



Lean Six Sigma Toolkit for Higher Education

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Literature Review

27th July 2012

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1.0 INTRODUCTION

Globalization has opened new avenues for growing businesses. Markets that were once open only for local players are now filled with foreign retail chains, manufacturing giants and service companies. This has benefitted smaller organizations as the opportunities now to expand and cater to a bigger market are possible and with increased demand, there is an increase in profit. However, to be able to sustain in a market where competition is high, companies have to find ways of satisfying their customers and preventing them to switch to another brand. Different technological advancements and expansions are being undertaken to earn a competitive edge over the rival company.

But expansion and high volume brings along various operational issues that needs to be tackled to function smoothly and efficiently. Achieving the desired quality and standardizing it across all functions and products, making business processes efficient and effective to reduce waste, lead time and inventory in order to satisfy the customer to the fullest on all occasions. As the business grows, the level of complexity associated to these factors grows enormously and the top management must deploy measures to tackle them and prevent them. In addition to this, satisfying the customer or achieving standard quality on each product produced is not a onetime objective and needs to be achieved every single time, with every single product. The improvement has to be continuous and across the organization as the final product or service is a cumulative effort of every department and every individual in an organization

The issues are not limited to manufacturing only and organizations in public or service sector face similar issues. These issues related to quality and efficiency are age old problems, only the complexity has increased with time. Several attempts and innovations have been made in the past to tackle these issues and over the years, they have been refined or advanced. Continuous Improvement initiatives have existed since the early 19th century and different methodologies have emerged to address a wider range and more complex problems.

This report will look into the evolution of quality initiatives through an extensive literature review, study the present scenario in different sectors and look at their application in the higher education after analyzing the present quality and continuous improvement efforts existing in the educational institutions. After identifying the key area of focus, the aim will be to develop a toolkit to address the core problem and further assess if a general toolkit can be developed specifically for the higher education institutions. The last part of the report will clearly define the objectives, the methodology to be used and project plan.

2.0 LITERATURE REVIEW

The quest for Quality goes back deep in the history. This section highlights the gradual developments in this regard and describes the different methodologies or approach in chronological order.

2.1 CONTINUOUS IMPROVEMENT

(Bessant et al. 1994) describes Continuous Improvement as “a company-wide process of focused and continuous incremental innovation”. The figure below further demonstrates the different stages of the Continuous Improvement Model by John Bessant that emphasizes on overall step-by-step learning across the organization for successful Continuous Improvement effort.

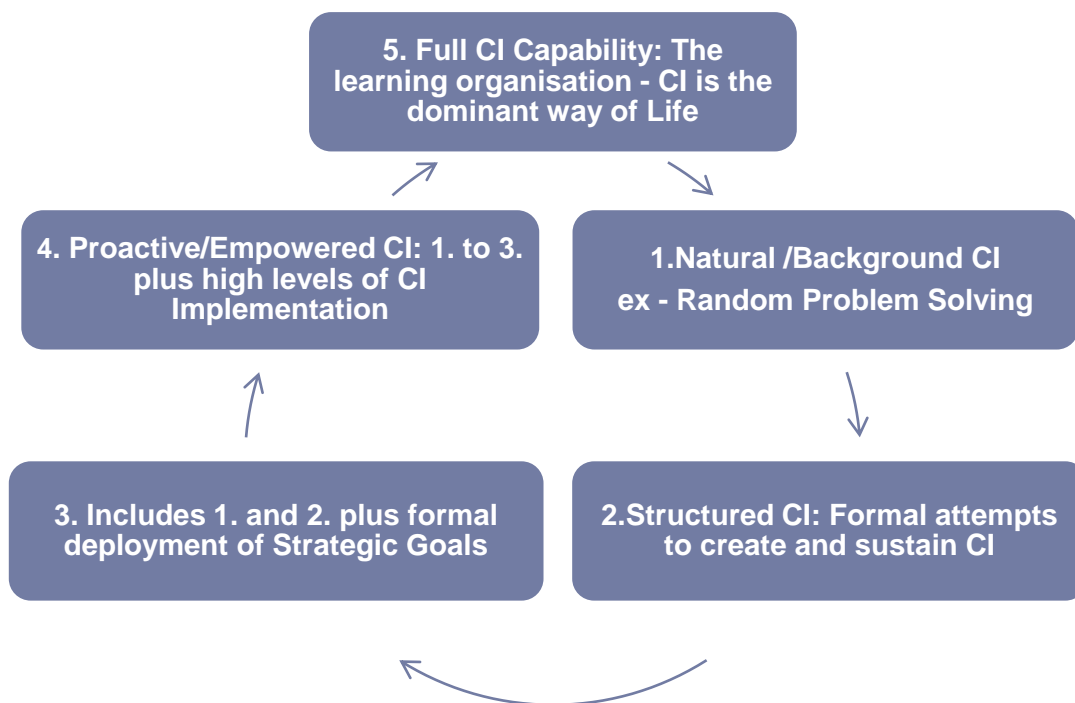


Figure I: John Bessant’s CI Model (Bessant & Caffyn 1996)

As per (Schroeder & Robinson 2002) Continuous Improvement originated in the 19th century and a awards scheme started in 1871 by a Scottish Shipbuilder in Dumbarton named Denny was the first ever suggestion system in the United Kingdom as claimed by Denny himself. Another prominent Continuous Improvement initiative was the origination of the Just-In-Time (JIT) concept at Toyota Motor Corporation where its first president, Kiichiro Toyoda planned to have a flow type production system in the company’s’ new plant in Koromo in 1938 as opposed to mass production to reduce inventory and eliminate need for storage space. During the Second World War, Japan fought against the United States and the Japanese government provided Toyota Corporation with materials to produce trucks as per the demand from the military. This led to problem for the JIT system as the order and the material allocation was from two different agencies and was uncoordinated. After the war

Taiichi Ohno, a plant manager at Toyota took the idea of JIT ahead and over the next two decades mastered its development which was later called as "The Toyota Production System" (Robinson & Robinson 1990). About the same time, Dr. W. Edward Deming, an American statistician was associated with Walter Shewart who worked at Bell Laboratories invented the control chart on May 16, 1924 (Juran 1997). Deming began teaching at the New York University in 1947 and travelled to Japan to conduct lectures on sampling techniques for the Japanese engineers. In 1950 he took a step ahead and moved from being a statistician to a management consultant and later went on to develop the PDSA cycle, an important pillar in the Continuous Improvement of the 20th century (Petersen 1999) (Washbush 2002). The second half of the 20th century saw further developments in the field of Continuous Improvement and different methodologies were established. The following is a brief description of these in a chronological order.

1900

2.1.1 QUALITY CONTROL

Statistical Quality Control can be defined as "a process that ensures that the output meets standards" (Yasin, Green & Wafa 1991). (Cheng 1990) claims that the Egyptians were the first to begin standardizing measurements, about 5000 years ago. 2000 years later, Egyptians, Greeks and Romans established standards of measurement for trade. However, as narrated by Juran in (Juran 1995) the first wave of statistical quality control was the initiative from Bell Telephone Laboratories to make use of newly invented Shewart control charts, using Probability theory to put scientific sampling inspection in place to evaluate the quality of telephone products that were produced. Later during the World War 2 there were shortages and resulted in declining quality. The army had to struggle to meet the requirements and the minimum level of quality. Generally, contracts were awarded based on bidding and the quality was examined through sample inspection or in some cases every single item was inspected for quality. The same approach was put to use during the war that experienced expansion of inspection teams which led to other problems related to recruitment. To deal with the situation teams were formed and professors of Statistics were appointed that gave free training across the country teaching topics such as Probability theory, sampling theory and Shewart Control Charts. Several engineers also attended this course and soon a new job category came into existence called the Quality Control Engineer. Post war period saw huge shortage in general supplies and the focus was on volume to meet the demands which severely brought down the quality. There were several Statistical Quality Control Programs run during the war as the expenses were paid by the government. However, the several departments set up that were tackling quality issues using tools such as control charts were now vulnerable of the next economic recession. In addition to this, there was a very extensive use of control charts but wasn't put to use correctly. As a result there was a divide in opinion and where one group favored SQC and the other favored operations that was directly related to the production. Marking the decline of SQC, there was a general downsizing and a rising belief that quality should be based on data analysis and not purely on sensory experience.

W. Shewart

Statistical Quality
Control

2.1.2 QUALITY ASSURANCE

World War 2

Quality assurance can be described as the contract or agreement between a service provider and its customer guaranteeing that the agreed level of quality will be delivered. One of the main requirements for this assurance is a Quality team that would review the quality standards, produce guidance notes and monitor the implementation of new legislation (Tattersley 1991).As stated by (Juran 1995), Post World War 2, a US Air Force review suggested a twelve times increase in the inspection force to cope with the huge wartime purchases. Due to problems related to recruitment and performance, a new approach was adopted to establish quality assurance under government surveillance. This approach was initially limited to military but later adopted by industries catering to general public. Pre World War period, a major portion of the Japanese budget went into building strong military front which paid off during the World War but during these years before the War, foreign exchange and general economy was affected and it was difficult to export high quality products. As a result, during the Post World War period, emphasis was on achieving the country level objectives by deploying peaceful activities and increasing foreign trade. The country soon realized a need to change its image as a good quality supplier. Gradually Japanese companies started competing with the US counterparts and this led to a chain reaction where companies started looking for alternatives and avenues for quality improvement.

2.1.3 TOTAL QUALITY MANAGEMENT

1949
JUSE

Total Quality management can be defined as a management methodology which has a clear problem statement that properly defines the measurement criteria, the time scale and the steps to be taken in solving the problem (Raisinghani et al. 2005).Another description suggests that Total Quality Management is a continuous effort to achieve excellence by establishing the appropriate skills and attitudes in the individuals of an organization to avoid defects and achieve complete customer satisfaction (Lakhe & Mohanty 1994). (Powell 1995) states that the birth of Total Quality Management dates back to 1949 when the Union of Japanese Scientists and Engineers (JUSE) formed a committee aimed at improving Japans overall productivity and quality of life. There were quality control programs introduced widely and soon it was evident that the philosophy of Total Quality Management can be successfully extended to public and service sector as well.



Figure 2: The Total Quality Management Evolution (Mangelsdorf 1999)

As the figure above suggests, it was the effort that had seen the evolution of Quality from mere sample examination to assurance under surveillance, but now there was a need for higher emphasis on the processes that produced products and services (Mangelsdorf 1999). As mentioned before, the post-war produce from Japan started eating into American share of markets and soon across America, the need to embed higher quality in their produce to compete with the Japanese was felt. Total Quality Management was the first quality approach and there was a sudden rush to embrace Total Quality Management and apply Deming-Juran ideas of quality in their respective businesses. This period also saw several books on Total Quality Management being introduced and it soon became a hot topic not only in manufacturing, but also in public sector as well as service sector (Goldman 2005).

2.1.4 LEAN

As mentioned before, in the post war period, Taiichi Ohno, a plant manager at Toyota Automobile Corporation continued the use of Just-In-Time developed by Kiichiro Toyoda and championed it over the next two decades. The concept of Just-In-Time that was developed to enable flow type production gradually developed and was used to reduce waste from the process. There were several innovations within Toyota to fight the scarcity of resources and growing domestic competition. In addition to Just-In-Time, the Kanban method, respect for employees and high level automated problem solving etc were some of these innovations. This approach of waste reduction saw expansion to vehicle assembly in 1960's and later to the wider supply chain in 1970's under the leadership of Taiichi Ohno. This methodology was called Toyota Production System and had not been shared with the rest of the world but later was introduced when Kanban system was shared with the suppliers (Holweg 2007)

Toyota Production System developed into Lean Thinking. Following are the seven forms of waste:

1. Transportation – movement of production parts unnecessarily
2. Inventory – High level of inventory for production or delivery
3. Motion – Movement of individuals unnecessarily while working on products
4. Waiting – Waste of time by individuals who need to wait to begin the next step in a production line
5. Over-processing – additional non value adding steps in production of a product
6. Over-production – unnecessary production of products not needed
7. Defects – defects in the products produced (Womack & Jones 2003)

Just – In – Time

Toyota Production System

TIMWOOD

These were identified by Taiichi Ohno using Lean philosophy. Lean thinking was based on the following five principles:

1. Specify value – Customer identifies the value of a product and this opinion of the customer is disturbed by that from the organization, especially the engineers and experts. This does not help the customer
2. Value Stream Identification: This shows all the necessary steps in the journey of a product from raw state to finished item.
3. Flow – Get rid of departments that execute a single task process on large batches. The steps that create value should flow
4. Pull – the customer must demand the product as opposed to it being pushed into the market for the customer.
5. Continuous attempt to achieve Perfection – The process of achieving perfection is continuous and there is no end to reducing waste, defects and costs. (Womack & Jones 2003)

Motorola, USA

2.1.5 SIX SIGMA

Six Sigma was developed by Bill Smith, an engineer at Motorola that aimed at almost eliminating defects and reducing variability in process (Antony 2006). Many companies such as General Electric, Honeywell, Sony and Ford followed the footsteps of Motorola after observing the success of Six Sigma and adopted the methodology (Bhuiyan & Baghel 2005). Six Sigma methodology aims at reducing the variation within the tolerance or the product specification limit (Antony 2011). The use of Greek letter Sigma in the name of the methodology is because it represents statistical measure of the capability of a process to produce no defective products. Statistically, Six Sigma means 3.4 defects per million opportunities (DPMO) (Klefsjö, Wiklund & Edgeman 2001). Six Sigma uses Define-Measure-Analyze-Improve-Control (DMAIC) quality improvement framework that uses statistical tools and quality management principles to improve the quality of product and services and meet customer demands (Tang et al. 2007)

Six Sigma initiatives require top down commitment from the senior management defining the scope and objectives of the projects and the allocation of resources. Training of suitable candidate in the organization who will be able to devote all of their working hours towards the implementation of Six Sigma in the organization is also important. Every individual in the organization is required to undergo Six Sigma training for its successful implementation across the organization (Raisinghani et al. 2005).

D-M-A-I-C

The following are the critical success factors for successful implementation of Six Sigma in an organization:

1. Management Involvement and Commitment:

For the success of Six Sigma initiative it is important for the people in the top management to actively participate and promote it across the organization. This is vital as has been observed in the case of Motorola, General Electric, etc.

2. Cultural Change:

Six Sigma implementation requires adjustment throughout the organization and in order to carry it out smoothly, the cultural change needs to be handled correctly. These can be in terms of employee behavior, general perception etc.

3. Communication:

Six Sigma is an organization wide change and it is imperative to have a communication plan to spread information about the Six Sigma projects in order to motivate them and to earn their support.

4. Organisational Infrastructure:

Six Sigma projects require a set of resources and financial investments in order for it to be successful. In addition to that there needs to be regular interaction, teamwork, strategic vision etc.

Critical Success Factors

5. Training:

Six Sigma has different levels of training depending upon the belt certification. Hence, training is very important to explain the uses and the application of the various tools and techniques of the methodology

6. Linking Six Sigma to Business Strategy:

To bring about overall continuous improvement, it is important to link the Six Sigma initiative to the core business processes and hence make Six Sigma an integral part of the business strategy

7. Linking Six Sigma to Customer:

Six Sigma projects should ultimately benefit and meet the requirement of the customer. In order to do that, the customer's expectation should be clearly defined.

8. Linking Six Sigma to Human Resources:

Six Sigma projects require a change in behavior of the employees during the change across the organization. Therefore, Six Sigma in Human resource activities, to encourage desired behavior is important.

9. Linking Six Sigma to Suppliers:

Linking Six Sigma to supplier makes the movement of raw materials, other resources and later the supply of finished products and services more efficient and adds to the company's profit.

10. Understanding Tools and Techniques:

This factor emphasizes on the importance of having an understanding of the methodology, tools and techniques surrounding LSS. How well the employees understand Six Sigma methodology will influence how well they can they can tailor it to meet the needs of the organization.

11. Project Management Skills:

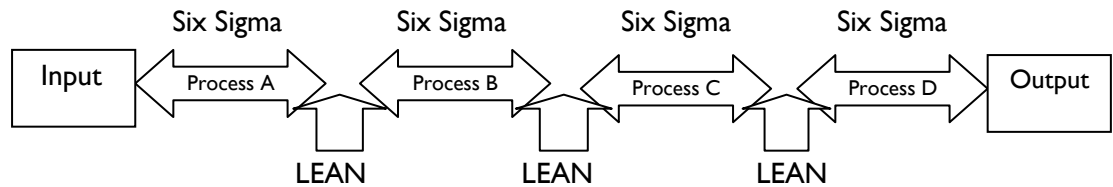
Six Sigma is more effective than the previous Continuous Improvement methodologies as it can define projects. In order to carry out these projects successfully, it is important for the project managers to possess basic project management skills.

12. Project Prioritization and Selection:

In order to achieve maximum benefits from the projects, it is important to prioritize them and align them with the business goals and objectives. (Coronado & Antony 2002)

2.1.6 LEAN SIX SIGMA

Lean and Six Sigma are two different methodologies - Lean focuses on reducing waste through its application between the processes while Six Sigma reduces variation while being applied within a process (Antony 2011)



Lean + Six Sigma =
Lean Six Sigma

Figure 3 – Lean Six Sigma Application

However, both Lean and Six Sigma put more weighting on the customer. Lean is focused at continuously producing products without delay and of specifications exactly matching that of the customer requirement. Six Sigma on the other hand pays attention to the critical to quality processes and aims at reducing cost by attacking variability and better yield management (Manville et al. 2012). Any organization applying Six Sigma to reduce variation from their processes will after a certain period of time realize that the benefits begin to fall. Similarly any organization applying Lean will notice a gradual decline in the returns after a certain period of time. Reducing waste alone cannot improve the process entirely and similarly reducing variation still leaves behind waste. (Arnheiter & Maleyeff 2005) Both the methodologies have different set of tools but the skills to use them effectively and appropriately is essential for a better outcome from the project.

Lean tools attack complexity and interactions thereby highlighting avenues where further improvement can be made by using Six Sigma tools and techniques taking the continuous improvement a step further ahead (Pepper & Spedding 2010). The two methodologies are complementary in nature but many Lean tools have been used along with the available Six Sigma toolset at the different stages of the Six Sigma DMAIC methodology. Certain lean tools, in addition to reducing waste also help in identifying the root cause of variation and thereby help a Six Sigma program achieve its main objective (Arumugam, Antony & Douglas 2012).

(Antony, Escamilla & Caine 2003) provides an integrated toolset for Lean Six Sigma methodology as shown below.

Lean Six Sigma
Toolbox

Six Sigma Toolkit	Lean Production Toolkit
Statistical Process Control (SPC)	Setup time reduction (SMED)
Process Capability Analysis	Pull System (Kanban)
Measurement System Analysis	Total Productive Maintenance (TPM)
Design of Experiments (DOE)	Mistake proofing (Poka-Yoke)
Robust Design	5S Practice
Quality Function Deployment (QFD)	Value Stream Mapping
Failure mode Effects and Critical Analysis (FMECA)	SIPOC
Regression Analysis	Just-In-Time
Analysis of Variance (ANOVA)	Visual Management
Hypothesis test	One Piece Flow(Takt Time)
Root Cause Analysis	Kaizen
Process mapping	
Change management tools	

Table 1: Adapted table of Six Sigma and Lean tools for Lean Six sigma approach (Antony, Escamilla & Caine 2003)

3.0 TOOLS AND TECHNIQUES: AN INTRODUCTION

3.1 LITERATURE

This section aims to review the importance of tools and techniques from both lean and Six Sigma toolbox by studying tables and models established in different case studies and articles.

Case Study 1: (Clegg, Rees & Titchen 2010)

This is an article that describes the aim, structure, outcome and conclusion of a survey that was conducted on the internet. The survey was intended at studying the importance of quality management. In order to determine this, generally used tools and critical success factors were studied using the survey. This survey had 238 questions that were based around 77 tools and 30 critical success factors that were chosen from the literature available and other resources. The survey suggested that despite developments in quality management, the basic critical success factors and tools are relevant even today. The survey also confirmed that quality management is used in all the sectors, performs on most of the occasions and a major requirement for its success is training. The survey conducted by using the following table

6

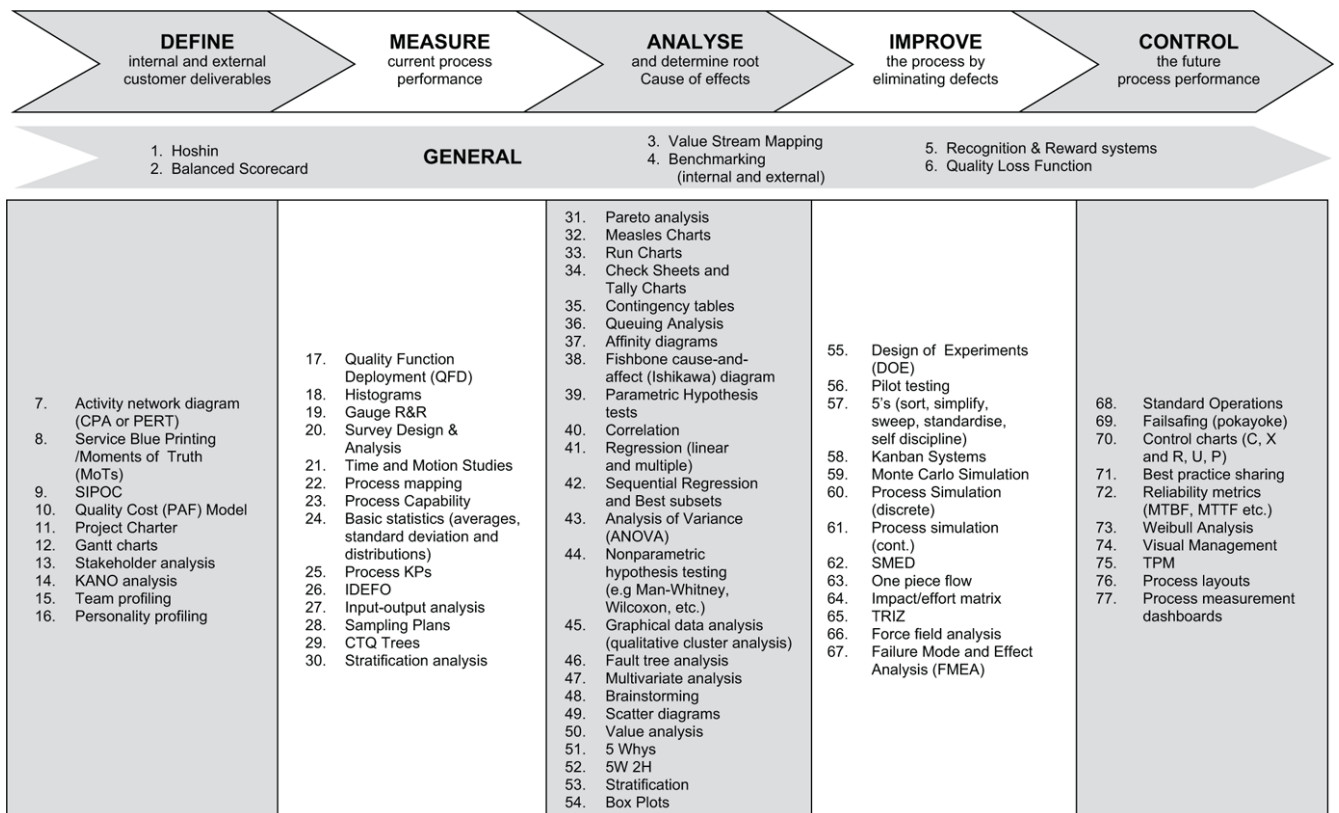


Table 2: 12Tools from the survey (Clegg, Rees & Titchen 2010)

Project Report

This table is unique and very helpful as it clearly classifies the tools as per their application at different stages of the DMAIC methodology. This can also be helpful to form a framework and to identify the correct set of tools relevant to a specific process.

Similarly (Arumugam, Antony & Douglas 2012) has described the different stages of DMAIC methodology and the relevant tools used at each level. Following table is based on this description

DMAIC Stage	Purpose	Tools
Define	Determine project aim, objective, timeframe and financial returns	Process Maps Flow Charts Project Charter
Measure	Identify variable affecting the critical to quality factors	SPC, Measurement system analysis, Cause and Effect Diagram, Cause and Effect analysis, data collection
Analyze	Data analysis and narrow down on variables disturbing the CTQ. Also, assist to choose the right solution from a set	Hypothesis testing, Regression analysis, FMEA, DOE
Improve	Selection and implementation of the solution	Brainstorming, DOE
Control	Control the process where the new solution has been implemented	Control Plan, SPC

Table 3: Purpose and Tools at every stage of DMAIC methodology

Case Study 2: (Antony, Kumar & Madu 2005)

This is the second case study which is aimed at the UK SME's which currently is a popular topic. The article initially discusses the background of these SME's and then the critical success factors of Lean Six Sigma implementation. The paper also enlists the positive and the negative factors of a UK SE based on the available literature and their experience in this industry. The main objective of the survey was to identify the scale of lean six sigma implementation in UK SME's. This survey was constructed based on previous experience and available literature and was sent out to 400 SE's for their feedback. Of all the surveys, only 60 feedbacks could be used and was further analyzed. Apart from various other findings the following table shows one of the findings of this survey.

Tools/Techniques	Familiar	Unfamiliar	Usage	Usefulness
Process Mapping	100	0	4.438	4.600
Project Charter	44	56	3.857	3.500
Cause and Effect Analysis	100	0	4.188	4.333
Histogram	100	0	4.125	4.357
Scatter Plot	94	6	2.333	2.462
Run Charts	56	44	3.111	4.200
Control Charts	94	6	3.267	4.154

ANOVA	88	12	3.429	3.538
Regression Analysis ⁶	94	6	1.800	3.167
DOE	88	12	3.071	3.230
Taguchi Methods	81	19	2.846	3.100
MSA	63	37	2.700	3.500
Non Parametric tests	25	75	2.000	2.333
Hypothesis testing	94	6	1.867	3.571
QFD	69	31	3.273	3.889
FMEA	100	0	3.938	4.200
Poka-Yoke	94	6	3.067	4.083
Process Capability Analysis	100	0	3.188	4.231
Affinity Diagram	31	69	2.400	2.333
Benchmarking	94	6	2.067	3.714
Quality Costing Analysis	50	50	3.000	3.667
SIPOCModel	44	56	3.286	3.167

TABLE 4: Tools and techniques used by SMEs utilizing Six Sigma

This is a very important table and a very important finding from the survey which clearly highlights the important tools and techniques that are being used in SMEs and the ones that are not so popular. In addition to that numerical value to the level of usefulness also classifies the tools in terms of level of difficulty and usage. Also in comparison to the first case study most of the tools are recurring in this table as well. A very important conclusion at the end of the analysis of this table is made in the article which states that individuals prefer to use tools that provide visual information of the process and highlight the key issues as opposed to more advanced tools.

Similarly, (Antony 2004) provides findings as tabulated below, classifying the tools and techniques in terms of ease of use. Studying the findings further, so many different relationships can be identified.

Most Commonly Used Tools	Least Commonly used Tools
Brainstorming;	Quality Function Deployment
process mapping;	Hoshin-Kanri (Policy Deployment)
affinity diagrams;	Kano Model
root cause analysis;	Design of Experiments
control charts;	Statistical Process Control
benchmarking;	Poka-Yoke
Pareto analysis	

3.2 ANALYSIS

As per (Antony 2004), one of the critical success factors of Six Sigma implementation is training and education of tools and techniques. It is interesting to see how in table 4, Design of Experiments is regarded as a very popular tool but the next table it has been classified as least commonly used. These models incorporating tools and techniques along with the level of difficult or their application at different stages is a very handy tool in itself which can be very useful. Also, Lean as well as Six Sigma tools have been used at different stages of DMAIC methodology and have been regarded as useful. An integrated model that can be customized as per the need of the process can be an interesting area to explore.

4.0 HIGHER EDUCATION SYSTEM: CONTINUOUS IMPROVEMENT

As mentioned before, quality issues are not limited just to manufacturing sector and higher education sectors have to deploy strategies to continually improve their process to provide better education. In order to understand the meaning of quality in education, the seven models suggested by (Cheng & Tam 1997) will be discussed below.

- Process Model – This model perceives quality in education as an equal contribution at various stages considered as processes to achieve a set outcome. The aim is to deliver effective teaching and fruitful learning. This model derives the quality of an educational institution with the level of easy functioning and productivity. This model however ignores the functioning of the various processes when in motion and only considers the end result
- Satisfaction Model – This model defines quality of an educational institution as the level to which its customers are satisfied. It considers both internal as well as external customers ranging from the teachers, management board to the students, their parents, the authorities in the government. This model is based on the fact that it is easier to rate the quality of an educational institution by the level to which it satisfies its customer rather than quantifying their expectations that would invite different complexities and differences.
- Legitimacy Model – This model takes into consideration the ever growing competition and a need for every institution to establish itself portraying a strong image supported by its achievements. The model measures the quality of an educational institutional based on its public image and status. It also explains why the educational institutions have been become more focused about marketing themselves appropriately and sufficiently.
- Absence of Problems Model – This model examines the quality of an educational institution by determining the number of problems in its functioning. Absence of difficulties in the working of an institution tells that the systems in place are efficient and that the overall performance is of high quality and desired standards. This model further explains that in this way it is easier to find out the incapable or wrong strategies or decisions and to solve the problem by correcting the mistakes
- Organizational Learning Model – Imparting education to students and achieving organizational as well as societal objectives is a continuous process and therefore an educational institution must continuously strive towards maintaining continuous improvement. This model is based on this model is based on this idea though it only focuses on the internal learning process but does not form a relation to the education quality.
- Goal and Specification Model – This model defines quality of an educational institution by its ability to achieve set goals. These goals can be objectives set by the governing body of all educational institutions or the assessment bodies etc. The advantage of this model is that it points out the problem areas that the management of the educational institution needs to look upon.
- Resource Input Model – This model determines the quality of an educational institution by taking into consideration the resources and support it possesses. The model is based on the assumption that to achieve varied expectations from different section of the society, the government and the internal objectives, an institution needs to be backed by strong, unique and limited resource. This can be its campus size, variety of study programs, etc.

Project Report

Higher education has grown into a mass service producer and amidst numerous competitors; the institutions have to cater good quality education and experience to a huge number of students (O'Neill & Palmer 2004). (Roffe 1998) has pointed out a few important problems with the implementation of any continuous improvement initiative in higher education. One of the fundamental problems is that higher education institutions are made of people and the meaning of continuous improvement may mean different to different people. Besides, Continuous improvement is about small incremental improvements which is a long process and involves commitment from everyone in the institution. Total Quality management therefore has had its own share of resistance for its implementation as in the case with other service sector organizations. Six Sigma has an edge over previous continuous improvement methodologies including Total Quality Management for its capability to provide a framework for Continuous Improvement implementation and roll out projects across an organization.

(Ho, Xie & Goh 2006) has discussed some basic problems related to implementation of Six Sigma DMAIC methodology and in establishing a training program. However, the article suggests that considering the success Six Sigma has had in its implementation in non manufacturing sector, the available literature supports that Six Sigma implementation in higher education can be achieved.

5.0 REFERENCES

- Antony, J 2004, 'Six Sigma in the UK service organisations: results from a pilot survey', *Managerial Auditing Journal*, vol 19, no. 8, pp. 1006-1013.
- Antony, J 2006, 'Six Siga for Service Processes', *Business Process Management Journal*, vol 12, no. 2, pp. 234-248.
- Antony, J 2011, 'Six Sigma vs Lean - Some perspectives from leading academics and practitioners', *International Journal of Productivity and Performance Management*, vol 60, no. 2, pp. 185-190.
- Antony, J, Escamilla, JL & Caine, P 2003, 'Lean Sigma', *Manufacturing Engineer*, vol 82, no. 2, pp. 40-42.
- Antony, J, Kumar, M & Madu, CN 2005, 'Six Sigma in small and medium sized UK manufacturing enterprises:Some empirical observations', *International Journal of Quality and Reliability Management*, vol 22, no. 8, pp. 860-874.
- Arnheiter, ED & Maleyeff, J 2005, 'The integration of lean management and Six Sigma', *The TQM Magazine*, vol 17, no. 1, pp. 5-18.
- Arumugam, V, Antony, J & Douglas, A 2012, 'Observation: a Lean tool for improving the effectiveness of Lean Six Sigma', *The TQM Journal*, vol 24, no. 3, pp. 275-287.
- Bessant, J & Caffyn, S 1996, 'High involvement innovation through continuous improvement', *International Journal of Technology Management*, vol 14, no. 1, pp. 7-28.
- Bessant, J, Caffyn, S, Gibert, J, Harding, S & Webb, S 1994, 'Rediscovering Continuous Improvement', *Technovation*, vol 14, no. 1, pp. 17-29.
- Bhuiyan, N & Baghel, A 2005, 'An overview of continuous improvement: from the past to the present', *Management Decision*, vol 43, no. 5, pp. 761-771.
- Cheng, TCE 1990, 'Quality Control: Changing with the Times', *International Journal of Quality and Reliability Management*, vol 7, no. 6.
- Cheng, YC & Tam, WM 1997, 'Multi-models of quality in education', *Quality Assurance in Education*, vol 5, no. 1, p. 22-31.
- Clegg, B, Rees, C & Titchen, M 2010, 'A study into the effectiveness of quality management training:A focus on tools and critical success factors', *The TQM Journal*, vol 22, no. 2, pp. 188-208.
- Coronado, RB & 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.
- Goldman, HH 2005, 'The origins and development of quality initiatives in American business', *The TQM Magazine*, vol 17, no. 3, pp. 217-225.
- Holweg, M 2007, 'The genealogy of lean production', *Journal of Operations Management*, vol 25, no. 2, pp. 420-437.

Project Report

Ho, SL, Xie, M & Goh, TN 2006, 'Adopting Six Sigma in higher education: some issues and challenges', *International Journal of Six Sigma and Competitive Advantage*, vol 2, no. 4, pp. 335-352.

Juran, JM 1995, 'World War 2 and the Quality ovement', in BD Ruben (ed.), *Quality in Higher Education*, Transaction Publishers, New Jersey.

Juran, J 1997, 'Early SQC : A historical supplement', *Quality Progress*, vol 30, no. 9, pp. 73-81.

Klefsjö, B, Wiklund, H & Edgeman, RL 2001, 'Six sigma seen as a methodology for total quality management', *Measuring Business Excellence*, vol 5, no. 1, pp. 31-35.

Lakhe, RR & Mohanty, RP 1994, 'Total Quality Management', *International Journal of Quality and Reliability Management*, vol 11, no. 9, pp. 9-33.

Mangelsdorf, D 1999, 'Evolution from quality management to an integrative management system based on TQM and its impact on the profession of quality managers in industry', *The TQM Magazine*, vol 11, no. 6, pp. 419-425.

Manville, G, Greatbanks, R, Krishnasamy, R & Parker, DW 2012, 'Critical success factors for Lean Six Sigma programmes: a view from middle management', *International Journal of Quality & Reliability Management*, vol 29, no. 1, pp. 7-20.

O'Neill, MA & Palmer, A 2004, 'Importance-performance analysis: a useful tool for directing continuous quality improvement in higher education', *Quality Assurance in Education*, vol 12, no. 1, pp. 39-52.

Pepper, MPJ & Spedding, TA 2010, 'The evolution of lean Six Sigma', *International Journal of Quality & Reliability Management*, vol 27, no. 2, pp. 138-155.

Petersen, PB 1999, 'Total quality management and the Deming approach to quality management', *Journal of Management History (Archive)*, vol 5, no. 8, pp. 468-488.

Powell, TC 1995, 'Total Quality Management as Competitive Advantage: A Review and Empirical Study', *Strategic Management Journal*, vol 16, no. 1, pp. 15-37.

Raisinghani, MS, Ette, H, Pierce, R, Cannon, G & Daripaly, P 2005, 'Six Sigma: concepts, tools, and applications', *Industrial Management & Data Systems*, vol 105, no. 4, pp. 491-505.

Raisinghani, MS, Ette, H, Pierce, R, Cannon, G & Daripaly, P 2005, 'Six Sigma: concepts, tools, and applications', *Industrial Management & Data Systems*, vol 105, no. 4, pp. 491-505.

Robinson, A & Robinson, CJ 1990, *Modern Approaches to Manufacturing Improvement: The Shingo System (Manufacturing & Production)*, 1st edn, Productivity Press.

Roffe, IM 1998, 'Conceptual problems of continuous quality improvement and innovation in higher education', *Quality Assurance in Education*, vol 6, no. 2, pp. 74-82.

Schroeder, DM & Robinson, AG 2002, 'America's most succesful export to Japan: Continuous Improvement Programmes', *Managing Innovation and Change*, vol 2, no. 1, pp. 230-242.

Project Report

Tang, LC, Goh, TN, Lam, SW & Zhang, CW 2007, 'Fortification of Six Sigma:Expanding the DMAIC Toolset', *Quality and Reliability Engineering International*, vol 23, no. 3, pp. 3-18.

Tattersley, P 1991, 'The Quality Approach', *Managing Service Quality*, vol 1, no. 6, pp. 353-356.

Washbush, JB 2002, 'Deming: a new philosophy or another voice?', *Management Decision*, vol 40, no. 10, pp. 1029-1036.

Womack, JP & Jones, DT 2003, *Lean Thinking: Banish Waste and Create Wealth in your corporation*, 2nd edn, Free Press, Simon & Schuster, Inc, New York.

Yasin, MM, Green, RF & Wafa, M 1991, 'Statistical Quality Control in Retail Banking', *International Journal of Bank Marketing*, vol 9, no. 2, pp. 12-16.