Lean Six Sigma
in Higher Education

Edited by
Jiju Antony

A Practical Guide for Continuous
Improvement Professionals
in Higher Education

Lean Six Sigma in Higher Education

Praise for Lean Six Sigma in Higher Education

'Higher Education institutions create true value when knowledge is being developed and transferred. Today's Higher Education institutions however comprise of many processes that are supportive to these purposes, but in itself do not create true value. This book is an excellent guide for managers and professionals in the Higher Education sector looking for process or product optimization within their institutes. It guides in separating value adding from non-value adding or even wasteful activities, and provides practical aids and tools for process optimization in the Higher Education sector.'

– **Bart A. Lameijer**, *Assistant Professor and Senior Consultant, University of Amsterdam Business School, Netherlands*

'The importance of a long term strategic improvement framework for Higher Education has never been more necessary than today. Many attempts have been made by external policy makers in government, or internally by career administrators. Most have failed miserably to make any improvement in efficiency or effectiveness over the past 30 years. Costs have gone up and Quality has come down. Professor Jiju Antony and his team have gone outside of Academia to study the use of principles, tools and techniques with a proven track record in Manufacturing, business and service organisations. It is shown without doubt that Lean Six Sigma in Higher Education is needed right now! The book breaks down many myths and misconceptions about Lean Six Sigma and I encourage all administrators, leaders and policy makers to give this book a chance and read it with an open mind. Lean Six Sigma is a game-changer for Higher Education...and it needs to be given an opportunity to show its power.'

–**John Dennis**, *Chairman International Lean Six Sigma Institute, UK*

'This is another piece of art for the entire Lean Six Sigma global community! Higher Education (HE) is definitely an area full of improvement opportunities and Lean Six Sigma can be a critical component to change this game. The Editor of this book has addressed this topic brilliantly by showcasing a collection of articles including a dedicated chapter on the tools and techniques of LSS relevant to Higher Education context. This is a must-read book not only for academic leaders in HE but also for all continuous improvement practitioners that aim to promote a positive impact in this area.'

–**Marcelo Machado Fernandes**, *MF Operational Excellence, ASQ Certified Master Black Belt, Minitab Certified Trainer, Brazil*

Lean Six Sigma in Higher Education: A Practical Guide for Continuous Improvement Professionals in Higher Education

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INVESTOR IN PEOPLE

Dedicated to my wife Frenie Antony and my daughter Evelyn Antony

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Preface

Businesses today are always on the lookout for ways to improve their bottom line by systematically eliminating waste from business processes as well as reducing unnecessary or undesirable variation in business processes which result in defects, errors or even failures leading to customer dissatisfaction. Lean Six Sigma (LSS) has become predominant in many fields. It is among the most common continuous improvement methodologies today. And while other industries, namely, manufacturing, service and some public healthcare services have adopted LSS to improve operations and focus on efficiency and effectiveness, Higher Education Institutions (HEIs) have largely been impervious to such continuous improvement efforts.

HEIs have been a cornerstone in educating society's leaders, an incubator for advanced technologies and an accelerator for economic development. The situation within the Higher Education (HE) sector is very similar to that of firms within the manufacturing and service industry – facing fierce competition, limited budget availability, government funding slashed, and students adopting a consumer approach to their learning. There are a few books on Lean in Higher Education, but the editor and contributors of this book would like to highlight the point to readers that both Lean and Six Sigma or even its integrated approach (Lean Six Sigma) can equally be applied to improve the efficiency and effectiveness of business processes in the HE sector. Moreover, only some problems can be tackled using the Lean approach in our view and hence the integrated approach can be more beneficial for tackling problems where variation is the primary issue (e.g. variation in turnaround times, variation in recruitment times of research staff for funded projects, etc.).

Higher education has become a competitive enterprise, with the characteristics of an organization that must compete for scarcity, as students replace funding from state resources. As universities compete for status and rank, the competitive nature can contribute toward a decline in the sense of academic mission, community and values. The ability to maintain the academy requires effort from a variety of resources, disciplines and ideas as the commercialization of higher education strains the social mission. LSS as a powerful Operational Excellence strategy is one contributing effort that can impact these trends of massification of the academy, and we hope the literature presented in this work will support a concerted effort to respond to the concern for quality in Higher Education.

This book is a collection of articles written by a number of contributors from three continents: Asia, Europe and North America. The book is a carefully edited

work by an academic and a practitioner of Operational Excellence based in the Higher Education sector. The book encompasses state-of-the-art literature review on LSS in HE sector, case studies of LSS in HE, tools of LSS which can be used in HE, challenges in the implementation of LSS in the HE setting, significance of Voice of the Customer, LSS Maturity Model for HE and emerging trends in the area. This book will benefit students, researchers, professional staff who would like to engage in process improvement projects in HE environments, and academics who would like to understand the concepts of Lean Six Sigma, as well as the challenges and barriers in the implementation and sustenance of this powerful Operational Excellence methodology. I firmly believe that the applications of LSS in HE will continue to grow over the years and this book is very timely. The book can be a great resource for training staff members in the HE sector or for self-study to understand the challenges in the implementation. Moreover, it provides the most powerful tools of LSS which can be used in Higher Education setting for problem-solving scenarios. Finally, I would like to thank all readers who are using this book for the LSS journey, and we wish the very best of luck with your endeavours.

Acknowledgements

I am deeply indebted to a number of people who, in essence, have made this book what it is today. First, and foremost, I would like to thank a number of contributors who have devoted their time in writing a chapter or chapters for the book. I am most grateful to the reviewers of the proposal and sample chapters for their invaluable suggestions that guided the preparation of this book. It is my sincere hope that by reading this edited book, you will find something new which will challenge your personal thoughts in a new way. Your suggestions and constructive feedback regarding the contents of the book will be taken into account, and I will do my best to overcome any shortcoming in the future editions of this book. Finally, I would like to express my sincere thanks to my family for their encouragement and patience as the book stole countless hours away from family activities. Finally, I take this opportunity to thank Emerald Publishing for their incessant support and forbearance during the course of the project.

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Chapter 1

An Overview of Lean Six Sigma*

Jiju Antony, Roger Hoerl and Ronald Snee

1.1 Introduction

This chapter is an overview of Lean Six Sigma (LSS) as a powerful Operational Excellence (OPEX) methodology adopted by many Fortune 500 organisations around the world. OPEX has become an important strategy for many organisations today across the globe, despite of their nature and size. This includes manufacturers, financial service organisations, healthcare services, public sector organisations and most recently third sector organisations. Development of an effective OPEX strategy is a key factor for long-term success of modern organisations. Over the last decade, LSS has become one of the most popular and proven OPEX methodologies organisations ever witnessed in the past.

The concept of Lean Thinking (LT) developed from Toyota Production System (TPS) involves determining the value of any process by distinguishing value-added activities or steps from non–value-added activities or steps and eliminating waste so that every step adds value to the process. Lean focuses on efficiency, aiming to produce products and services at the lowest cost and as fast as possible (Antony, 2011). The commitment to LT must start at the top management level and should be cascaded down to various levels across the organisation to improve flow and efficiency of processes.

Six Sigma was developed at Motorola by an engineer Bill Smith in the mid-1980's. Six Sigma is a business improvement approach that seeks to find and eliminate causes of defects or mistakes in business processes by focussing on process outputs that are critical in the eyes of customers. Six Sigma principles can be used to shift the process average, help create robust products and processes and reduce excessive variation in processes which lead to poor quality (Shah, Chandrasekaran, & Linderman, 2008). The statistically based problem-solving

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methodology of Six Sigma delivers data to drive solutions, delivering dramatic bottom-line results (Snee & Hoerl, 2007).

The term Lean Six Sigma was first introduced into literature around 2000, and LSS teaching was established in 2003 as part of the evolution of Six Sigma (Timans, Antony, Ahaus, & Solingen, 2012). Since that time, there has been a noticeable increase in LSS popularity and deployment in the industrial world, especially in large organisations in the West such as Motorola, Honeywell, General Electric and many others (Laureani & Antony, 2012; Timans et al., 2012) and in some small and medium-sized enterprises (Timans, Ahaus, Solingen, Kumar, & Antony, 2014). LSS has been defined by Snee (2010) as 'a business strategy and methodology that increases process performance resulting in enhanced customer satisfaction and improved bottom line results'.

This chapter addresses three aspects of LSS: the yesterday, then the today and finally the tomorrow. The yesterday aspects of LSS will be presenting the background to LSS, history of LSS and also the rationale behind the integration of Lean and Six Sigma. The today aspects will be looking into a number of themes including, LSS for public sector, LSS and innovation and standards for LSS certification. The tomorrow aspects will be looking into the future trends of LSS, the importance of developing a holistic approach of OPEX in organisations, the synergy between Big Data and LSS for problem-solving, sustainability of LSS and the use of LSS for dealing with human variation.

1.2 Lean Six Sigma Yesterday – The History of Lean Six Sigma

1.2.1 The Launch of Six Sigma

Within this context, Motorola was facing extreme pressures from overseas competition, particularly Japan. While it is impossible to set a definitive date for the beginning of Six Sigma, around 1987 Bill Smith and others began improvement projects that in many ways looked similar to TQM projects. Eventually, Mikel Harry and others helped Smith formulate this approach into an overall business initiative aimed at protecting Motorola's pager business. They named the initiative 'Six Sigma' based on the desire to reduce variation to the extent that specification limits for key process metrics were six standard deviations away from target.

Importantly, Six Sigma provided an overall 'roadmap' within Motorola, or problem-solving process, known as MAIC, which stood for measure, analyse, improve, control. MAIC effectively linked and integrated the individual tools. Therefore, employees could be trained in this one approach that was generic enough to be applied to a wide variety of problems, eliminating the need to reinvent the wheel with each new project. In addition, Six Sigma received clear management support, including supporting infrastructure, such as line items in budgets, resources, project selection systems, and so on.

Motorola achieved tangible results, and other organisations began to take notice. Honeywell and AlliedSignal, other organisations in similar markets to Motorola, launched Six Sigma initiatives around 1990. These also met with

success. However, it was when GE CEO Jack Welch loudly proclaimed that GE was jumping into the Six Sigma game in late 1995 that the initiative moved off the back pages of the business section to the front page of the newspaper. Welch told Wall Street analysts that Six Sigma would be the biggest initiative ever launched by GE, and that it would be his personal number one priority for the next 5 years (Welch, 2001). Even before results started to pour in, GE stock began to rise sharply, and many other companies started looking more closely at Six Sigma.

GE also played a very significant role in the development of Six Sigma as a methodology. After some projects stalled because there was a lack of clarity on the specific problem being addressed, and on the overall objectives, GE decided to add a 'Define' step at the beginning of the MAIC process and created the process we now know as DMAIC (Hoerl, 2001). The Define step became critical – a make or break step that often determined long-term success of the project. The need for careful problem definition is well-understood among those researching problem-solving in general.

Based in part on GE Capital's success, other financial institutions began Six Sigma initiatives. One of the most successful has been by Bank of America, which was publishing savings in the billions of dollars annually. Similarly, Commonwealth Health Corporation launched the first major Six Sigma deployment in healthcare in the late 1990s and produced millions of dollars of savings in the radiology department alone within a year (Snee & Hoerl, 2005).

In the late 1990s and early 2000s, a large number of organisations, in diverse industries, launched Six Sigma initiatives, including DuPont, Dow Chemical, 3M, Ford and American Express, to name just a few. The US military began major investments in Six Sigma at this time as well. Overseas, companies in Europe and Asia began to implement Six Sigma to varying degrees, particularly Korean companies such as Samsung.

1.2.2 A Brief History of Lean

Lean has had somewhat of a tangential development history to Six Sigma. Much of what we call Lean Enterprise today is based on the TPS (Womack, Jones, & Roos, 2007). Of course, the TPS has roots that go back to Henry Ford's development of the assembly line and Frederick Taylor's work. This approach to manufacturing cars, which emphasised removal of all types of waste, including non–value-added human motion, began taking shape at Toyota in the 1930s and has progressed ever since. Krafcik (1988) is generally credited with the first use of the term 'Lean manufacturing'.

In our view, there is some confusion between Lean and the TPS, in that some authors use the term Lean to refer to any business practice utilised by Toyota, while others use Lean to refer to a specific set of principles and tools (George, 2002). For clarity, we will refer to Lean Enterprise as the set of principles and accompanying tools outlined in George (2002), MacInnes (2002) and other sources that see Lean as based on TPS, but having a unique identity from Toyota.

While Six Sigma focused on collecting data in order to apply statistical methods to solve baffling problems, Lean was generally applied in a more knowledge-based approach, by applying time-tested principles, such as reducing inventories, pull versus push production systems, line of sight, continuous versus batch processing, cell manufacturing and so on, to reduce waste and enhance productivity. That is, while knowledge and data were needed by both methodologies, one can be reasonably accurate in generalising that Six Sigma was more data oriented and Lean was more oriented on applying proven principles based on knowledge and experience. All processes have waste, and sound principles can be applied outside of manufacturing to reduce waste and improve productivity. For example, the principle of line of sight – being able to physically see the production line – can be applied to financial transactions, in that those working in the financial process should have process transparency, in order to be able to 'see' the process in operation, at least electronically. Workflow-based IT systems are one example of providing line of sight to financial systems.

1.2.3 The Marriage of Six Sigma and Lean

Because both Six Sigma and Lean had produced tremendous results, but had limitations, some type of integration of the two was appealing and made intuitive sense. Books and seminars on the topic of LSS began to appear in the early 2000s, such as George (2002). As noted previously, Lean is not well suited to resolving complex problems that require intensive data analysis and advanced statistical methods.

Conversely, those implementing Six Sigma found that not every problem needed several months of data collection to resolve. Do we really need to collect data for 3 months in order to repave a parking lot that has potholes? Quality professionals found that Lean principles could be broadly and effectively applied with minimal data collection and achieve immediate benefits. Then, for more complex problems requiring intense data analysis, Six Sigma could be utilised. In our view, the key questions to ask when considering a Six Sigma versus Lean approach are

- Is the solution known or unknown?
- Is the root cause of the problem believed to be in a value-adding step in the process, or in the linkages between value-adding steps?

We have found that in many Lean applications, what must be done is known; we just need a method and tools to implement the known solution. This is because Lean is primarily a set of known principles, as opposed to data analysis techniques. The second question points to the fact that the principles of Lean are focused on the flow of information and material through the process. Therefore, if the root cause of the problem is a flow issue – in the linkages between value-adding steps – Lean is likely to work well. Conversely, if the root cause of the problem is in a value-adding step, Six Sigma is more likely to succeed for such problems. Fig. 1.1, from Snee and Hoerl (2007), illustrates this point.

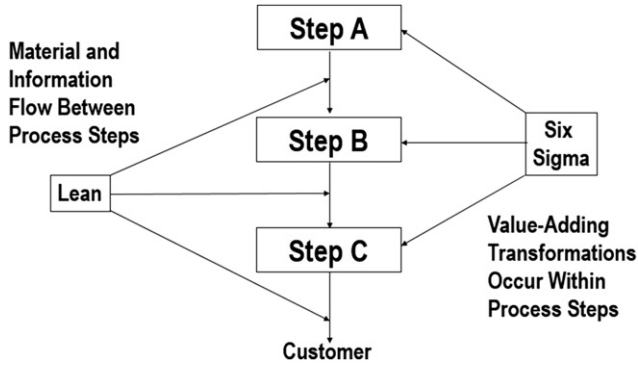

Fig. 1.1. Process View of Lean Six Sigma.

The key point is that organisations need to avoid having 'favorite' methods that they apply to all problems, even if the method is not suited for that particular problem. Integrating Six Sigma and Lean into a broader approach called LSS has enabled many organisations, including GE and many of those mentioned previously, to solve more problems quicker and enhance the bottom line faster. It can be considered state of the art in improvement at the time of this writing.

1.2.4 Lean Six Sigma Today – The Current State of Lean Six Sigma

This section presents the today aspects of LSS which includes LSS for the public sector, the link between LSS and Innovation, standards for LSS certification and the current burning issues around the certification process.

1.2.4.1 Lean Six Sigma for Public Sector Organisations

Although Lean has been widely used by many public sector organisations in Europe, the use of Six Sigma and LSS are in their early stages. The challenge for many public sector organisations today is to reduce spending, while retaining or even improving the efficiency and effectiveness of service delivery. Using LT, we need to reduce waste and maximise the value-added activities for customers, and by using Six Sigma, we need to deliver consistent services by reducing process variation. Some of the benefits of utilising LSS in public sector organisations include

- Costs associated with fire-fighting and misdirected problem-solving efforts with no structured or disciplined methodology could be significantly reduced
- Increased understanding of the VOC (Voice of the Customer) and the associated CTQs (critical-to-quality characteristics, e.g., teaching quality of a professor in a university sector) which will have the greatest impact on customer satisfaction

- Reduced number of non–value-added operations through systematic elimination, leading to faster delivery of service, faster lead time, faster cycle time to process critical performance characteristics to customers and stakeholders, etc.
- Transformation of organisational culture from being reactive to proactive thinking/mindset
- Many managers lack statistical knowledge and the ability to apply statistics to problem-solving. LSS provides a fundamental framework for managers to use practical and proven applied statistical tools and techniques for problem-solving in public sector organisations
- Greater responsiveness and flexibility to meet customer needs

1.2.4.2 Lean Six Sigma and Innovation

Xerox has seen impressive results by pairing its LSS initiatives and innovation teams together to drive product development. Recently, the use of LSS techniques during an innovation project resulted in millions of dollars in total savings and nearly 50% return on investment for Xerox (Hildebrand, 2010). As Bisgaard (2008) explains, innovation can be either incremental innovation – making modest enhancements to an existing product or service – or radical, 'disruptive' innovation – delivering something totally new to the marketplace. Federal Express, when it introduced overnight mail delivery years ago, was also clearly innovative in a radical way, as no other overnight mail delivery service existed at the time, and many thought such a service would be impossible to implement (Hoerl & Gardner, 2010).

Antony et al. (2014) have carried an exploratory study in 10 UK-based companies to explore the relationship between LSS and product/process/service innovation. A multiple case study design was employed across manufacturing and service companies in the United Kingdom of varied size. The companies participated in the study have been involved in LSS implementation for a minimum of 3 years. The findings of the study have clearly indicated that companies engaging with LSS initiatives experience a positive effect of LSS on Incremental Innovation and Innovation Capability.

The study has also looked at the perceived enablers and hinders of innovation in LSS organisations. The perceived enablers include senior management openness, recognition of the best ideas, a communication system that allows the free flow of ideas, top management attention and their support, culture of the organisation, a learning environment and so on. The perceived hinders include organisations with no learning culture, silo mentality, poor or weak leadership that does not support innovation, poor communication, etc.

1.2.4.3 Standards for Lean Six Sigma Certification

LSS has no globally accepted standard for certification: the proliferation of schools, organisations and training providers that now offer some level of certification has led to a wide variation in assessment criteria, leaving many hiring managers, recruiters and continuous improvement leaders sceptical of external

certifications. Some certifications currently existing on the market do not require to prove some technical competence or to show project work: you can indeed pay to attend a small course and get a certificate, without ever actually doing a project (Laureani & Antony, 2011). In authors' opinion, American Society for Quality Certifications represents a third party and has gained acceptance for Master Black Belts as well as Black Belts and Green Belts.

The actual set of tools and theories in the background of LSS, which ultimately stems from the Quality Management and Quality Engineering gurus like Deming, Juan, Crosby, Ishikawa, Feigenbaum and Taguchi, are the same across industries, hence a common Body of Knowledge. The differences in application of the principles should be reflected in the Body of Experience and the type of projects used for certification. As in any other discipline, the evolution of the field, and the emphasis on application of the tools, is such that only with constant practice can a certified practitioner retain mastery of the tools: as a result, it is advisable to require practitioners to either recertify or remain involved in professional development activities to retain certification (Laureani & Antony, 2011).

1.2.5 Future of Lean Six Sigma …. Getting Better All the Time

Much has changed and much has been accomplished in the world since Six Sigma was introduced by Motorola in 1987. Many organisations around the globe, large and small, have used first Six Sigma and now LSS to become more successful: quality has been improved, delivery times have been reduced, waste has been decreased and customer satisfaction has been enhanced. A critically important by-product of this work has been the saving of billions of dollars around the world. LSS has benefitted organisations of all types, including manufacturing, service, healthcare, government, nonprofits and education. The expansion of the LSS methodology and application of the approach to improvement will continue as new needs and opportunities are encountered. In this section, the authors will be providing some of the future trends of LSS, which include importance of a holistic approach to OPEX in any organisation irrespective of its size and nature, integration of LSS with Big Data for effective problem-solving, sustainability of LSS and the use of LSS for dealing with human variation.

1.2.5.1 Holistic Improvement Strategy and Methodology

Holistic improvement views an organisation as a system which can be optimised (Snee & Hoerl, 2007, 2019). A holistic improvement system can successfully create and sustain significant improvements of any type, in any culture for any type of organisation. Parsing this definition we find 'create and sustain' referring to infrastructure – management systems and resources, continuous improvement culture, leadership development and related issues. Here 'significant improvements' refer to improving performance as measured quality, cost, delivery and customer satisfaction in a way that improves the bottom line. 'Any type of improvement' refers to improving any measure of performance including flow, variation, optimisation, design, improvement and control. 'Any culture' refers to

any country around the globe and any function within an organisation. 'Any organisation' refers to manufacturing, service, public sector and third sector.

The holistic improvement methodology integrates Lean principles with LSS methods and other approaches (e.g., Kaizen, Agile, etc.) that are used as the problem at hand requires. The nature of the problem should guide identification of the approach, rather than assuming that one methodology is ideal for all problems. As the old saying goes, '*if all you have is a hammer, every problem looks like a nail*'. Project identification and selection becomes a critical step, for in this step, the approach to be used to solve the problem becomes apparent. The organisation's improvement system must be robust enough to handle any problem the organization encounters in the course of its improvement work. Integration of multiple methodologies is clearly required.

1.2.5.2 Taking Advantage of Big Data

Data mining has been in vogue for the last 15–20 years. Around 2005, the trend picked up steam with advent of the 'Big Data', which was and will continue to be fuelled by the ubiquitous availability of the Internet and IT hardware and software (Davenport & Harris, 2007). We are now talking about terabytes and petabytes of data, and we now have the software that can help us 'tame' Big Data. The Big Data focus, as with all new developments, is good news–bad news situation.

The Big Data revolution is breathing new life into Lean principles and Six Sigma standards. In effect, it provides back door entry into a data-rich realm of reasoning that can unlock infinite efficiencies and savings when approached in the right way. Big Data offers the opportunity for professionals to solve problems previously thought to be unsolvable. While much progress has been made in medical research and Internet marketing, one area overlooked to date is the use of Big Data in the design and improvement of products, services and process quality. Customer surveys can help us better understand customer needs and experiences. The collection of manufacturing data and integrating it with customer data can help improve products and processes.

The bad news is that most data used in data mining and Big Data studies are what are called 'observational data', in that they are passively collected, rather than produced by carefully designed and randomised experiments. Such data require a close assessment of the data pedigree as typically no study design is used to assure that good data and the right data needed to solve the problem are collected (Snee & Hoerl, 2012). These data often have many limitations which need to be taken into account. On the other hand, many have adopted a philosophy of 'Big Data + Fancy Algorithms = Great Results'.

1.2.5.3 Sustaining Lean Six Sigma

Hardly a month goes by without seeing one or two articles related to sustaining improvement. There are two critical issues within this macro problem: sustaining the improvement initiative itself and sustaining the results of individual improvement projects. There are many reasons for the lack of sustainment including the new procedures not followed, important projects not identified and