advanced Science, Engineering and Information Technology, 8(1), pp.141-149.

Arnheiter E. D., Maleyeff J., 2005. The integration of Lean management and Six Sigma, , The TQM Magazine, Vol. 17 No. 1, 2005, pp. 5-18, Emerald Group Publishing Limited

Aronson, Z.H., Reilly, R.R. and Lynn, G.S., 2006, "The impact of leader personality on new product development teamwork and performance: the moderating role of uncertainty", Journal of Engineering and Technology Management, Vol. 23 No. 3, pp. 221-247.

Arumugam, V., Antony, J. and Kumar, M., 2013, "Linking learning and knowledge creation to project success in Six Sigma projects: an empirical investigation", International Journal of Production Economics, Vol. 141 No. 1, pp. 388-402.

Avison, D.E., Lau, F., Myers, M.D. and Nielsen, P.A., 1999. Action research. Communications of the ACM, 42(1), pp.94-97

Azis Yudi, Osada Hiroshi, 2010. Innovation in management system by Six Sigma: an empirical study of world-class companies, International Journal of Lean Six Sigma, Vol. 1 Iss: 3, pp.172 - 190

Babajide, B., & Moore, T., 2015. Engineering university-industry projects: A design for Six Sigma framework. Proceedings of the 2015 IEEE frontiers in education conference (FIE), IEEE Computer Society, Washington,DC, pp. 1–4.

Bai, C., A. Satir, and J. Sarkis, 2019. "Investing in Lean Manufacturing Practices: an Environmental and Operational Perspective." International Journal of Production Research 57 (4): 1037–1051

Balzer, W. K., Brodke, M. H., & Kizhakethalackal, E. T., 2015. Lean higher education: Successes, challenges, and realizing potential. International Journal of Quality & ReliabilityManagement, 32(9), 924–933.

Balzer, W. K., Francis, D. E., Krehbiel, T. C., & Shea, N. 2016. A review and perspective on Lean in higher education. Quality Assurance in Education, 24(4), 442–462.

Bandyopadhyay, J. 2014. A framework for design, development and delivery of high quality online higher education program in the U.S using Six Sigma approach. Journal of Business Behavioral Sciences, 26(3), 43–53.

Bandyopadhyay, J. K., & Lichtman, R., 2007. Six Sigma approach to quality and productivity improvement in the institutions for higher education in the United States. International Journal of Management, 24(4), 1–5.

Banuelas Coronado, R. and Antony, J., 2002, "Critical success factors for the successful implementation of Six Sigma projects in organisations", The TQM Magazine, Vol. 14 No. 2, pp. 92-99.

Banuelas, R., Tennant, C., Tuersley, I. and Tang, S., 2006, “Selection of Six Sigma projects in the UK”, The TQM Magazine, Vol. 18 No. 5, pp. 514-527.

Barboza, A.B., Shetty, R., Shetty, P., Shetty, J. and Shetty, A.D., 2016. Emperical study on customer satisfaction in public sector and private sector banks in India. Asian Journal of Management Sciences & Education, 5(1), pp.18-26.

Barrick, M.R. and Mount, M.K., 1991, “The big five personality dimensions and job performance: a meta-analysis”, Personnel Psychology, Vol. 44 No. 1, pp. 1-26.

Barrick, M.R., Stewart, G.L., Neubert, M.J. and Mount, M.K., 1998, “Relating member ability and personality to work-team processes and team effectiveness”, Journal of Applied Psychology, Vol. 83 No. 3, pp. 377-391.

Barry, B. and Stewart, G.L., 1997, “Composition, process, and performance in self-managed groups: the role of personality”, Journal of Applied Psychology, Vol. 82 No. 1, pp. 62-78.

Baruch, Y. & Holtom, B.C., 2008. Survey response rate levels and trends in organizational research. Human Relations, 61(8), pp.1139–1160.

Basu, R. 2004, “Six-sigma to operational excellence: role of tools and techniques”, International Journal of Six Sigma and Competitive Advantage, Vol. 1 No. 1, pp. 44-64.

Baty, P., Standing Still is not an option, The Times World University Rankings 2016-2017, Published by Time Higher Education

Beal, D.J., Cohen, R.R., Burke, M.J. and McLendon, C.L., 2003, “Cohesion and performance in groups: a meta-analytic clarification of construct relations”, Journal of Applied Psychology, Vol. 88 No. 6, pp. 989-1004.

Bell, S.T., 2007, “Deep-level composition variables as predictors of team performance: a meta-analysis”, Journal of Applied Psychology, Vol. 92 No. 3, pp. 595-615.

Ben Romdhane, T., Badreddine, A. and Sansa, M., 2017. “A new model to implement Six Sigma in small - and medium-sized enterprises”, International Journal of Production Research, Vol. 55 No. 15, pp. 4319-4340.

Ben-David, J. and Zloczower, A., 1962. Universities and academic systems in modern societies. European Journal of Sociology/Archives Européennes de Sociologie/Europäisches Archiv für Soziologie, 3(1), pp.45-84.

Bennis W., Thomas R.J., 2002. Crucibles of leadership. Harvard Business Review. Vol. 80(9). pp. 39-45, 2002

Bhasin, S., 2011. ‘Measuring the Leanness of an organisation’, International journal of Lean six sigma. Bingley: Emerald, 2(1), pp. 55–74. doi: 10.1108/20401461111119459.

Bhatnagar, J. and Pandey, A., 2005, “HR metrics: HR Six Sigma in Indian organizations”, Management and Labour Studies, Vol. 30 No. 4, pp. 327-354.

Bhatt, G.D., 2001. Knowledge management in organizations: examining the interaction between technologies, techniques, and people. Journal of knowledge management.

Bhattacherjee, A. 2012. Social science research. USF Tampa Bay: Open University Press, pp.103 -111.

Bhattacherjee, A., 2012. Social Science Research: Principles, Methods, and Practices.

Biberoglu, E., & Haddad, H. 2002. A survey of industrial experiences with CMM and the teaching of CMM practices. Journal of Computing Sciences in Colleges, 18(2), 143–152.

Biedry, J., 2001, “Linking Six Sigma with human creativity”, Journal for Quality and Participation, Vol. 24 No. 4, pp. 36-38.

Black, K. and McGlashan, R., 2006, “Essential characteristics of Six Sigma black belt candidates: a study of US companies”, International Journal of Six Sigma and Competitive Advantage, Vol. 2 No. 3, pp. 301-312.

Bolden R., Gosling J., Peters K., Ryam M., 2012. Academic Leadership: changing conceptions, identities and experiences in UK higher education. Leadership Foundation for Higher Education, Series 3 Publication 4, 2012

Boone, C., Van Olffen, W. and Van Witteloostuijn, A., 2005, “Team locus-of-control composition, leadership structure, information acquisition, and financial performance: a business simulation study”, Academy of Management Journal, Vol. 48 No. 5, pp. 889-909.

Bosch, Van den A Menno D. T. de Jong Wim J. L. Elving, 2011. Managing corporate Visual identify, Exploring the Differences Between Manufacturing and Service, and Profit-Making and Non-profit Organizations Journal of Business Communication, Volume 43, Number 2, April 2006 138-157 DOI: 10.1177/0021943605285476, downloaded from job.sagepub.com at SAGE Publications on February 15, 2011

Bothwell E., 2020. THE Impact Rankings 2020 – methodology, https://www.timeshighereducation.com/university-impact-rankings-2020-methodology

Boudreau, J., Hopp, W., McClain, J.O. and Thomas, L.J., 2003, “On the interface between operations and human resources management”, Manufacturing & Service Operations Management, Vol. 5 No. 3, pp. 179-202.

Bowden, A ; Fox - Rushby, Ja ; Nyandieka, L ; Wanjau, J., 2002. Methods for pre-testing and piloting survey questions: illustrations from the KENQOL survey of health-related quality of life. Health Policy and Planning, 17(3), pp.322–330.

Box, T. 2006. Six Sigma quality: Experiential learning. S.A.M. Advanced Management Journal, 71 (1), 20–23.

Boynton, A.C. and Zmud, R.W., 1984. “An assessment of critical success factors”, Sloan Management Review, Vol. 25 No. 4, pp. 17-27.

Brady, J.E. and Allen, T.T., 2006, “Six sigma literature: a review and agenda for future research”, Quality and Reliability Engineering International, Vol. 22 No. 3, pp. 335-367.

Bramwell, D., 2016, Interview with the president of Promontory Management Group (PMG), an international Six Sigma consultancy (Layton, UT, USA). This interview elicited details about these PMG Six Sigma projects over the last eight years: an engagement to improve coordination with vendors at Areva (Saved $76,000 in one month, Richland, WA, USA); an engagement to reduce sample collection times for health physicists at Washington Hanford Closue (saved $742,000 Richland, WA, USA); an engagement to improved reaction speed to order mix changes at Sandvik specialty Metals (reduced throughput coefficient of variation for titanium rod pilgering line by 24%, Finley, WA, USA); an engagement to reduce resolution time for credit card fraud at Gesa Federal Credit Union (reduced by 52%, Richland, WA, USA); an engagement to reduce inventories at Areva (Richland, WA, USA); an engagement to improve patient flow time at Grace Medical Clinic (reduced by 17.5%, Kennewick, WA, USA); an engagement to increase returns on the 755 Personality characteristics and Six Sigma Downloaded by University of Nebraska at Omaha, Doctor Phillip Witt At 13:42 05 March 2018 (PT) disposition of spare parts at Areva (Richland, WA); an engagement to determine if a large purchasing cost variance from one year to the next was legitimate and replicable at Areva (it was determined that this variance was due to inconsistent protocol in interacting with databases: the problem was fixed, Richland, WA, USA).

Breakwell G.M. and Tytherleigh M.Y., 2008. The Characteristics, Roles and Selection of Vice-Chancellors. Final Report. Leadership Foundation for Higher Education, 2008

Breakwell, G. M., Hammond, S., Fife-Schaw, C., & Smith, J. A., 2004. Research methods in psychology, Sage Publications, Inc.

Brewer, P.C., 2004, “Six sigma helps a company create a culture of accountability”, Journal of Organizational Excellence, Vol. 23 No. 3, pp. 45-59.

Bruce, C.S., 1994. Research students' early experiences of the dissertation literature review. Studies in Higher Education, 19(2), pp.217-229.

Brun, A., 2011. Critical success factors of Six Sigma implementations in Italian companies. International Journal of Production Economics, 131(1), pp.158-164.

Bryman A., 2007. Barriers to integrating quantitative and qualitative research, Journal of Mixed Methods, Research, 1(1): 8-22, 2007

Bryman A., 2009. Effective leadership in higher education – final report, Leadership Foundation for Higher Education, May 2009

Bryman, A., 1989 Research Methods and Organisational Studies, Contemporary Social Research, 20, London Routledge

Buck, J.M. and Watson, J.L., 2002. Retaining staff employees: The relationship between human resources management strategies and organizational commitment. Innovative higher education, 26(3), pp.175-193.

Burnard, P., 1991. A method of analysing interview transcripts in qualitative research. Nurse education today, 11(6), pp.461-466.

Burnard, P., Gill, P., Stewart, K., Treasure, E. and Chadwick, B., 2008. Analysing and presenting qualitative data. British dental journal, 204(8), pp.429-432.

Byrne, G., 2003, "Ensuring optimal success with Six Sigma implementations", Journal of Organizational Excellence, Vol. 22 No. 2, pp. 43-50.

Campatelli, G., Citti, P. and Meneghin, A., 2011. Development of a simplified approach based on the EFQM model and Six Sigma for the implementation of TQM principles in a university administration. Total Quality Management & Business Excellence, 22(7), pp.691-704.

Carvalho, C., Lopes, M., Ramos, A., Avila, P., Bastos, J., Fonseca, L., & Martens, I., 2013. Lean learning academy: An innovative framework for lean manufacturing training. 1st international conference of the Portuguese Society for Engineering Education (CISPEE), IEEE, Porto, pp. 1–4.

Caulcutt, R. 2001, "Why is Six Sigma so successful?", Journal of Applied Statistics, Vol. 28 Nos 3-4, pp. 301-306.

Chakravorty, S.S., 2009. "Six Sigma programs: an implementation model", International Journal of Production Economics, Vol. 119 No. 1, pp. 1-16

Chakravorty, S.S., 2010, "Where process-improvement projects go wrong", Wall Street Journal, Vol. 255 No. 19.

Charan, R., (2006), "Home depot's blueprint for culture change", Harvard Business Review, Vol. 84 No. 4, pp. 60-70.

Chaudhuri, A. and Stenger, H., 2005. Survey sampling: theory and methods. CRC Press

Chemers, M.M., Watson, C.B. and May, S.T., 2000, "Dispositional affect and leader effectiveness: a comparison of self-esteem, optimism, and efficacy", Personality and Social Psychology, Vol. 26 No. 3, pp. 267-277.

Chen MingNan, Lyu JrJung, 2009. A Lean Six Sigma approach to touch panel quality improvement, Production Planning and Control Journal, Vol 20, No5, July 2009, pp 445-454

Chen, D.Q., Preston, D.S. and Xia, W., 2010. Antecedents and effects of CIO supply-side and demand-side leadership: A staged maturity model. Journal of Management Information Systems, 27(1), pp.231-272.

Cheng, M.Y., Ho, J.S.Y. and Lau, P.M., 2009. Knowledge sharing in academic institutions: A study of Multimedia University Malaysia. Electronic Journal of Knowledge Management, 7(3).

Cho, J.H., Lee, J.H., Ahn, D.G. and Jang, J.S., 2011, “Selection of Six Sigma key ingredients (KIs) in Korean companies”, The TQM Journal, Vol. 23 No. 6, pp. 611-628.

Choo, A.S., Linderman, K.W. and Schroeder, R.G., 2007, “Method and context perspectives on learning and knowledge creation in quality management”, Journal of Operations Management,

Chua, W.F., 1986. Radical developments in accounting thought. Accounting review, pp.601-632.

Cima R., Brown M. J., Hebl J.R.., Moore R., Rogers J. C., Kollengode A., Amstutz G. J., Weisbrod C. A., Narr B. J., Deschamps C., 2011. Use of Lean and Six Sigma Methodology to Improve Operating Room Efficiency in a High-Volume Tertiary-Care Academic Medical Center Journal of the American College of Surgeons, Volume 213, Issue 1, July 2011, Pages 83-92

Clark, B.R., 1987. The Academic Life. Small Worlds, Different Worlds. A Carnegie Foundation Special Report. Princeton University Press, 3175 Princeton Pike, Lawrenceville, NJ 08648.

Clark, B.R., 2003. Sustaining change in universities: Continuities in case studies and concepts. Tertiary education and management, 9(2), pp.99-116.

Coccari, R.L. and Javalgi, R.G., 1995. Analysis of students' needs in selecting a college or university in a changing environment. Journal of Marketing for HIGHER EDUCATION, 6(2), pp.27-40.

Cojocar, B., 2009. Adaptive Leadership: Leadership Theory or Theoretical Derivative?, Academic leadership: The online journal, 7(1), p.5.

Colbert, A.E., Judge, T.A., Choi, D. and Wang, G. 2012, “Assessing the trait theory of leadership using self and observer ratings of personality: the mediating role of contributions to group success”,

Collins J., 2001. Level 5 Leadership, The Triumph of Humility and Fierce Resolve: Harvard Business Review 2001

Collis, J. & Hussey, R., 2003 Business Research. A Practical Guide for Undergraduate and Graduate Students 2nd edition, Palgrave Macmillan

Comm, C. L., & Mathaisel, D., 2005. A case study in applying lean sustainability concepts to universities. International Journal of Sustainability in Higher Education, 6(2), 134–146.

Coronado, BR and Antony, J., 2002. Critical success factors for the successful implementation of Six Sigma projects in organisations, TQM magazine. Emerald, 14(2), pp. 92–99.

Cortina, J., 1993, What Is Coefficient Alpha? An Examination of Theory and Applications, Journal of Applied Psychology Vol. 78, Iss. 1, (Feb 1993): 98-104

Coughlan, M., Cronin, P. and Ryan, F., 2007. Step-by-step guide to critiquing research. Part 1: quantitative research. British journal of nursing, 16(11), pp.658-663.

Craven, E.D., Clark, J., Cramer, M., Corwin, S.J. and Cooper, M.R., 2006, "New York-presbyterian hospital uses Six Sigma to build a culture of quality and innovation", Journal of Organizational Excellence, Vol. 25 No. 4, pp. 11-19.

Crom S., 2010, Leadership and Lean Six Sigma opens doors to innovation: February 2010, www.isixsigma.com

Cronbach, L.J., 1951. Coefficient alpha and the internal structure of tests. psychometrika, 16(3), pp.297-334.

Cronemyr, P., 2007, "DMAIC and DMADV – differences, similarities and synergies", International Journal of Six Sigma and Competitive Advantage, Vol. 3 No. 3, pp. 193-209.

Crosby, P. B. (1980). Quality is free: the art of making quality certain. New York: New American Library.

Cudney, E., & Elrod, C., 2011. A comparative analysis of integrating lean concepts into supply chain management in manufacturing and service industries. International Journal of Lean Six Sigma,2(1), 5–22.

Cudney, E., & Kanigolla, D., 2014. Measuring the impact of project-based learning in Six Sigma education. Journal of Enterprise Transformation, 4(3), 272–288.

Cudney, E., Elrod, C., & Stanley, S., 2014. A systematic literature review of Six Sigma practices in education. International Journal of Six Sigma and Competitive Advantage, 8(3/4), 163–175.

Cudney, E., Furterer, S., & Dietrich, D. 2013. Lean systems: Applications and case studies in manufacturing, service, and healthcare. New York, NY: CRC Press.

Cudney, E., Venuthurumilli, S., Materla, T., Antony, J., 2020. Systematic review of Lean and Six Sigma approaches in higher education. Total Quality Management & Business Excellence, 31(3-4), pp.231–244.

Cunningham, J., 1997. Case study principles for different types of cases. Quality and Quantity, 31(4), pp.401–423.

Cusumano, M.A., 1994. The limits of "Lean". Sloan management review, 35, pp.27-27.

Dahlgaard, Jens J & Mi Dahlgaard-Park, Su, 2006. Lean production, Six Sigma quality, TQM and company culture. TQM magazine, 18(3), pp.263–281.

Daniel, B., 2015. Big Data and analytics in higher education: Opportunities and challenges. British journal of educational technology, 46(5), pp.904-920.

Das, S.K. and Sahoo, P., 2010. Wear performance optimization of electroless Ni-B coating using Taguchi design of experiments. Tribology in industry, 32(4), pp.17-27.

Daumiller, M., Stupnisky, R. and Janke, S., 2020. Motivation of higher education faculty: Theoretical approaches, empirical evidence, and future directions. International Journal of Educational Research, 99, p.101502.

Davison, L. and Al-Shaghana, K., 2007, “The link between Six Sigma and quality culture – an empirical study”, Total Quality Management & Business Excellence, Vol. 18 No. 3, pp. 249-265.

De Bruin, T., Rosemann, M., Freeze, R. and Kaulkarni, U., 2005. Understanding the main phases of developing a maturity assessment model. In Australasian Conference on Information Systems (ACIS): (pp. 8-19). Australasian Chapter of the Association for Information Systems.

De Hoyos, M. and Barnes, S.A., 2012. Analysing interview data. Warwick Institute for employment research.

De Mast, J., 2006, “Six sigma and competitive advantage”, Total Quality Management & Business Excellence, Vol. 17 No. 4, pp. 455-464.

Dean, J.W. Jr and Bowen, D.E., 1994, “Management theory and total quality: improving research and practice through theory development”, The Academy of Management Review, Vol. 19 No. 3,pp. 392-418.

DeFeo, J.A., 2000, “Six sigma: new opportunities for HR, new career growth for employees”, Employment Relations Today, Vol. 27 No. 2, pp. 1-6.

Detert, J.R., Schroeder, R.G. and Mauriel, J.J., 2000, “A framework for linking culture and improvement initiatives in organizations”, Academy of Management Review, Vol. 25 No. 4, pp. 850-863. 756 IJQRM 35,3 Downloaded by University of Nebraska at Omaha, Doctor Phillip Witt At 13:42 05 March 2018 (PT)

Dey, E, 1997, Working with low survey response rates: The Efficacy of Weighting Adjustments Research in Higher Education, Vol. 38. No. 2.

Dijkman, R., Lammers, S. V., & de Jong, A. (2015). Properties that influence business process management maturity and its effect on organizational performance, Information Systems Frontiers, 1-18. DOI 10.1007/s10796-015-9554-5

Djokovic, D. and Souitaris, V., 2008. Spinouts from academic institutions: a literature review with suggestions for further research. The journal of technology transfer, 33(3), pp.225-247.

Doman, M. S., 2011. A new lean paradigm in higher education: A case study. Quality Assurance in Education, 19(3), 248–262.

Douglas J., Muturi D., Douglaa A., Ochieng J., 2017. The role of organisational climate in readiness for change to Lean Six Sigma. The TQM Journal, 29(5), pp.666–676.

Douglas, J. A., Antony, J., & Douglas, A., 2015. Waste identification and elimination in HEIs: The role of Lean thinking. International Journal of Quality & Reliability Management, 32(9), 970–981.

Drucker P. F., 1955. The practice of management, 1955, Pam books limited

Drucker P.F., 2004. What makes an effective executive?, Harvard Business Review. Vol. 82 (6). pp. 58-63, 2004

Duarte, D. and Martins, P.V., 2013. A maturity model for higher education institutions. Journal of Spatial and Organizational Dynamics, 1(1), pp.25-44.

Duderstadt, J.J., 1999. New roles for the 21st-century university. Issues in Science and Technology, 16(2), pp.37-44.

Dudovskiy, J., 2018. Exploratory Research - Research-Methodology. Available at: https://research- 31 methodology.net/research-methodology/research-design/exploratoryresearch/ [Accessed 1 Jun. 2018].

Earthy, J., 1997. Usability Maturity Model: Processes. Final Deliverable (Version 0.2). Lloyd’s Register, London

Easton, G.S., and Rosenzweig E.D., 2012. ‘The role of experience in Six Sigma project success: An empirical analysis of improvement projects’, Journal of operations management. Wiley, 30(7-8), pp. 481–493. doi: 10.1016/j.jom.2012.08.002.

Eckes, G., 2001, Making Six Sigma Last: Managing Cultural and Technical Change, Wiley,New York, NY.

Edmondson, A., 1999, “Psychological safety and learning behavior in work teams”, AdministrativeScience Quarterly, Vol. 44 No. 2, pp. 350-383.

Edwards, J.E. and Thomas, M.D., 1993. The organizational survey process: General steps and practical considerations. American Behavioral Scientist, 36(4), pp.419-442.

Eisenhardt K., Building Theories from Case Study Research. The Academy of Management Reviewm Vol. 14, No. 4 (Oct., 1989), pp. 532-550

Eisenhardt K., Graebner M. E., Theory building from cases: opportunities and challenges, Academy of Management Journal 2007, Vol. 50, No. 1, 25–32.

Eisenhardt, Kathleen M., 1989 Building Theories from Case Study Research, Academy of Management Review, Oct 1989, 14, 4, pg 532

Eisenhardt, Kathleen M., Graebner Melissa E 2007 Theory Building From Case Studies: Opportunities and Challenges, Academy of Management Journal, 2007, Vol 50 No.1 25-32

Emiliani M.L., Emiliani Michael, 2013, Music as a framework to better understand lean leadership: No407, Leadership and Organisational Development Journal, Vol 34, No. 5 2013, Emerald Group Publishing Limited (2002) Lean Six Sigma – Combining Six Sigma quality with lean speed, McGraw–Hill, 1st Edition, April 25th 2002

Emiliani, Bob 2005 Lean in higher education, Publish date: February 2005, Superfactory, www.superfactory.com

Emiliani, M. L., 2004. Improving business school courses by applying Lean principles and practices. Quality Assurance in Education, 12(4), 175–187.

Emiliani, M. L., 2005. Using kaizen to improve graduate business school degree programs. Quality Assurance in Education, 13(1), 37–52.

Estrada, A.; Sinn, J. W,. 2012 The Audit Answer How one university leveraged lean Six Sigma and the DMAIC method to develop an audit system that improved a statewide quality program QUALITY PROGRESS; 2012, 45(6):36-43,

Evans, E., Burritt, R. and Guthrie, J., 2011. Bridging the gap between academic accounting research and professional practice. Institute of Chartered Accountants in Australia.

Felch, V., Asdecker, B. and Sucky, E., 2019. Maturity models in the age of Industry 4.0–Do the available models correspond to the needs of business practice?

Fernandes, M.M., Hurst, J., Antony, J., Turrioni, J.B. & Silva, M.B., 2019, 18 Steps To Six Sigma Project Success, American Society for Quality, Milwaukee

Fernando J & Oliveira, O., 2019. Synergies between critical success factors of Lean Six Sigma and public values. Total Quality Management & Business Excellence, 30(15-16), pp.1563–1577.

Fisher, D.M., 2004. The business process maturity model: a practical approach for identifying opportunities for optimization. Business Process Trends, 9(4), pp.11-15.

Fornari, A. and Maszle, G., 2004, August. Lean Six Sigma leads xerox. In *Six Sigma Forum Magazine* (Vol. 3, No. 4, pp. 11-16).

Freiesleben, J., 2007, “Can Six Sigma claim to be a generic strategy? Reassessing the competitive implications of quality improvement”, International Journal of Six Sigma and Competitive Advantage, Vol. 3 No. 3, pp. 248-265.

Fuller, H.T., 2000, “Observations about the success and evolution of Six Sigma at seagate”, Quality Engineering, Vol. 12 No. 3, pp. 311-315.

Galli, B.J. and Kaviani, M.A., 2018. The impacts of risk on deploying and sustaining Lean Six Sigma initiatives. International Journal of Risk and Contingency Management (IJRCM), 7(1), pp.46-70

García, J., Rivera, D. and Iniesta, A., 2013, “Critical success factors for Kaizen implementation in manufacturing industries in Mexico”, International Journal of Advanced Manufacturing Technology, Vol. 68 Nos 1/4, pp. 537-545

Garkaz, M., Banimahd, B. and Esmaeili, H., 2011. Factors affecting accounting students’ performance: The case of students at the Islamic Azad University. Procedia-Social and Behavioral Sciences, 29, pp.122-128.

George B., Sims P., McLean A., Mayer D., 2007 “Discovering Your Authentic Leadership.” Harvard Business Review. Vol. 85(2). pp. 129-138, 2007

George, M.L., 2003. Lean Six Sigma for service: New York, N.Y.: McGraw-Hill

Gerring, J. and Seawright, J., 2007 ‘Techniques for choosing cases’ in Gerring, J (ed) Case Study Research: Principles and Practices. New York: Cambridge University Press, pp. 86-150.

Gibbs G. Knapper C., Piccinin S., “Departmental leadership of teaching in research-intensive environments. Final Report.” Research & Development Series. Leadership Foundation for Higher Education, London, 2009

Gijo, E.V. and Rao, T.S., 2005, “Six sigma implementation – hurdles and more hurdles”, Total Quality Management & Business Excellence, Vol. 16 No. 6, pp. 721-725.

Gill, J. and Johnson, P., 1997 Research methods for managers, Paul Chapman Publishing Ltd, London.

Given, Lisa M., 2008. The Sage encyclopaedia of qualitative research methods. Los Angeles, Sage Publications. ISBN 1-4129-4163-6.

Glaser, B.G. & Strauss, A.L., 2012, The Discovery of Grounded Theory: Strategies for Qualitative Research, Aldine Transaction

Glasgow, J.M., Caziewell, S., Jill, R. and Kaboli, P.J. 2010, “Guiding inpatient quality improvement: a systematic review of lean and Six Sigma”, Joint Commission Journal on Quality and Patient Safety, Vol. 36 No. 12, pp. 533-540

Godfrey Blanton, Fornari Arthur, Maszle George, 2004, Lean Six Sigma Leads Xerox, Six Sigma Forum Magazine, August 2004

Goffee R., Jones G., 2006 “Why should anyone be led by you? What it takes to be an authentic leader.” Harvard Business Press, 2006

Goleman D., 1996 “Emotional Intelligence: Why it can matter more than IQ.” Bloomsbury Publishing. London, 1996

Goleman D., 2004 What makes a leader?, January 2004 Harvard Business Review

Goodhall A., 2009 “Socrates in the boardroom: why research universities should be led by top scholars.” Princeton University Press, Princeton, NY.2009

Goransson, B. and Brundenius, C., 2011. Universities in transition. The Changing Role and Challenges for Academic Institutions. Ottawa: Springer.

Graeff, C.L., 1997. Evolution of situational leadership theory: A critical review. The Leadership Quarterly, 8(2), pp.153-170.

Graneheim, U.H., Lindgren, B.M. and Lundman, B., 2017. Methodological challenges in qualitative content analysis: A discussion paper. Nurse education today, 56, pp.29-34.

Griffin, B. and Hesketh, B., 2004, “Why openness to experience is not a good predictor of job performance”, International Journal of Selection & Assessment, Vol. 12 No. 3, pp. 243-251.

Guba, E.G. and Lincoln, Y.S., 1994. Competing paradigms in qualitative research. Handbook of qualitative research, 2(163-194), p.105.

Gubrium, J.F. and Holstein, J.A., 2008. Narrative ethnography. Handbook of emergent methods, pp.241-264.

Gupta, S.K., Antony, J., Lacher, F. and Douglas, J., 2020. Lean Six Sigma for reducing student dropouts in higher education–an exploratory study. Total Quality Management & Business Excellence, 31(1-2), pp.178-193.

Gustavsson, B. and Bäccman, C., 2005, “Team-personality: how to use relevant measurements to predict team-performance”, paper presented at the 47th International Military Testing Association, November 8-10, Singapore.

Gutiérrez Gutiérrez, L.J., Lloréns-Montes, F.J. and Bustinza Sánchez, Ó.F., 2009, “Six sigma: from a goal-theoretic perspective to shared-vision development”, International Journal of Operations & Production Management, Vol. 29 No. 2, pp. 151-169.

Hach, A. B., 2009 ‘Leading the way: while technical skills are important, those driving a lean Six Sigma implementation need to possess strong leadership skills as well’, Quality (Wheaton). BNP Media, 48(9), p. 48.

Hadid, W. and Mansouri, S.A., 2014. The lean-performance relationship in services: a theoretical model. International Journal of Operations & Production Management.

Haerizadeh, M. & Sunder M, V., 2019. Impacts of Lean Six Sigma on improving a higher education system: a case study. International Journal of Quality & Reliability Management, 36(6), pp.983–998.

Hagen, M., 2010, “The wisdom of the coach: a review of managerial coaching in the Six Sigma context”, Total Quality Management & Business Excellence, Vol. 21 No. 8, pp. 791-798

Hahn, G.J., 2005, “Six Sigma: 20 key lessons learned”, Quality & Reliability Engineering International, Vol. 21 No. 3, pp. 225-233.

Hakim C., 2000 Research design: successful designs for social and economic research. Social research today. (2nd Re). Routledge, London, UK. ISBN 9780415223126

Hall Robert, 1983 Zero Inventories: McGraw-Hill; 1 edition August 1, 1983

Hammer, M., 2007. The process audit. Harvard business review, 85(4), p.111.

Hanaysha, J.R. and Majid, M., 2018. Employee motivation and its role in improving the productivity and organizational commitment at higher education institutions. Journal of Entrepreneurship and Business, 6(1), pp.17-28.

Harrison, D.A., Price, K.H., Gavin, J.H. and Florey, A.T. 2002, “Time, teams, and task performance: changing effects of surface- and deep-level diversity on group functioning”, The Academy of Management Journal, Vol. 45 No. 5, pp. 1029-1045.

Harry M. and Crawford D., 2005 Six Sig – The next generation, Machine Design, February 17th 2005

Harry, M. J., and Crawford D., 2004. Six sigma for the little guy. Mechanical Engineering Magazine 126 (11): 8–1

Harvey-Jones, J., 1988 Making it happen, reflections of leadership, 1988, Harper Collings publications

Haskins, C.H., 1923. European History and American Scholarship. *The American Historical Review*, *28*(2), pp.215-227.

HBR Podcast: 3rd January 2013, Jeff Bezos, CEO Amazon, HBR Pod cast number 333

HBR Podcast: Ernest Shackleton's lessons for leaders in harsh climates, Nancy Koehn, HBR Pod cast number 326 2012

He, Z., 2009. Learn something about your Six Sigma program's maturity. Quality progress, 15(August) 2007 pp.23-28.

Heifetz R.A., Laurie D.L., “The work of leadership.” Harvard Business Review. Vol. 75(1). pp. 124-134, 1997

Henderson, K.M. and Evans, J.R., 2000, “Successful implementation of six sigma: benchmarking general electric company”, Benchmarking: An International Journal, Vol. 7 No. 4, pp. 260-282.

Hensley, R.L. and Dobie, K., 2005, “Assessing readiness for Six Sigma in a service setting”, Managing Service Quality: An International Journal, Vol. 15 No. 1, pp. 82-101.

Herbsleb, J.D. and Goldenson, D.R., 1996, March. A systematic survey of CMM experience and results. In Proceedings of IEEE 18th International Conference on Software Engineering (pp. 323-330). IEEE.

Hersey, P., & Blanchard, K. H., 1977 Management of organization behavior: Utilizing human resources. 3rd ed. Englewood Cliffs, N. J.: Prentice Hall, Inc. 1977.

Hersh, R.H. and Merrow, J., 2015. Declining by degrees: Higher education at risk. St. Martin's Press.

Hess, James D. & Benjamin, Bruce A., 2015. Applying Lean Six Sigma within the university: opportunities for process improvement and cultural change. International Journal of Lean Six Sigma, 6(3), pp.249–262.

Heuve Jaap van den, Does Ronald J.M.M, Verver John P.S., 2005 Six Sigma in healthcare: lessons learned from a hospital, Int. J. Six Sigma and Competitive Advantage, Vol. 1, No. 4, 2005

Heuvel Jaap van den, Does Ronald, Bisgaard Soren 2006 Six Sigma forum magazine, February 2008

Hill, W., Breyfogle, F., Enck, D., Meadows, B. and Bailey, S., 2001, “Six sigma black belts: what do they need to know?”, Journal of Quality Technology, Vol. 33 No. 4, pp. 391-435.

Hilton, R. J. H., and A. Sohal, 2012. A conceptual model for the successful deployment of Lean Six Sigma. International Journal of Quality & Reliability Management 29, no. 1:54-70

Hilton, R., Balla, M. and Sohal, A.S., 2008, “Factors critical to the success of a six-sigma quality program in an Australian hospital”, Total Quality Management & Business Excellence, Vol. 19 No. 9, pp. 887-902.

Hilton, R.J. and Sohal, A., 2012, “A conceptual model for the successful deployment of lean six sigma”, International Journal of Quality and Reliability Management, Vol. 29 No. 1, pp. 54-70.

Hines Peter, Holweg Matthias, Rich Nick 2004 Learning to evolve: A review of contemporary lean thinking, Internaitonal Journal of Operations and Production Management, Vol 24 No 10, 2004, pp 994-1011

Hines, P., & Lethbridge, S., 2008. New development: Creating a Lean university. Public Money and Management, 28(1), 53–56.

Hines, P., Taylor D., & Walsh, Aidan. 2018. The Lean journey: have we got it wrong? Total Quality Management & Business Excellence. 10.1080/14783363.2018.1429258.

Ho, S. K., & Wearn, K., 1995. A TQM model for higher education and training. Training for Quality, 3(2), 25–33.

Hoerl Roger, 2004 What influence is the Six Sigma movement having on universities? What influence should it be having? ASQ Six Sigma Forum Magazine, Feb 2004; 3,2, pp 37-40

Hoerl, R., Montgomery, D., Lawson, C., Molnau, W., Elias, R., Abraham, B., MacKay, J., Snee, R., Pyzdek, T.,Hogan, R., Curphy, G.J. and Hogan, J., 1994, "What we know about leadership: effectiveness and personality", American Psychologist, Vol. 49 No. 6, pp. 493-504.

Holden, Richard, 2011 Lean Thinking in emergency Departments: A critical review, Annals of emergency Medicine, Vol 57 No3 March 2011

Holweg Matthias, 2006 The genealogy of Lean production, Journal of operations management, 25, (2007) 420-437

Hopen, D., & Cudney, E., 2016. Educator's world: Fostering individual, organizational, and societal success. Journal of Quality and Participation, 39(1), 13–16.

Howell, M.C. and Prevenier, W., 2001. From reliable sources: An introduction to historical methods. Cornell University Press.

Hox, J.J. & Boeije, H.R., 2005. Data collection, primary versus secondary. In p. 593.

Huq, Z., 2006, "Six-sigma implementation through competency based perspective (CBP)", Journal of Change Management, Vol. 6 No. 3, pp. 277-289.

Immaneni, A., McCombs, A., Cheatham, G. and Andrews, R., 2007, "Capital one banks on Six Sigma for strategy execution and culture transformation", Global Business & Organizational Excellence, Vol. 26 No. 6, pp. 43-54.

Ingle, S. and Roe, W., 2001, "Six sigma black belt implementation", The TQM Magazine, Vol. 13 No. 4, pp. 273-280. 757 Personality characteristics and Six Sigma Downloaded by University of Nebraska at Omaha, Doctor Phillip Witt At 13:42 05 March 2018 (PT)

Isa, M.F.M. & Usmen, M., 2015. Improving university facilities services using Lean Six Sigma: a case study. Journal of Facilities Management, 13(1), pp.70–84

Ismyrlis, V. and Moschidis, O., 2013, "Six sigma's critical success factors and toolbox", International Journal of Lean Six Sigma, Vol. 4 No. 2, pp. 108-117.

Ivankova, N. and Wingo, 2018. Applying Mixed Methods in Action Research: Methodological Potentials and Advantages. American Behavioral Scientist, 62(7), pp.978–997.

Jackson, S.L., 2011. Research methods. Wadsworth/Cengage Learning, Jacobs, B.W., Swink, M. and Linderman, K., 2015, “Performance effects of early and late Six Sigma adoptions”, Journal of Operations Management, Vol. 36, pp. 244-257.

Jagdeep Singh & Harwinder Singh, 2013, Continuous Improvement Strategies: An Overview. ICFAI journal of operations management, 12(1), p.32.

Jain, P., 2011, New trends and future applications/directions of institutional repositories in academic institutions. Library Review.

Janin, H., 2014. The university in medieval life, 1179-1499. McFarland.

Jason Seawright & John Gerring, 2008. Case Selection Techniques in Case Study Research: A Menu of Qualitative and Quantitative Options. Political Research Quarterly, 61(2), pp.294–308.

Jenab, K, Wu, C and Moslehpour, S., 2018 ‘Design for six sigma: A review’, Management science letters. Growing Science, 8(1), pp. 1–18. doi: 10.5267/j.msl.2017.11.001.

Jenicke Lawrence, Kumar Anil, Holmes Monica, 2008, A framework for applying Six Sigma improvement methodology in an academic environment, The TQM journal, Vol 20, No5, 2008, pp 453-462

Jesson, J., Matheson, L. and Lacey, F.M., 2011. Doing your literature review: Traditional and systematic techniques. Sage.

Jeyaraman, K. and Teo, L.K., 2010, “A conceptual framework for critical success factors of Lean Six Sigma”, International Journal of Lean Six Sigma, Vol. 1 No. 3, pp. 191-215

Johannsen, F., Leist, S. and Zellner, G., 2011, “Six sigma as a business process management method in services: analysis of the key application problems”, Information Systems and E-Business Management, Vol. 9 No. 3, pp. 307-332.

John, O.P., Donahue, E.M. and Kentle, R.L., 1991, The Big Five Inventory – Versions 4a and 54, University of California, Berkeley, Institute of Personality and Social Research, Berkeley, CA.

John, O.P., Naumann, L.P. and Soto, C.J., 2008, “Paradigm shift to the integrative big-five trait taxonomy: history, measurement, and conceptual issues”, in John, O.P., Robins, R.W. and Pervin, L.A. (Eds), Handbook of Personality: Theory and Research, Guilford Press, New York, NY, pp. 114-158.

Johnson, A., 2006, “Lessons learned from Six Sigma in R&D”, Research Technology Management, Vol. 49 No. 2, pp. 15-19.

Johnson, P. and Clark, M. eds., 2006. Business and management research methodologies. Sage.

Johnson, T. and Owens, L., 2003, May. Survey response rate reporting in the professional literature. In 58th Annual Meeting of the American Association for Public Opinion Research, Nashville

Jones G., 2011 “Academic leadership and departmental headship in turbulent times.” Tertiary Education and Management. Vol. 17(4), pp. 279-288, 2011

Jones G., 2013 “The horizontal and vertical fragmentation of academic work and the challenge for academic government and leadership”, Asia Pacific Educational Review, Vol 14, No1, 2013 pp 75-83, 2013

Joshi, A, Kale, S., Chandel, S., and Pal, D., 2015. "Likert scale: Explored and explained." British Journal of Applied Science & Technology 7.4: 396.

Joyce P., O’Boyle C., 2013 “Sustaining academic leadership in higher education,” Institute of Leadership Articles, Royal College of Surgeons in Ireland, 1-5, 2013

Judge, T.A., Ilies, R., Bono, J.E. and Gerhardt, M.W., 2002, “Personality and leadership: a qualitative and quantitative review”, Journal of Applied Psychology, Vol. 87 No. 4, pp. 765-780.

Kajornboon, A.B., 2005. Using interviews as research instruments. E-journal for Research Teachers, 2(1), pp.1-9.

Kanakana, G., Wyk, B., & Pretorius, J., 2015. Framework assessment for costs of poor quality in higher education processes. Proceedings of 2015 International Conference on Management of Engineering and Technology (PICMET ‘15), IEEE, Portland, OR, pp. 1133–1136.

Kaner, M. and Karni, R., 2004. A capability maturity model for knowledge-based decision making. Information Knowledge Systems Management, 4(4), pp.225-252.

Kanigolla, D., Cudney, E., & Corns, S., 2013. Employing project-based learning in Six Sigma education. The Journal for Quality and Participation, 36(1), 45–61.

Kanigolla, D., Cudney, E., Corns, S., & Samaranayake, V. A., 2014, Project based learning for and Six Sigma education. International Journal of Six Sigma and Competitive Advantage, 8(1), 51–68.

Kapoulas, A. and Mitic, M., 2012. Understanding challenges of qualitative research: Rhetorical issues and reality traps. Qualitative Market Research: An International Journal.

Karbasian, M. and Aghadaee, A., 2006, Six-Sigma and Quality Control Costs, Arkan Danesh, Tehran

Kempster Stephen, Parry Ken W, 2011 Grounded Theory and leadership research, a Critical Realist perspective, 2011, The Leadership Quarterly, 22, pp 106-120

Kh, A. (2018) ‘Measuring organizational culture: An empirical assessment of the hofstede questionnaire in a Mongolian setting’, Proceedings of the Mongolian Academy of Sciences. Mongolian Academy of Sciences, 58(1), pp. 140–159. doi: 10.5564/pmas.v58i1.979.

Khadijah Mohammed., Alotibie, B.A. and Abdulaziz, A., 2016. Total quality management in Saudi higher education. *International Journal of Computer Applications*, *135*(4), pp.6-12.

Khan, M.S., Al-Ashaab A., Shehab E., Haque B., Ewers P., Sorli M., Sopelana A,. 2013,“Towards Lean Product and Process Development.” International Journal of Computer Integrated Manufacturing 26 (12): 1105–1116

Kichuk, S.L. and Wiesner, W.H., 1997, “The big five personality factors and team performance: implications for selecting successful product design teams”, Journal of Engineering and Technology Management, Vol. 14 Nos 3-4, pp. 195-221.

Kichuk, S.L. and Wiesner, W.H., 1998, “Work teams: selecting members for optimal performance”, Canadian Psychology/Psychologie canadienne, Vol. 39 Nos 1-2, pp. 23-32.

Kickul, J. and Neuman, G., 2000, “Emergent leadership behaviors: the function of personality and cognitive ability in determining teamwork performance and KSAS”, Journal of Business & Psychology, Vol. 15 No. 1, pp. 27-51.

Kleasen, K., 2007, “Building human resources strategic planning, process and measurement capability: using Six Sigma as a foundation”, Organization Development Journal, Vol. 25 No. 2, pp. P37-P41.

Kleiner Art, 1996, The age of heretics, hero's, outlaws and the forerunners of corporate change: 1996, Nicholas Brealey Publishing

Knoster, T., 1991, Managing complex change. In Session presented at TASH Conference, November, Washington, DC.

Knox, S. and Burkard, A.W., 2009, Qualitative research interviews. Psychotherapy research, 19(4-5), pp.566-575.

Koning Hen de, Verver John, Heuvel Jaap van den, Bisgaard Soren, Does Ronal, 2006, Lean Six Sigma in Health Care, Journal of Health Care Quality, Vol28, No2, 2006, pp 4-11

Kosieradzka, A., 2017, Maturity model for production management. Procedia Engineering, 182, pp.342-349.

Kotter J, Cohen D, 2002, The heart of change, real life stories of how people change their organisations: 2002 Harvard Business School Press

Kotter, J.P., 1990, A force for change: how leadership differs from management, Free press publication. 1990

Kovach, J.V. and Ingle, D., 2020. An approach for identifying and selecting improvement projects. Total Quality Management & Business Excellence, 31(1-2), pp.149-160.

Kozlowski, S.W.J. and Ilgen, D.R., 2006, “Enhancing the effectiveness of work groups and teams”, Psychological Science in the Public Interest, Vol. 7 No. 3, pp. 77-124.

Krueger, R. and Casey, M.A., 2002. Focus group interviewing on the telephone.

Kubiak, 2011, 3.4 per million, the way to fail – how to unsuccessfully charter projects and miss expectations, Quality Progress, December 2011

Kumar, M. and Antony, J., 2008, Comparing the quality management practices in UK SMEs. Industrial Management & Data Systems.

Kumar, M., Antony, J., Madu, C.N., Montgomery, D.C. and Park, S.H., 2008, “Common myths of Six Sigma demystified”, International Journal of Quality & Reliability Management, Vol. 25 No. 8, pp. 878-895.

Kumar, N., Kumar, S., Haleem, A. and Gahlot, P., 2013. Implementing lean manufacturing system: ISM approach. Journal of Industrial Engineering and Management (JIEM), 6(4), pp.996-1012.

Kumar, S., Kumar, R.S. and PRABHU, M.G.N., 2020. SAMPLING FRAMEWORK FOR PERSONAL INTERVIEWS IN QUALITATIVE RESEARCH. PalArch's Journal of Archaeology of Egypt/Egyptology, 17(7), pp.7102-7114.

Kumi, S., & Morrow, J., 2006. Improving self service the Six Sigma way at Newcastle university library. Electronic Library and Information Systems, 40(2), 123–136.

Kurniawan Agung Widhi and Puspitaningtyas Zarah 2013 Leadership in higher education: academic leader or manager? Buletin Studi Ekonom, Vol 18, No. 1, February 2013. (PP 1-84)

Kuznets, S., 1965. Economic growth and structural change. Nueva York: Norton.

Kwak, Y.H. and Anbari, F.T., 2006, “Benefits, obstacles, and future of Six Sigma approach”, Technovation, Vol. 26 Nos 5-6, pp. 708-715.

Laing L., Laing, Gregory K., 2011 “The student as customer model and its impact on the academic leadership role in higher education,” ATN Assessment Conference, Meeting The Challenges, 2011

Lanyon, S., 2003, “At raytheon Six Sigma works, too, to improve HR management processes”, Journal of Organizational Excellence, Vol. 22 No. 4, pp. 29-42.

Laosirihongthong, T., Rahman, S.-U. and Saykhun, K., 2006, “Critical success factors of six-sigma implementation: an analytic hierarchy process based study”, International Journal of Innovation & Technology Management, Vol. 3 No. 3, pp. 303-319.

Laureani, A. and Antony, J., 2012, Standards for Lean Six Sigma certification. International Journal of Productivity and Performance Management.

Laureani, Alessandro & Antony, Jiju, 2018, Leadership - a critical success factor for the effective implementation of Lean Six Sigma. Total Quality Management & Business Excellence, 29(5-6), pp.502–523.

Lavy, S., Garcia, J.A. and Dixit, M.K., 2010. Establishment of KPIs for facility performance measurement: review of literature. Facilities.

Layer Brigadier General Brain, 2013, 10 ways to make each day a leadership masterpiece, 2013, Forbes

LePine, J.A. 2003, "Team adaptation and post change performance: effects of team composition in terms of members' cognitive ability and personality", Journal of Applied Psychology, Vol. 88 No. 1, pp. 27-39.

Lertwattanapongchai, S. and William Swierczek, F., 2014, "Assessing the change process of lean six sigma: a case analysis", International Journal of Lean Six Sigma, Vol. 5 No. 4, pp. 423-443.

Li T., and Lin L.C., 2011, A unified model for the implementation of both CMMI and 6σ, Total Quality Management & Business Excellence, 22:4, 407-424, DOI: 10.1080/14783363.2010.532318

Liker J, Morgan J, 2006, The Toyota way in services: the case of lean product development, Academy of management perspectives, May 2006 pp 5-20

Lin, L.-C., Li, T.-S. and Kiang, J.P., 2009, A continual improvement framework with integration of CMMI and six-sigma model for auto industry. Qual. Reliab. Engng. Int., 25: 551-569. doi:10.1002/qre.988

Lincoln, Y. S. and E. C. Guba 1985. Naturalistic Inquiry. Beverly Hills, CA: Sage.

Linden, B., 2008. Basic Blue Skies Research in the UK: Are we losing out?. Journal of Biomedical Discovery and Collaboration, 3(1), p.3.

Linderman, K., Schroeder, R.G. and Choo, A.S., 2006, "Six sigma: the role of goals in improvement teams", Journal of Operations Management, Vol. 24 No. 6, pp. 779-790.

Linderman, K., Schroeder, R.G., Zaheer, S. and Choo, A.S., 2003, "Six sigma: a goal-theoretic perspective", Journal of Operations Management, Vol. 21 No. 2, pp. 193-203. 758 IJQRM 35,3 Downloaded by University of Nebraska at Omaha, Doctor Phillip Witt At 13:42 05 March 2018 (PT)

Lockamy, 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.

Loethen Lori, 2008 Six Sigma and Leadership – there is a connection, Quality digest, online articles

Lu, J., Laux, C. & Antony, J., 2017. Lean Six Sigma leadership in higher education institutions. International Journal of Productivity and Performance Management, 66(5), pp.638–650.

Macfarlane, B., 2011 “Professors as intellectual leaders: formation, identity and role,” Studies in Higher Education, Vol. 36(1), pp. 57-73.

Madhavan, V. and Gurumurthy, A., 2019. Development of Lean Six Sigma training module: evidence from an emerging economy. International Journal of Quality & Reliability Management.

Maleyeff John, 2014, Sustaining Public Sector Lean Six Sigma: Perspectives from North America, Management and Organisational Studies, Vol 1 No2 2014, pp 92-99

Malmbrandt, M. and Åhlström, P., 2013. An instrument for assessing lean service adoption. International Journal of Operations & Production Management.

Manville G, Greatbanks R, Krishnasamy R, Parker D., 2012, ‘Critical success factors for Lean Six Sigma programmes: a view from middle management’ Emerald, Vol: 29 (1), pp: 7-20.

Marshall, B., P. Cardon, A. Poddar and R. Fontenot 2013. ‘Does sample size matter in qualitative research: a review of qualitative interviews in IS research’, Journal of Computer Information Systems, 54, pp. 11–22.

Marsick, V., and K. Watkins, 2003. “Demonstrating the Value of an Organization’s Learning Culture: the Dimensions of the Learning Organization Questionnaire.” Advances in Developing Human Resources 5 (2): 132–151

Martin Roger L., 2014, The Big Lie of Strategic Planning Harvard Business Review, January–February 2014 Issue

Martin Roger, 2007, How successful leaders think, , Harvard Business Review June 2007 Volume 85 No. 6

Martin, J.S. and Marion, R., 2005, “Higher education leadership roles in knowledge processing”, The Learning Organization, Vol. 12 No. 2, pp. 140-51.

Maslow, A.H., 1954, The instinctoid nature of basic needs. Journal of personality.

Mathieu, J., Maynard, M.T., Rapp, T. and Gilson, L., 2008, “Team effectiveness 1997-2007: a review of recent advancements and a glimpse into the future”, Journal of Management, Vol. 34 No. 3, pp. 410-476.

Mathieu, J.E., Tannenbaum, S.I., Donsbach, J.S. and Alliger, G.M., 2013, “A review and integration of team composition models: moving toward a dynamic and temporal framework”, Journal of Management, Vol. 40 No. 1, pp. 130-160.

Maxwell J and Chmiel M 2014. Analysing interviews. The SAGE handbook of qualitative data analysis, pp.297-312.

Mayo Anthony J, Nohria Nitin, 2005 In their time, the greatest business leaders of the twentieth

Mazumder Quamrul H., Applying Six Sigma in Higher Education Quality Improvement, 121st ASEE Annual conference, Indianapolis, paper id #8594, June 15th – 18th 2014,

McAdam, R. and Evans, A., 2004, “Challenges to Six Sigma in a high technology mass manufacturing environment”, Total Quality Management & Business Excellence, Vol. 15 Nos 5- 6, pp. 699-706.

McAdam, R. and Lafferty, B., 2004, “A multilevel case study critique of six sigma: statistical control or strategic change?”, International Journal of Operations & Production Management, Vol. 24 No. 5, pp. 530-549.

McAssey, R. & Yorkstone, S. 2016. Establishing Process Improvement Capability in an HE environment. UCISA: UCISA-PCMG

McCormack, K., & Johnson, W. C.2001. Business process orientation. Florida: St. Lucie Press.

McGlinchey S., 2014, The 'Student as Customer' Phenomenon, https://www.e-ir.info/2014/02/09/student-as-customer

McRae, R.R. and Costa, P.T., 1987, “Validation of the five-factor model of personality across instruments and observers”, Journal of Personality and Social Psychology, Vol. 52 No. 1, p. 81.

Mehmood Ijaz, Khan Shahinshah Baber, Raziq Khan, Tahirkheli Shaheen Ashraf, 2012 Role of academic leadership in change management for quality in higher education in Pakistan, Journal of education and practice, Vol 3, No16, 2012

Mello, A.S. and Ruckes, M.E., 2006, “Team composition”, Journal of Business, Vol. 79 No. 3, pp. 1019-1039.

Meredith, J. R., Raturi, A., Amoako-Gyampah, K., & Kaplan, B. 1989. Alternative research paradigms in operations. Journal of operations management, 8(4), 297-326.

Mettler, T. 2009. A Design Science Research Perspective on Maturity Models in Information Systems (Vol. 41).

Mettler, T. 2009. A Design Science Research Perspective on Maturity Models in Information Systems (Vol. 41).

Meyrick, J. 2006. ‘What is good qualitative research? A first step towards a comprehensive approach to finding rigour/quality’, Journal of Health Psychology, 11, pp. 799–808

Meza, D. and Jeong, K.Y., 2013. Measuring efficiency of Lean Six Sigma project implementation using data envelopment analysis at NASA. Journal of Industrial Engineering and Management (JIEM), 6(2), pp.401-422.

Mi Dahlgaard Park, S. and Näslund, D., 2013, “Lean and Six Sigma – critical success factors revisited”, International Journal of Quality and Service Sciences, Vol. 5 No. 1, pp. 86-100.

Mikel, J Harry, The Nature of Six Sigma Quality, Motorola University Press, 1988

Miller, D., 2011. Miller revisited: A reflection on EO research and some suggestions for the future. Entrepreneurship theory and practice, 35(5), pp.873-894.

Mills D Quinn, 2005 “Leadership, how to lead, how to live”, Harvard Business Press, 2005

Mintzberg, H. 1980. Structure in 5’s: A Synthesis of the Research on Organization Design. Management Science, 26(3), 322–341. https://doi.org/10.1287/mnsc.26.3.322

Mischel, Walter, Shoda, Yuichi & Rodriguez, Monica L., 1989. Delay of gratification in children. Science, 244(4907), pp.933–938.

Mohammed, S. and Angell, L.C., 2003, “Personality heterogeneity in teams: which differences make a difference for team performance?”, Small Group Research, Vol. 34 No. 6, pp. 651-677.

Montgomery D., 2017, Lean six-sigma in higher education, Quality and reliability engineering international, 2017, Vol.33 (5), p.935-936

Montgomery D.C., 1991 Design and analysis of experiments, 3rd edn. Wiley, New York, pp 270–569

Montgomery, D.C. and Woodall, W.H., 2008, “An overview of six sigma”, International Statistical Review/Revue Internationale de Statistique, Vol. 76 No. 3, pp. 329-346.

Moore, M.R. and Diamond, M.A., 2000. Academic Leadership Turning Vision into Reality, The Ernst & Young Foundation.

Moorman, D.H.J. and Rosemann, M., 2010, “Uptake and success factors of Six Sigma in the financial services industry”, Business Process Management Journal, Vol. 16 No. 3, pp. 436-472.

Morgeson, F.P., Reider, M.H. and Campion, M.A., 2005, “Selecting individuals in team settings: the importance of social skills, personality characteristics, and teamwork knowledge”, Personnel Psychology, Vol. 58 No. 3, pp. 583-611.

Morse JM. Confusing Categories and Themes. Qualitative Health Research. 2008;18(6):727-728.Aboelmaged, M.G., 2009. An empirical analysis of ERP implementation in a developing country: toward a generic framework. International Journal of Enterprise Network Management, 3(4), pp.309-331.

Morse, J. 1994. 'Designing funded qualitative research'. In N. Denzin and Y. Lincoln (eds), Handbook for Qualitative Research, pp. 220–235. Thousand Oaks, CA: Sag

Moser, C. & Kalton, G., 1971. Survey methods in social investigation / 2nd ed., Surrey: Ashgate

Motwani, J., Kumar, A. and Antony, J., 2004, "A business process change framework for examining the implementation of six sigma: a case study of dow chemicals", The TQM Magazine, Vol. 16 No. 4, pp. 273-283.

Mount, M.K., Barrick, M.R. and Stewart, G.L., 1998, "Five-factor model of personality and performance in jobs involving interpersonal interactions", Human Performance, Vol. 11 Nos 2-3, p. 145.

Moya, C.A. , Galvez D., Muller L,. Camargo M., 2019. A new framework to support Lean Six Sigma deployment in SMEs. International Journal of Lean Six Sigma, 10(1), pp.58–80.

Mueller, C.E. and Hart, C.O., 2010. Effective use of secondary data analysis in gifted education research: Opportunities and challenges. Gifted Children, 4(2), p.3.

Muldoon, J., 2012 The Hawthorne legacy: A reassessment of the impact of the Hawthorne studies on management scholarship, 1930-1958. Journal of Management History, 18 (1) 2012, pp.105-119. Emerald

Murphree, P., Vath, R.R. and Daigle, L., 2011. Sustaining Lean Six Sigma projects in health care. Physician executive, 37(1), p.44.+

Murphy, S.A., 2009, Leveraging Lean Six Sigma to culture, nurture, and sustain assessment and change in the academic library environment. College & Research Libraries, 70(3), pp.215-226.

Nadeau, S., 2017, "Lean, Six Sigma and Lean Six Sigma in higher education: a review of experiences around the world", American Journal of Industrial and Business Management, Vol. 07 No. 5, pp. 591-603.

Nair, A., Malhotra, M.K. and Ahire, S.L., 2011, "Toward a theory of managing context in Six Sigma process-improvement projects: an action research investigation", Journal of Operations Management, Vol. 29 No. 5, pp. 529-548.

Nakhai, B. and Neves, J.S., 2009, "The challenges of Six Sigma in improving service quality", International Journal of Quality & Reliability Management, Vol. 26 No. 7, pp. 663-684.

Narayanamurthy G., Gurumurthy A., Subramanian N., Moser R., 2018. Assessing the readiness to implement lean in healthcare institutions – A case study. International Journal of Production Economics, 197, pp.123–142.

Näslund, D., 2008, “Lean, Six Sigma and lean sigma: fads or real process improvement methods?”, Business Process Management Journal, Vol. 14 No. 3, pp. 269-287

Naveh, G., Tubin, D. and Pliskin, N., 2010. Student LMS use and satisfaction in academic institutions: The organizational perspective. The Internet and Higher Education, 13(3), pp.127-133.

Nelson, E., 2015 ‘Using Six Sigma and Lean in the Library’, College & Undergraduate Libraries: The Business of Libraries. Routledge, 22(3-4), pp. 312–324. doi: 10.1080/10691316.2015.1070701.

Neuman, G.A. and Wright, J., 1999, “Team effectiveness: beyond skills and cognitive ability”, Journal of Applied Psychology, Vol. 84 No. 3, pp. 376-389.

Neuman, G.A., Wagner, S.H. and Christiansen, N.D., 1999, “The relationship between work-team personality composition and the job performance of teams”, Group & Organization Management, Vol. 24 No. 1, pp. 28-45.

Ngui, K.N., Hong, K.S., Gan, S.L., Usop, H.H., Mustafa, R., 2010 “Perceptions of senior executive leadership behaviour and effectiveness in Malaysian public universities. Research and Development in Higher Education: Reshaping Higher Education, Vol. 33, pp. 515–52. 2010

Niemeijer, G.C., Trip, A., de Jong, L.J., Wendt, K.W. and Does, R.J., 2012. Impact of 5 years of Lean Six Sigma in a University Medical Center. Quality Management in Healthcare, 21(4), pp.262-268.

Nolan, R.L., 1973. Managing the computer resource: a stage hypothesis. Communications of the ACM, 16(7), pp.399-405.

Norton D. P., Kaplan R. S., 1996 The Balanced Scorecard: Translating Strategy into Action Book by and Harvard Business Press, 1996

O’Reilly S., Healy J., Murphy T., Ó’Dubhghaill R., 2019, Lean Six Sigma in higher education institutes: an Irish case study. International Journal of Lean Six Sigma, 10(4), pp.948–974

O'Gorman, K.D. and MacIntosh, R., 2014. Research methods for business and management. Goodfellow Publishers Limited.

Oxman, A.D. and Guyatt, G.H., 1993. The science of reviewing research a. Annals of the New York Academy of Sciences, 703(1), pp.125-134.

Palmer Benjamin, Walls Melissa Burgess, Zena, Stough Con, 2001, Emotional intelligence and effective leadership: Leadership and Organisational Development Journal, 22/1 2001 5-10 MCB University Press

Pande P., 2007, The Six Sigma Leader: How Top Executives Will Prevail in the 21st Century McGraw-Hill; 1 edition

Papadopoulos T., Radnot Z., Merali Y., 2011 The role of actor associations in understanding the implementation of Lean Thinking in healthcare, International journal of operations and production management, Vol 31 No2 2011 pp 167-191

Paradeise, C. and Thoenig, J.C., 2013, Academic institutions in search of quality: Local orders and global standards. Organization studies, 34(2), pp.189-218.

Parast, M. M., 2011, The effect of Six Sigma projects on innovation and firm performance. Journal of Project Management, 29(1), 45–55.

Park, S. H. and Antony, J., 2008, Robust design for quality engineering and Six Sigma /. Singapore ; Hackensack, NJ: World Scientific.

Patel, A. and Chudgar, C., 2020, Understanding basics of Six Sigma. Understanding basics of Six Sigma , International Journal of Engineering Research & Technology (IJERT), IJERTV9IS050866 Vol. 9 Issue 05

Patel, Mihir and Desai, Darshak Arunbhai, 2018, 'Critical review and analysis of measuring the success of Six Sigma implementation in manufacturing sector', The International journal of quality & reliability management. Bradford: Emerald, 35(8), pp. 1519–1545. doi: 10.1108/ijqrm-04-2017-0081.

Pearson, T. A., 2001, 'Measure for Six Sigma success', Quality progress. Milwaukee: American Society for Quality, 34(2), p. 35.

Pee, L.G., Teah, H.Y. and KANKANHALLi, A., 2006, Development of a general knowledge management maturity model. In Korean Knowledge Management Society Conference, Seoul, Korea.

Peeters, M.A.G., Rutte, C.G., van Tuijl, H.F.J.M. and Reyman, I.M.M.J., 2006, "The big five personality traits and individual satisfaction with the team", Small Group Research, Vol. 37 No. 2, pp. 187-211.

Pepper M.P.J., Spedding T.A., 2010, The evolution of Lean Six Sigma, International Journal of Quality and Reliability Management, Vol 27, No2, 2010, pp 138-155

Pesic, A.M., 2009, September. Business process management maturity model and six sigma: An integrated approach for easier networking. In Proceedings of the international conference on economics and management of networks, EMNet. Springer, Sarajevo (Vol. 19, pp. 3-5).

Peterson, R.S., Martorana, P.V., Smith, D.B. and Owens, P.D., 2003, "The impact of chief executive officer personality on top management team dynamics: one mechanism by which leadership affects organizational performance", Journal of Applied Psychology, Vol. 88 No. 5, p. 795. 759 Personality characteristics and Six Sigma Downloaded by University of Nebraska at Omaha, Doctor Phillip Witt At 13:42 05 March 2018 (PT)

Phillips, E.M. and Pugh, D.S., 2005, How to get a PhD a handbook for students and their supervisors Maidenhead.

Pollock, N. and Cornford, J., 2004, ERP systems and the university as a “unique” organisation. Information technology & people.

Poppelbub, J. and Roglinger, M., 2011, June. What makes a useful maturity model? A framework of general design principles for maturity models and its demonstration in BPM. In 19th European Conference on Information Systems (ECIS) (pp. 9-11).

Porra, J., Hirschheim, R. and Parks, M.S., 2014, The historical research method and information systems research. Journal of the Association for Information Systems, 15(9), p.3.

Porter S., 2004, Pros and cons of paper and electronic surveys, New Directions for Institutional Research Volume 2004 issue 121 – Special Issue Over coming Survey Research Problems, Pages 91 – 97

Posselt, T., Abdelkafi, N., Fischer, L. and Tangour, C., 2019. Opportunities and challenges of Higher Education institutions in Europe: An analysis from a business model perspective. Higher Education Quarterly, 73(1), pp.100-115.

Prasad K.G. Durga, Subbaiah K.Venkata, Padmavathi G., 2012, Application of Six Sigma Methodology in an Engineering Educational Institution Int. J. Emerg. Sci., 2(2), 222-237, June 2012

Prosci, I., 2007, Why use change management. Retrieved from Change Management Learning Centre: http://www. change-management. com/tutorial-2007 prep-why-CM. htm.

Pryor, M., Alexander, C., Taneja, S., Tirumalasetty, S., & Chadalavada, D., 2012, The application of Six Sigma methodologies to university processes: The use of student teams. Journal of Case Studies in Accreditation and Assessment, 2, 1–14.

Pulakanam, V., 2012, Costs and savings of Six Sigma programs: An empirical study. Quality Management Journal, 19(4), pp.39-54.

Pyzdek T, 2007, Letters to the editor – is Six Sigma the way, CFO, May 2007

Quinn, A., Lemay, G., Larsen, P., & Johnson, D., 2009, Service quality in higher education. Total Quality Management & Business Excellence, 20(2), 139–152.

Radnor Z., Holweh M., and Waring J., 2012, Lean in healthcare – the unfulfilled promise, Social Science and Medicine, no. 74, 2012, pp 364 - 371

Radnor, Z. J. and Walley, P., 2008 Learning to walk before we try to run: adapting Lean for the public sector. Public Money & Management, Vol.**28 (No.1). pp. 13-20. ISSN 0954-0962**

Radnor, Z., and Bucci, G., 2011, Analysis of lean implementation in UK business schools and universities. Association of Business Schools, London.

Rahman, S.U., 2001, A comparative study of TQM practice and organisational performance of SMEs with and without ISO 9000 certification. International Journal of Quality & Reliability Management.

Rajamanoharan, I.D. and Collier, P., 2006, “Six sigma implementation, organisational change and the impact on performance measurement systems”, International Journal of Six Sigma and Competitive Advantage, Vol. 2 No. 1, pp. 48-68.

Ramasubramanian P., Six Sigma in Educational Institutions, International Journal of Engineering Practical Research, IJEPR Volume 1, Issue 1, August 2012 PP. 1-5

Ramsden P., Prosser M., Trigwell K., Martin E., 2007, “University teachers’ experiences on academic leaderhip and their approaches to teaching,” Learning and Instruction, Vol 17, 2007, pp 140-155. 2007

Rathi, R., Khanduja, D. and Sharma, S., 2016, A fuzzy MADM approach for project selection: a Six Sigma case study. Decision Science Letters, 5(2), pp.255-268.

Raval, Shruti J, Kant, Ravi and Shankar, Ravi, 2019, ‘Benchmarking the Lean Six Sigma performance measures: a balanced score card approach’, Benchmarking : an international journal. Emerald, 26(6), pp. 1921–1947. doi: 10.1108/bij-06-2018-0160.

Ray, S., Das, P., Bhattacharyay, B.K. and Antony, J., 2013, “Measuring Six Sigma project effectiveness using fuzzy approach”, Quality & Reliability Engineering International, Vol. 29 No. 3, pp. 417-430.

Reichhart A. and Holweg M., 2007, Lean distribution – concepts, International journal of production research, vol 45, no.16, August 2007, pp – 3699-3722

Reilly, R.R., Lynn, G.S. and Aronson, Z.H., 2002, “The role of personality in new product development team performance”, Journal of Engineering and Technology Management, Vol. 19 No. 1, pp. 39-58.

Remenyi, D., Williams, B., Money, A. and Swartz, E., 1998, The case study. Doing research in business and management: An Introduction to process and method, London: Sage.

Revere, L., Kadipasaoglu, S.N. and Zalila, F., 2006, “An empirical investigation into Six Sigma critical success factors”, International Journal of Productivity and Quality Management, Vol. 1 No. 3, pp. 224-252.

Richards, D., 2007. Types of data. Evidence-Based Dentistry, 8(2), pp.57–58.

Robinson, M. and Yorkstone, S., 2014, Becoming a lean university: The case of the University of St Andrews. Leadership and Governance in Higher Education: Handbook for Decision-Makers and Administrators.

Robinson, O. C. 2014. ‘Sampling in interview based qualitative research: a theoretical and practical guide’, Qualitative Research in Psychology, 11, pp. 25–41.

Robson, C., 2002, Real world research: A resource for social scientists and practitioner-researchers (Vol. 2). Oxford: Blackwell.

Roebuck, Chris, 2011, Developing effective leadership in the NHS to maximise the quality of patient care - The need for urgent action, The King's Fund to inform the leadership commission, 2011

Röglinger, M., Pöppelbuß, J. and Becker, J., 2012, Maturity models in business process management. Business process management journal.

Rooke, D., Torbet, W.R., “7 transformations of leadership.” Harvard Business Review, Vol. 83(4), pp. 67-76, 2005

Rosemann, M., Recker, J., Indulska, M. and Green, P., 2006, June. A study of the evolution of the representational capabilities of process modeling grammars. In International Conference on Advanced Information Systems Engineering (pp. 447-461). Springer, Berlin, Heidelberg.

Rosemann, Michael & De Bruin, Tonia 2005 Towards a Business Process Management Maturity Model. In Rajola, F, Avison, D, Winter, R, Becker, J, Ein-Dor, P, Bartmann, D, et al. (Eds.) ECIS 2005 Proceedings of the Thirteenth European Conference on Information Systems. Verlag and the London School of Economics, CD Rom, pp. 1-12.

Rowley, J., 2000, Is higher education ready for knowledge management?. International journal of educational management.

Rummler, G.A. and Brache, A.P., 1990, How to manage the white space on the organization chart.

Sabry, A., 2014, “Factors critical to the success of six-sigma quality program and their influence on performance indicators in some of Lebanese hospitals”, Arab Economic and Business Journal, Vol. 9 No. 2, pp. 93-114.

Sadeh, E. & Garkaz, M., 2015, Explaining the mediating role of service quality between quality management enablers and students' satisfaction in higher education institutes: the perception of managers. Total Quality Management & Business Excellence, 26(11-12), pp.1335–1356.

Sakthivel P. B., 2007, Top management commitment and overall engineering education excellence. TQM Magazine, 2007, Vol. 19 Issue 3, p259-273, 15p. Publisher: Emerald Group Publishing Limited.

Saraph, J.V., Benson, P.G. and Schroeder, R.G., 1989, An instrument for measuring the critical factors of quality management. Decision sciences, 20(4), pp.810-829.

Saunders, M. N. K., & Townsend, K. (2016). Reporting and Justifying the Number of Interview Participants in Organization and Workplace Research. British Journal of Management, 27(4), 836–852. https://doi.org/10.1111/1467-8551.1218

Saunders, M. N. K., & Townsend, K. 2016. Reporting and Justifying the Number of Interview Participants in Organization and Workplace Research. British Journal of Management, 27(4), 836–852. https://doi.org/10.1111/1467-8551.1218

Saunders, M., Lewis, P. & Thornhill, A. 2012. Research Methods for Business Students. 6th edition, Pearson Education Limited.

Saunders, M., Lewis, P. and Thornhill, A., 2009, Research onion. Research methods for business students, pp.136-162.

Schilpzand, M.C., Herold, D.M. and Shalley, C.E., 2011, “Members’ openness to experience and teams’ creative performance”, Small Group Research, Vol. 42 No. 1, pp. 55-76.

Schon Karin, Bergquist Bjarne, Klefsjo Bengt, 2010, The consequences of Six Sigma on job satisfaction: a study at three companies in Sweden, International Journal of Lean Six Sigma, Vol 1 No 2 2010 pp 99-118

Schroeder Roger, Linderman Kevin, Liedtke Charles, Choo Adrian, 2008, Six Sigma: Definition and underlying theory, Journal of operations management, 26, 2008, pp 536-554

Scibilia B., 2017, How Taguchi Designs Differ from Factorial Designs, Published by Minitab Inc. available at: https://blog.minitab.com/blog/applying-statistics-in-quality-projects/how-taguchi-designs-differ-from-factorial-designs

Scotland, J. 2012. Exploring the Philosophical Underpinnings of Research: Relating Ontology and Epistemology to the Methodology and Methods of the Scientific, Interpretive, and Critical Research Paradigms. English Language Teaching, 5(9), pp.9-16

Seawright, J. and Gerring, J., 2008, Case selection techniques in case study research: A menu of qualitative and quantitative options. Political research quarterly, 61(2), pp.294-308.

Selesho, J.M. and Naile, I., 2014, Academic staff retention as a human resource factor: University perspective. International Business & Economics Research Journal (IBER), 13(2), pp.295-304.

Selingo, J., Chheng, S. and Clark, C., 2017, Pathways to the university presidency: The future of higher education leadership. Deloitte Insights.

Senge, P., 1990, The Fifth Discipline. New York: Doubleday

Setijono, D., Pinedo-Cuenca, R., Olalla, P.G. and Setijono, D., 2012, “Linking six sigma’s critical success/ hindering factors and organizational change (development)”, International Journal of Lean Six Sigma, Vol. 3 No. 4, pp. 284-298.

Shah R. and Ward P., 2007, Defining and developing measures of lean production, Journal of operations management, vol 25, 2007, pp 785-805

Shah R., Chandrasekaran A., and Linderman K., 2008, In pursuit of implementation patterns: the context of lean and six sigma, International Journal of Production Research: Vol 46, No. 23, December 2008, pp 6679-6699

Shah, R., & Ward, P. T., 2007, Defining and developing measures of lean production. Journal of Operations Management, 25(4), 785–805.

Shahmandi Elham, Silong Abu Daud, Ismail Ismi Arif, Samah Bahaman Bin Abu, Othman Jamilah, 2011, Competencies, Roles and Effective Academic Leadership in World Class university, International journal of business administration, Vol 2 No1 February 2011

Shamandi E., Silong Abu D., Ismail Ismi A., Samah Bahaman Bin A., Omar Z., 2013, “Structural equation modelling test for relationships between selected leadership competencies and effective academic leadership styles,” World Applied Sciences Journal, Vol 21, 2013, pp 1566-1576, 2013

Shamandi E., Silong Abu D., Ismail Ismi A., Samah Bahaman Bin A., Othman J., 2011, “Competencies, Roles and Effective Academic Leadership in World Class university,” International Journal of Business Administration, Vol 2 No1 February 2011

Shamandi E., Silong Abu D., Ismail Ismi A., Samah Bahaman Bin A., Omar Zohara, 2013, Structural equation modelling test for relationships between selected leadership competencies and effective academic leadership styles, World applied sciences journal, Vol 21, 2013, pp 1566-1576

Shanmugam, V., 2007, “Six sigma cup: establishing ground rules for successful Six Sigma deployment”, Total Quality Management & Business Excellence, Vol. 18 Nos 1-2, pp. 77-82.

Sheikh, Y.A., 2017. Higher education in India: Challenges and opportunities. Journal of Education and Practice, 8(1), pp.39-42.

Shoeibi M., Zahmatdoost E., 2015, The role of Six Sigma in improving the quality of higher education institutions, The SIJ Transactions on Industrial, Financial & Business Management (IFBM), Vol. 3, No. 6, June 2015

Shokri, A., Oglethorpe, D. and Nabhani, F., 2014, “Evaluating Six Sigma methodology to improve logistical measures of food distribution SMEs”, Journal of Manufacturing Technology Management, Vol. 25 No. 7, pp. 998-1027.

Siddique A., Aslam Hassan D., Khan M., Fatima U., 2011, “Impact of academic leadership on faculty’s motivation and organisational effectiveness in higher education,” International Journal of Business and Social Science, Vol 2 No8, May 2011

Simmons, R., & Young, G., 2014, Improving the student academic experience through Lean engineering principles. Proceedings of 2014 IEEE frontiers in education conference (FIE), IEEE, Madrid, pp. 1–4.

Simon, T., 2012, “University of Miami to launch Lean Six Sigma Green Belt certification program”, available at: www.bus.miami.edu/news-and-media/news-releases/six-sigma-2012.html (accessed February 27, 2017).

Simons, N., 2013, The business case for Lean Six Sigma in higher education. ASQ Higher Education Brief, 6(3), 1–6

Simpson Sarah, 2012, The styles, models and philosophy of leadership:, bookboon.com

Sin, A.B., Zailani, S., Iranmanesh, M. and Ramayah, T., 2015, “Structural equation modelling on knowledge creation in Six Sigma DMAIC project and its impact on organizational performance”, International Journal of Production Economics, Vol. 168, pp. 105-117.

Singh, M. and Rathi, R., 2019, A structured review of Lean Six Sigma in various industrial sectors. International Journal of Lean Six Sigma.

Skrinjar, R., Bosilj-Vuksic, V., & Stemberger, M. I. 2008. The impact of business process orientation on financial and non-financial performance. Business Process Management Journal, 14(5), 738-754.

Snee R, 2011, Understanding formulation systems – a Six Sigma approach, Quality engineer vol 23, pp 278-286 2011

Snee R., 2006, What can improve Six Sigma’s effectiveness, ASQ Six Sigma Forum Magazine, Guest Editorial, Feb 2006; 5,2, pp 12-13

Snee R., 2007, Managing Six Sigma’s most profound change of all: a new way of thinking, ASQ Six Sigma Forum Magazine, Feb 2007; 6,2, pp 41-43

Snee Ron, Hoerl Roger W, 2002, Leading Six Sigma : A Step-by-Step Guide Based on Experience with GE and Other Six Sigma Companies, Hardback| Financial Times (Prentice Hall)|

Snee, R., 2007, Managing Six Sigma’s most profound change of all: a new way of thinking, ASQ Six Sigma Forum Magazine, Feb 2007; 6,2, pp 41-43

Snee, R., and Hoerl W, 2009, Turning to service sectors, Industrial engineer, October 2009

Snee, R.D., 2010, Lean Six Sigma–getting better all the time. International Journal of Lean Six Sigma.

Soni, R.G., Chaubey, M.D. and Ryan, J.C., 2000, Implementing TQM in higher education institutions: A strategic management approach. Academy of Educational Leadership Journal, 4(1), pp.99-109.

Spear, S., 2009, Chasing the Rabbit: how Market Leaders Outdistance the Competition and how Great Companies can Catch up and win. New York: McGraw-Hill

Spendlove, M., 2007, “Competencies for effective leadership in higher education.” International Journal of Educational Management. Vol. 21(5). pp. 407-417.

Sreedharan R., Sunder M., Madhavan V., Gurumurthy, A., 2019, Development of Lean Six Sigma training module: evidence from an emerging economy. The International journal of quality & reliability management, 2019–07-19

Sreedharan V, Raja, Sunder M, Vijaya & R, Raju, 2018, Critical success factors of TQM, Six Sigma, Lean and Lean Six Sigma. Benchmarking: an international journal, 25(9), pp.3479–3504.

Sreedharan V, Raju R., Sunder M., Antony J., 2019 Assessment of Lean Six Sigma Readiness (LESIRE) for manufacturing industries using fuzzy logic. International Journal of Quality & Reliability Management, 36(2), pp.137–161

Sreedharan, V.R., Gopikumar, V., Nair, S., Chakraborty, A. and Antony, J., 2018, “Assessment of critical failure factors (CFFs) of Lean Six Sigma in real life scenario: evidence from manufacturing and service industries”, Benchmarking: An International Journal, Vol. 25 No. 8, pp. 3320-3336

Sreedharan, V.R., Sandhya, G. and Raju, R., 2018, “Development of a Green Lean Six Sigma model for public sectors”, International Journal of Lean Six Sigma, Vol. 9 No. 2, pp. 238-255

Stake, R.E., 1995. The art of case study research. Sage.

Stankalla, Roland, Chromjakova, Felicita & Koval, Oksana, 2019, A review of the Six Sigma belt system for manufacturing small and medium-sized enterprises. Quality Management Journal, 26(2), pp.100–117.

Steinlicht, C., Neary, A., LeBrun, T., Sauke, K., Sundermann, C. and Weber, J., 2010, “Program development work in progress: value stream mapping the educational process outcomes”, In Frontiers in Education Conference (FIE), 2010 IEEE (pp. T1H-1), IEEE.

Sue, V.M. and Ritter, L.A., 2012, Conducting online surveys. Sage.

Sumukadas, N., 2006, Employee involvement: A hierarchical conceptualisation of its effect on quality. International Journal of Quality & Reliability Management, 23(2), 143–161.

Sun, M., Vidalakis, C. and Oza, T., 2009, September. A change management maturity model for construction projects. In Proceedings 25th Annual ARCOM Conference, of Association of researchers in construction management (pp. 803-812).

Sunder M, V. & Antony, J., 2018, A conceptual Lean Six Sigma framework for quality excellence in higher education institutions. International Journal of Quality & Reliability Management, 35(4), pp.857–874.

Sunder M, V., 2016, Constructs of quality in higher education services. International Journal of Productivity and Performance Management, 65(8), pp.1091–1111.

Sunder M, Vijaya and Antony, J., 2018, ‘A conceptual Lean Six Sigma framework for quality excellence in higher education institutions’, The International journal of quality & reliability management. Bradford: Emerald, 35(4), pp. 857–874. doi: 10.1108/ijqrm-01-2017-0002.

Sunder, M. V., 2016, Lean Six Sigma in higher education institutions. International Journal of Quality and Service Sciences, 8(2), 159–178. Total Quality Management 243

Suresh, S., Antony, J., Kumar, M., & Douglas, A., 2012, Six Sigma and leadership: Some observations and agenda for future research. The TQM Journal, 24(3), 231–247.

Svensson, C., Antony, J., Ba-Essa, M., Bakhsh, M., & Albliwi, S., 2015, A Lean Six Sigma program in higher education. International Journal of Quality & Reliability Management, 32(9), 951–969.

Swami, S.P. and Prasad, V.M., 2010, “Critical success factors for Six Sigma implementation”, Journal of Contemporary Research, Vol. 5 No. 3, pp. 83-94.

Swink, M. and Jacobs, B.W., 2012, “Six sigma adoption: operating performance impacts and contextual drivers of success”, Journal of Operations Management, Vol. 30 No. 6, pp. 437-453.

Taguchi G., 1987, The System of Experimental Design: Engineering Methods to Optimize Quality and Minimize Costs, Quality Resources Dec 1987 ISBN-10: 0527916218

Talib, N., and Zia-ur-Rehman, M., 2012, Academic performance and perceived stress among university students. Educational Research and Reviews, 7(5), pp.127-132.

Tang Karen, 2013, Quality assurance improvements in Australian university libraries Performance Measurement and Metrics, Volume: 14 Issue: 1, 2013

Tarakci, H. 2016. “Two Types of Learning Effects on Maintenance Activities.” International Journal of Production Research 54 (6): 1721–1734

Tarhan, A., Turetken, O. and Reijers, H.A., 2016, Business Process Maturity Models: A Systematic Literature Review.

Tata, Roxanne M. and Jones, Gwen D, 2011, ‘Six Sigma culture as a management principle’, Transfusion (Philadelphia, Pa.), 51(7pt2), pp. 1604–1608. doi: 10.1111/j.1537-2995.2011.03220.x.

Tavčar, J., Demšar, I. & Duhovnik, J., 2018, Engineering change management maturity assessment model with lean criteria for automotive supply chain. Journal of Engineering Design, 29(4-5), pp.235–257.

Temponi Cecilia, 2005, "Continuous improvement framework: implications for academia", Quality Assurance in Education, Vol. 13 Iss: 1, pp.17 - 36

Tenali, S., Ganti, R.S. and Taranikanth, K., 2015, “Implementing Lean Six Sigma to improve the ratio of admissions to placements in an academic year: statistical and psychological case study of a technical institute”, In Industrial Engineering and Operations Management (IEOM), 2015 International Conference on, IEEE, pp. 1-12.

Terziovski, M. and Samson, D., 1999, The link between total quality management practice and organisational performance. International Journal of Quality & Reliability Management.

Tett, R.P., Jackson, D.N. and Rothstein, M., 1991, “Personality measures as predictors of job performance: a meta-analytic review”, Personnel Psychology, Vol. 44 No. 4, pp. 703-742.

Thawani, S., 2004, “Six sigma – strategy for organizational excellence”, Total Quality Management & Business Excellence, Vol. 15 Nos 5-6, pp. 655-664.

The corporate research foundation, 1999, Corporate strategies of the top UK companies of the future, 1999, Harper Collins Publications

The FTSE 100 2010 - How the share index has changed. The Financial Times, May 2010, www.ft.com 8th November 2012

Thirkell, E. and Ashman, I., 2014, “Lean towards learning: Connecting lean thinking and human resource management in UK higher education”, The International Journal of Human Resource Management, Vol. 25 No. 21, pp. 2957-2977.

Thomas, A., Antony, J., Haven-Tang, C., Francis, M.; Fisher, R., 2017, Implementing Lean Six Sigma into curriculum design and delivery – a case study in higher education. International Journal of Productivity and Performance Management, 66(5), pp.577–597.

Thoms, P., Moore, K.S. and Scott, K.S., 1996, “The relationship between self-efficacy for participating in self-managed work groups and the big five personality dimensions”, Journal of Organizational Behavior, Vol. 17 No. 4, pp. 349-362.

Thurmond, V.A., 2001, The point of triangulation. Journal of nursing scholarship, 33(3), pp.253-258.

Timans, W, Antony, J, Ahaus, K and van Solingen, R., 2017, ‘Implementation of Lean Six Sigma in small- and medium-sized manufacturing enterprises in the Netherlands’, The Journal of the Operational Research Society. Abingdon: Informa UK Limited, 63(3), pp. 339–353. doi: 10.1057/jors.2011.47

Timans, W., Antony, J., Ahaus, K. and Van Solingen, R., 2012, “Implementation of Lean Six Sigma in small- and medium-sized manufacturing enterprises in the Netherlands”, Journal of the Operational Research Society, Vol. 63 No. 3, pp. 339-353.

Tomaskovic-Devey, D., Leiter, J. & Thompson, S., 1994, Organizational Survey Nonresponse. Administrative Science Quarterly, 39(3), pp.439–457.

Tortorella L., Fettermann D., Cauchick M., Paulo A., Sawhney, R., 2020, Learning organisation and lean production: an empirical research on their relationship. International journal of production research, 58(12), pp.3650–3666.

Tranfield, D. and Starkey, K., 1998, The nature, social organization and promotion of management research: Towards policy. British journal of Management, 9(4), pp.341-353.

Tranfield, D., Denyer, D., & Smart, P., 2003, Towards a methodology for developing evidence informed management knowledge by means of systematic review. British Journal of Management, 14(3), 207–222.

Turner, P. & Turner, S., 2009, Triangulation in practice. Virtual Reality, 13(3), 171–181.

Uluskan, M. & Erginel, N., 2017, Six Sigma experience as a stochastic process. Quality Engineering, 29(2), pp.291–310.

Vaishnavi, V. and Suresh, M., 2020, Modelling of readiness factors for the implementation of Lean Six Sigma in healthcare organizations. International Journal of Lean Six Sigma.

van den Berg, Peter T. and Wilderom, Celeste P.M., 2004, 'Defining, Measuring, and Comparing Organisational Cultures', Applied psychology. Oxford, UK: Wiley, 53(4), pp. 570–582. doi: 10.1111/j.1464-0597.2004.00189.x

Vaske, J., Beaman J., & Sponarski, C., 2017, Rethinking Internal Consistency in Cronbach's Alpha, Leisure Sciences, 39:2, 163-173

Visconti, M. and Cook, C.R., 1998. Evolution of a maturity model–critical evaluation and lessons learned. Software Quality Journal, 7(3), pp.223-237.

Vogt W.P., 2010, Data Collection – 4 volumes, Sage Publications

Vogt W.P., 2011, SAGE Quantitative Research Methods, Pub. date: 2011 | Online Pub. Date: January 15, 2013 | DOI:http://ezproxy1.hw.ac.uk:2078/10.4135/9781446263341 | Print ISBN: 9781848606999 | Online ISBN: 9781446263341 | Publisher:SAGE Publications Ltd

Vogt, W., 2013, Looking at Big Data One Plant at a Time. Farm Industry http://farmindustrynews.com/blog/looking-big-data-one-plant-time

Vol. 25 No. 4, pp. 918-931. Choo, A.S., Linderman, K.W. and Schroeder, R.G. 2007b, "Method and psychological effects on learning behaviors and knowledge creation in quality improvement projects", Management Science, Vol. 53 No. 3, pp. 437-450.

Voyles Jeanne F., Dols Linda, Knight Ellen, 2008, Interlibrary Loan Meets Six Sigma: The University of Arizona Library's Success Applying Process Improvement Journal: Journal of Interlibrary Loan,Document Delivery & Electronic ReserveVolume 19, Issue 1, December 2008, pages 75-94

Waterbury, T., 2015, Learning from the pioneers: A multiple-case analysis of implementing Lean in higher education. International Journal of Quality & Reliability Management, 32(9), 934–950.

Watkins, K., and K. Kim, 2018, “Current Status and Promising Directions for Research on the Learning Organization.” Human Resource Development Quarterly 29 (1): 15–29

Watson, G.H., 1993, “How process benchmarking supports corporate strategy”, Planning Review, Vol. 21 No. 1, pp. 12-15.

Watson-Hemphill, K.W. and Bradley, K., 2012, Does your deployment measure up? Presenting a maturity model for Lean Six Sigma. In The quality management forum (Vol. 38, No. 3, pp. 1-8).

Watt, H.M. and Richardson, P.W., 2020. Motivation of higher education faculty:(How) it matters. International Journal of Educational Research, 100, p.101533.

Webber, S.S., 2002, “Leadership and trust facilitating cross-functional team success”, Journal of Management Development, Vol. 21 No. 3, pp. 201-214. 760 IJQRM 35,3 Downloaded by University of Nebraska at Omaha, Doctor Phillip Witt At 13:42 05 March 2018 (PT)

Weber, C., Curtis, B. and Gardiner, T., 2008, Business process maturity model (BPMM) version 1.0. Fecha de consulta, 4.

Webster, J. and Watson, R., 2002, “Analyzing the past to prepare for the future: writing a literature review”, MIS Quarterly, Vol. 26 No. 4, pp. 13-23.

Weinstein, L. B., Petrick, J., Castellano, J., & Vokurka, R. J., 2008, Integrating Six Sigma concepts in an MBA quality management class. Journal of Education for Business, 83(4), 233–238.

Winston, B., 2003, Extending Patterson’s servant leadership model. Retrieved April, 12, p.2008.

Witt, P.W. and Baker, T., 2018. Personality characteristics and Six Sigma: a review. International Journal of Quality & Reliability Management.

Womac, J.P., Jone, D.T., 2005, Lean Consumption, Harvard Business Review, March 2005

Womac, J.P., Jone, D.T., Roos, D., 1991, The Machine That Changed the World: The Story of Lean Production, Harper Perennial (November 1991)

Womack, J. P., & Jones, D. T., 2003, Lean thinking: Banish waste and create wealth in your corporation. New York, NY: Productivity Press.

Wyper, B. and Harrison, A., 2000, “Deployment of Six Sigma methodology in human resource function: a case study”, Total Quality Management and Business Excellence, Vol. 11 Nos 4-6, pp. 720-727.

Xingxing Zu, Fredendall, Lawrence D & Robbins, Tina L, 2006, ORGANIZATIONAL CULTURE AND QUALITY PRACTICES IN SIX SIGMA. Annual meeting proceedings (Academy of Management), 8(1), pp.F1–F6.

Yang, K., Basem, S. and El-Haik, B., 2003, Design for Six Sigma (pp. 184-186). New York: McGraw-Hill.

Yang, T. and Hsieh, C.H., 2009, Six-Sigma project selection using national quality award criteria and Delphi fuzzy multiple criteria decision-making method. Expert Systems with Applications, 36(4), pp.7594-7603.

Yeung, V.W.S., 2007, “Six sigma paradigm shift”, International Journal of Six Sigma and Competitive Advantage, Vol. 3 No. 4, pp. 317-332.

Yin R.K., 1994, Case study Research: Design And Methods, (2nd Edition) Newbury Press, CA: Sage

Yu, K.-T., & Ueng, R.-G., 2012. Enhancing teaching effectiveness by using the Six-Sigma DMAIC model. Assessment & Evaluation in Higher Education, 37(8), 949–961.

Yusuf, F.O. and Iwu-James, J., 2010, Use of academic library: A case study of Covenant University, Nigeria. Chinese librarianship: an international electronic journal, pp.1-12.

Zaccaro, S.J., Rittman, A.L. and Marks, M.A., 2001, “Team leadership”, The Leadership Quarterly, Vol. 12 No. 4, pp. 451-483.

Zahraee, S., 2016, "A survey on lean manufacturing implementation in a selected manufacturing industry in Iran", International Journal of Lean Six Sigma, Vol. 7 No. 2, pp. 136-148

Zare M.Y., 2011, ‘Six-Sigma: methodology, tools and its future’, Assembly Automation. Bedford: Emerald Group Publishing Limited, 31(1), pp. 79–88

Zargar, Ali M., 1994, TQM in a Multi-Campus Public University 1994 6 pp. (ED367269)
Zhao, L., 2005, China’s higher education quality management based on Six Sigma management principles. Proceedings of Artificial Intelligence, Management Science and Electronic Commerce (AIMSEC), IEEE, Deng Leng, pp. 6559–6561.

Zimbardo, P.G., 2004, Quiet rage: the Stanford prison experiment, Stanford University

Zu, X., Fredendall, L.D. and Douglas, T.J., 2008, “The evolving theory of quality management: the role of six sigma”, Journal of Operations Management, Vol. 26 No. 5, pp. 630-650.

Zu, X., Robbins, T.L. and Fredendall, L.D., 2010, “Mapping the critical links between organizational culture and TQM/Six sigma practices”, International Journal of Production Economics, Vol. 123 No. 1, pp. 86-106.

Appendix:

Contents of appendix:

1. Consent forms for both individual and organisational interviews
2. Code of conduct / ethics policy adopted by the researcher
3. Sample data from the questionnaire, interviews and informal Master Black Belt feedback

INDIVIDUAL CONSENT FORM: LSS Maturity Model for Higher Educational Institutions

Name of researcher: Stephen G. Anthony, Heriot-Watt University

PARTICIPATION IN THIS RESEARCH STUDY IS VOLUNTARY AND ALL RESPONSES WILL BE HELD IN THE STRICTEST CONFIDENCE

I have read and understood the model and pre-reading information dated [/ /] or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction prior to the interview.	YES/NO
I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	YES/NO
I agree to the [interview/focus group] being audio recorded	YES/NO
I understand that the information I provide will be used for the researcher's dissertation, thesis, research publication, etc. and that the information will be anonymised.	YES/NO
I agree that my information can be quoted in research outputs.	YES/NO
I understand that any personal information that can identify me – such as my name, address, will be kept confidential and not shared with anyone *[other than myself]*.	YES/NO
I give permission for the (anonymised) information I provide to be deposited in a data archive so that it may be used for future research.	YES/NO

Please retain a copy of this consent form.

Participant name:

Signature:______________________________ Date:____________

Interviewer name: Stephen G. Anthony

Signature:______________________________ Date:__________________

For information contact: *steve@isspro.co.uk*

ORGANISATIONAL CONSENT FORM: LSS Maturity Model for Higher Educational Institutions

Name of researcher: Stephen G. Anthony, Heriot-Watt University

PARTICIPATION IN THIS RESEARCH STUDY IS VOLUNTARY AND ALL RESPONSES WILL BE HELD IN THE STRICTIST CONFIDENCE

The main representative of the organisation or institution has read and understood the model and pre-reading information dated [/ /], or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction prior to the interview.	YES/NO
All institutional and organisational data shared with the researcher will be destroyed or returned to the institution or organisation after completion of the research thesis	YES/NO
The organisation or institution agree to the [interview/focus group] being audio recorded	YES/NO
The organisation or institution agree that all data and information provided will be used for *[my dissertation, thesis, research publication, etc.]* and that the information will be anonymised.	YES/NO

The organisation or institution agree that any personal information that can identify individuals within the organisation or institution – such as my name, address, will be kept confidential and not shared with anyone *[other than myself]*.	YES/NO
The organisation or institution give permission for the (anonymised) information they provide to be deposited in a data archive so that it may be used for future research.	YES/NO

Please retain a copy of this consent form.

Institution or organisation name:

Signature:_______________________________ Date:____________

Interviewer name: Stephen G. Anthony

Signature:___________________________________ Date: __________________

For information contact: steve@isspro.co.uk

Researcher's own code of conduct and research ethics policy:

Academic freedom is the freedom to teach, study and pursue knowledge and research without unreasonable interference or restriction from law, institutional regulations or public pressure. Its basic elements include the freedom of scholars to inquire into any subject that evokes intellectual concern, to present findings, to publish data and conclusions without control or censorship and to teach in the manner they consider professionally appropriate. At the same time, integrity, accountability and responsibility in conducting academic research form the cornerstone of any academic enterprise and violations of widely-recognized academic research standards represent serious offences to the entire academic community at the my institution and are considered injurious for its credibility and authority as an institution that promotes excellence in academic research in Europe.

Academic integrity requires that academic research follows elevated professional standards, including appropriate research design and frameworks, adheres to high levels of research ethics and abides by the requirements set out by professional and regulatory research guidance and research ethics frameworks issued in appropriate areas.

Principles and Values of Academic Integrity

Academic integrity is defined in terms of the commitment to the values of honesty, trust, fairness, respect, responsibility, legality and dissemination.

Honesty: An academic community should advance the quest for truth, knowledge, scholarship and understanding by requiring intellectual and personal honesty in learning, teaching and research.

Trust: An academic community should foster a climate of mutual trust to encourage the free exchange of ideas and enable all to reach their highest potential.

Fairness: An academic community should seek to ensure fairness in institutional standards, practices and procedures as well as fairness in interactions between members of the community.

Respect: An academic community should promote respect among students, staff and faculty: respect for self, for others, for scholarship and research, for the educational process and intellectual heritage.

Responsibility: An academic community should uphold high standards of conduct in learning, teaching and research by requiring shared responsibility for promoting academic integrity among all members of the community.

Legality: An academic community should observe valid legal norms related to the conduct and publication of research particularly in relations to copyright, the intellectual property rights of third parties, the terms and conditions regulating access to research resources and the laws of libel.

Communication: An academic community should seek to make the results of its research as widely and as freely available as possible

The researcher owes a duty of accountability to the University, to the participants in their research, and to any research funders, commensurate with their involvement in that research. The researcher is responsible for the conduct of their part in any research and for providing direction for the activities of any other potential researchers under their supervision.

The researcher will comply with all aspects of their university's research policies and procedures and are responsible themselves to keep up to date with any changes in those policies.

All conflicts of interest which arise during the course of the research must be disclosed to the research supervisor. The researcher will comply with all direction and instructions made by the university in relation to conflict of interest matters.

The researcher will adhere to all legal and regulatory requirements both expressed by the university or by UK law, including adherence to the Data Protection Act with regards to data and personal data security.

Specifically, due to the research being human centred, the researcher will follow the following principles:

1. ***Informed Consent:*** The researcher should inform potential participants in advance of any features of the research that might reasonably be expected to influence their willingness to take part in the study.
2. ***Accountable:*** Researchers should consider, from the outset, the potential beneficiaries of their research. The research should be based on the informed consent of participants and/or their guardians.
3. ***Confidentiality:*** The results of research should be communicated in such a way as to protect the confidentiality of participants. Researchers are required to ensure confidentiality of the participant's identity and data throughout the conduct and reporting of the research.
4. ***Openness & Honesty:*** So far as possible, researchers should be open and honest about the research, its purpose and application.
5. ***Anti-Discriminatory:*** Researchers should have a value base that rejects the legitimacy of discrimination against any person based on difference, such as age, gender, sexual preference, class, ability, ethnicity or religion, and should seek to make a contribution to social justice.

6. ***Protection from Harm:*** Researchers must endeavour to protect participants from physical and psychological harm at all times during the investigation.
7. ***Debriefing:*** Researchers should, (where possible), provide an account of the purpose of the study as well as its procedures. If this is not possible at the outset, then ideally it should be provided on completion of the study.
8. ***Reciprocal:*** Research should be based on mutual dialogue between researcher and participants and should seek to ensure that results can be used for the common good.
9. ***Honour Professional Values:*** Professions have their own ethical codes of conduct. These ethics should not in any way be undermined or subverted by research.
10. ***Accessibility:*** All research should be capable of being disseminated in the public domain and be appropriate to the teaching and learning role of the university.
11. ***Challenge:*** Research should seek to challenge received wisdom and embrace openness and creativity in order to further understanding.

Name: Stephen G Anthony

Date: 1/10/2017

Signature: 

Example of open letter to individuals to complete the questionnaire

Dear colleagues

Myself and Professor Jiju Antony are currently researching how academic institutions are using continuous improvement strategies to change, improve and deliver the institution's long term goals.

Below are 10 questions, developed from research, which will help us gauge your involvement in continuous improvement, the benefits you are achieving and your future plans.

We would appreciate it greatly if you could complete this document electronically and email it back to me at:

steve@isspro.co.uk

Your responses to these 10 questions will be held anonymously and collated with other sources of research to help develop a maturity model for implementing change in academia using Lean Six Sigma techniques. After the 10 questions is a free text area where you can make comments and contributions beyond the questions asked.

I have also attached a consent form and my code of ethics policy which I would appreciate you returning signed copies along with your questionnaire responses.

Your contribution is greatly appreciated, and please feel free to forward this document onto your colleagues if you feel it is of interest.

Kind regards

Stephen Anthony

Question:	Grounded In Research
1. Are you currently undergoing, or planning to implement, a continuous improvement programme / change agenda within the university**? I currently facilitate and mentor Lean Six Sigma projects at my university.**	Maleyeff (2014), Mehmood et al 2012, Shahmandi et al 2011, Temponi (2005)
2. What is your objective, or reason for undergoing this continuous improvement programme / change agenda? **My objectives are two-fold, one students from my Lean Six Sigma courses work on the projects for experiential learning and the departments who sponsor the projects (whether with students participants, or facilitated by me) want to improve their processes from a quality and efficiency perspective.**	Radnor and Walley (2008), Jenicke et al 2008
3. How will success of this continuous improvement programme / change agenda be measured? **We define Critical to Satisfaction (CTS) metrics for each project. The process owners/ project champions are responsible for maintaining the metrics.**	Manville et al (2012), Snee (2011), Siddique et al 2011, Sakthivel (2007)
4. Are you using a methodology, philosophy or structured approach, such as Lean or Six Sigma, for this continuous improvement activity - if so what kind of approach are you using? **Lean Six Sigma combined.**	Hines and Lethbridge 2008, Heuvel, 2005, Antony (2014), Jenicke and Holmes (2008)
5. Are you utilising outside expertise to assist in the continuous improvement programme / change agenda? **No**	Kurniawan and Puspitaningtyas (2013), Kumi and Morrow (2006)
6. Does the higher educational institution have a history of successful projects, change programmes or continuous improvement activity using structured approaches such as Lean, Six Sigma or Lean Six Sigma or your chosen approach? **Limited success, just at the beginning**	Azis and Osada (2010), Antony et al (2012)
7. Who is leading this continuous improvement programme / change agenda and where do they sit within the organisation? **Grassroots effort, no defined leader.**	Snee's (2007), Snee and Hoerl (2002)
8. Who is responsible at board or executive level for strategy and vision of the continuous improvement / change agenda? **No one**	Collins (2001), Loethen (2008), Bryman (2009)

9. What characteristics, competencies, knowledge, skills and behaviours within the leader/leadership team were particular required for this programme to be given the best chance of success? **No leadership team or steering committee defined yet.**	Mayo and Nohria (2005), Emiliani (2013)
10. How will the institution sustain any gains and successes made through the continuous improvement programme / change agenda? **Gains will be the responsibility of the project champions, project-by-project.**	Antony et al (2012), Jenicke and Holmes (2008)

Table 1.

Notes:

No additional notes added to this survey response.

Example of case study / structural interview questions and responses:

Type: Group interview

Time and Date: 10am, 18th January 2017

Duration of interviews: 2 hours, plus a site tour and project case studies shared

Opening statement: - Privacy statement, sharing ethics policy and request for consent form completion:

Questions: (partially steered by the original questionnaire, partially steered by the interviewee's responses)

Thank you for taking the time today to help with my research, can you explain a little about your institution, the team you work in and the LSS journey you are undertaking?

The continuous improvement team has been in place since 2011 under the title of Process Improvement Unit (PIU). Originally under the remit of the IT department. The team moved in 2015 to be under the Student Services team – giving them a wider remit to explore administrative processes, rather than just IT and system based projects across the schools within the institution.

What are the objectives of the PIU? How are you measured on your performance?

From day one, the team was set three performance metrics by the VC. Specifically, these are: Staff/Student Satisfaction, Processing Time and Cash Savings. In addition, project specific KPIs can be added to these three strategic metrics. It does vary from project to project but we are held accountable by our structures and VC.

How is the team led, or sponsored at senior management level?

The PIU team report into a steering committee which was chaired for the first 5 years by the Vice Chancellor (VC) and has only recently been handed over to the deputy VC as their role changed.

The VC was instrumental in setting up and launching the team and getting buy-in from senior managers and departmental heads – for example by entertaining them at his residence and insisting continuous improvement is here to stay.

How big is the team today?

Although we originally struggled to recruit and currently have four posts – with a 5th starting in late 2018, this team is the biggest team in place compared to other universities we know about. The 5th post will be a data collection position since the team and the VC believes that to maintain unbiased data in the projects, it must be collected independently.

What type of projects and how are you delivering these projects now you are part of the wider student services team?

The team has used a mix of Rapid Improvement Events and DMAIC projects to deliver over 40 change projects across the administrative functions. This has allowed the development to create several internal case studies to support the “selling” of process improvement to a wider audience.

The team has some experience of working outside of the administrative fields, with two projects infiltrating the teaching and research fields – including capital equipment requests for PhD students and the part time PhD process.

Have you tried applying projects to teaching or research processes?

No pure teaching and research processes have been tackled yet. But it is our hope to do so in the coming years.

Is there any key learning or experiences which you believe have contributed to your successes with these projects?

Language has been key to the success of the team. For example the team is called the process improvement unit, the word standardisation has been replaced with Process Consistency, and language such as Lean and Six Sigma are avoided. We have also changed the classic DMAIC model. Control has been replaced with continuous improvement. This has prevented people reacting to language in ways they have in the past.

Do you have any formal in-house training programmes for staff or use external training providers?

Formal training programmes exist for “doers” and “sponsors” on projects, and also general awareness sessions are delivered throughout the year. Most are delivered in-house by the team themselves.

Are you recognised outside of your areas of influence?

The team is recognised as a useful resource by departments and is involved in several large university wide reviews of service in addition to delivering local projects for departments – there is a vision by the VC that all processes should be reviewed every 5 years to match the changing needs of the academic sector, which we are trying to focus our activity on at the moment.

Notes from site tour and project examples shared:

There are examples of statistical tools being used – for example simple SPC charts to track administrative departmental performance. Visual management is in place to promote projects and activity.

Example of informal feedback from a Master Black Belt – lifted from an email, name withdrawn as requested by client.

Hello Stephen,

Please see my comments, I'm a little removed from things these days as I've gone into more of a technical role with the automation of management information (Using Microsoft Power BI, ArcGIS online,FME etc). All good lean stuff with lots of time/efficiency savings and I still cross over now and again using some of the tools so have commented where I can.

- The language of the model

  Good clear language which is easy to understand. If it's clear to me then that's good sign.

- The themes, characteristics and levels

  All the themes and characteristics I can think of are identified.

  Initially thought having 5 levels would be hard to clearly distinguish each level from another but it works well and very clear to see the difference in levels.

- The content of each level – is it a fair description for example of a "green" organisation?

  If I had to make an assessment on OS using the model its clear we would fall into different levels in different themes/characteristics based on what we are good at and where we need improvement. I guess this is the idea of the scoring and means an organisation could well fall into different levels so maybe tricky putting an organisation at 1 level like Green.

- Its strengths, weaknesses and most importantly – is there anything missing

  It gives a very clear indication to how far an organisation is progressing on the Lean Six Sigma Path and highlighted to me why OS has possibly not been able to fully embrace Lean Six Sigma. Eg Leadership not coming from the top and how projects are selected etc.

  Something a bit more interactive with a drill down etc would make it easier on the eye and easier to follow. Probably need the best of both worlds. As it is now is great for see all the information in one place but something like a PowerPoint presentation drilling down each Theme with a few visuals would work I think.

  Looks a good piece of work so far.

Cheers

XXXX XXXXX

Business Information Consultant

Master Belt

Ordnance Survey