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A comparative analysis of lean manufacturing, Six Sigma and Lean Six Sigma for their application in manufacturing organisations

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A comparative analysis of lean manufacturing, Six Sigma and Lean Six Sigma for their application in manufacturing organisations

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Abstract: Manufacturing organisations are always on lookout for the best available way to keep control over the scraps and other industrial wastes in order to keep them competitive in the present scenario. Nowadays, there is a matter of discussion among various manufacturing organisations on which waste management technique is better among leading techniques such as lean manufacturing, Six Sigma and Lean Six Sigma. Various experts had recorded their viewpoints in this regard, but still there is confusion in the minds of the practitioners regarding the comparison of these leading techniques. Therefore, in the present study, a systematic comparative analysis of lean manufacturing, Six Sigma and Lean Six Sigma has been presented on various basis such as the history and growth of these techniques, important tools and techniques of these techniques, critical success factors, their areas of implementations, etc.; so that practitioners can identify the basic difference among these techniques and can choose the best available technique for implementation in their manufacturing organisations on the basis of the requirement of the situations.

Keywords: quality standards; waste management; lean manufacturing; Six Sigma; Lean Six Sigma.

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1 Introduction

Inspired to maintain quality standards, various tools and techniques are often used by the manufacturing organisations (Allen et al., 2005). Lean manufacturing, Six Sigma and hybrid Lean Six Sigma are the top choices of the practitioners for implementation for maintaining the quality standards in their organisations (Andersson et al., 2014).

There is an ongoing debate in the business world about whether lean manufacturing, Six Sigma or Lean Six Sigma is the better system to implement when it comes to streamlining business processes and eliminating waste (Antony, 2017).

Pathways to implement a high-performing lean automation (LA). We asked 61 manufacturers from Brazil and India that are undergoing a lean implementation together with the adoption of disruptive digital technologies from Industry 4.0 (I4.0) to indicate their implementation sequence (Guilherme et al., 2020).

There have been so many researches, studies and case studies have been published so far showing the significance and impact of these quality tools individually, but still practitioners found it difficult to find out the most appropriate approach having highest impact among all other approaches (Augusto et al., 2019). The present study will provide an insight among lean manufacturing, Six Sigma and Lean Six Sigma techniques and provides a complete comparative analysis of all these techniques (Assarlind et al., 2018).

2 Literature review and methodology adopted

Lean manufacturing enhancing quality has become a key professional strategy for various organisations including manufacturers, suppliers, shipping businesses, financial services, health care, and governmental agencies. An enterprise proficient of delighting clients, through enhancing and controlling quality, has the competence to dominate its competitors. The lean eight manufacturing is an effective philosophy in manufacturing to extend productivity, for client satisfaction and to reduce wastes. The term lean manufacturing came into existence in 1990s, whereas the studies on the philosophy started from the starting decades of 20th century itself. Till the term lean manufacturing is coined, it was generally known as Toyota Production System, as the philosophy was put forward by Toyota motors of Japan. Lean manufacturing is an efficient philosophy to increase the value of product/ service through reducing the non-value-added process wastes (Mathaisel, 2018).

American Society for Quality (ASQ), National Institute of MSME (NIMSME), Indian Statistical Institutes (ISI) and many such organisations taken efforts to improve the situations by providing education and certification to Six Sigma programs. Agencies are giving Six sigma certificates such as yellow, green, black and master black belts to the experts based on their courses and successful six sigma implementation projects. As in lean manufacturing, many literatures also insight facts about the CSFs, barriers of Six Sigma implementation, methodologies generally adopted to achieve Six Sigma implementation, etc. The literatures, suggests that, Six Sigma is a strong methodology for reducing variations in processes and thus achieving near zero defects.

2.1 Methodology adopted

This section of the study presents a general outline of the methodology adopted in the present research work. Initial extensive literature based on lean manufacturing, Six Sigma and LSS have been reviewed. From the literature, it has been noticed that there is a huge scope of implementing LSS technique in manufacturing SMEs to reap subsequent advantages in terms of reduction of scrap. Figure 1 represents the research methodology adopted in present work.

Figure 1 Methodology adopted (see online version for colours)



2.2 History and growth of lean manufacturing

The concept of lean manufacturing in modern days industries was firstly introduced by Henry ford. Focusing upon keep the standards of industrial manufacturing world class, tools and techniques of Lean Manufacturing were introduced to the market (Assarlind et al., 2018). Following the same steps afterwards Toyota then introduced, Toyota Production System which became one of the most efficient production system in the world. The biggest difference between lean vs. Six Sigma is that they view the causes of waste very differently. Lean manufacturing basically focuses upon the waste elimination by removing the bottlenecks in a systematical manner. Below mentioned are the seven areas of waste which are focused in the lean manufacturing systems.

2.2.1 Types of waste eliminated by lean manufacturing

- Overproduction: Overproduction means that there is no demand in the market for the specific products but they are being produced continuously by the manufacturing organisation.
- Waiting: The time lag in between the two operational steps resulting the wastage of time of workers as well as machines.
- Transport: Inefficient movements of the manufactured products.
- Motion: Poor standards of working and workers moving ineffectively in between the assigned tasks.
- Over-processing: Too much extra time being spent in producing a product and getting it produced in an inefficient manner.
- Inventory: Extra material being procured in the stores or the inventories of the manufacturing organisations leads to the wastage of resources as well.
- Defects: Unwanted faults or failures observed in the produced products leads to the defects increasing the wastage in the productions.

Implementing lean will allow employees to move materials less frequently which will improve the quality and require less overall inventory. It also allows quality issues to be dealt with during the manufacturing process, which saves both time and resources because employees are not scrambling to fix mistakes later. All of the improvements listed above will result in a more successful manufacturing process. As the products are being produced and delivered on time, the customers will have a more satisfying experience. And because the products were produced to a higher standard of quality, there will be fewer customer complaints.

2.2.2 Principles and philosophy of lean manufacturing

The principles and philosophy of lean manufacturing are listed below.

- Identifying the value of the product perceived by the consumer.
- Identifying the value stream of the manufacturing processes.
- Making the value flow in the manufacturing unit.
- Maximum pull from the value stream.
- Achieving the perfection.

2.2.3 Critical success factors of lean manufacturing

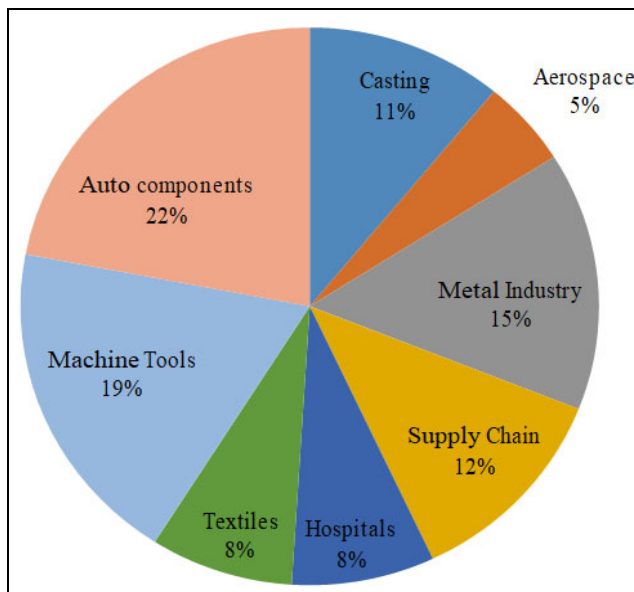
On the basis of surveyed literature critical success factors identified for lean manufacturing are listed in Table 1.

Table 1 Critical success factors for the implementation of lean manufacturing

<i>S. no.</i>	<i>Critical success factors of lean manufacturing</i>	<i>Cronbach's alpha</i>
1	Leadership and management	0.95
2	Employees involvement	0.83
3	Alignment to strategy and long-term plan	0.87
4	Quality data and analysis	0.74
5	Supplier involvement	0.82
6	Total cost management	0.92
7	Organisation infrastructure	0.76
8	Performance measurement	0.65
9	Benchmarking of standards	0.71

Source: Abdul et al. (2018) and Albliwi et al. (2014)

Figure 2 Cluster wise implementation of lean manufacturing (see online version for colours)



Source: Chen and Lyu (2017), Chiarini (2013) and Galdino and Gomes (2019)

2.2.4 Cluster wise implementation of lean manufacturing

Lean manufacturing finds its wide applications in different industrial clusters. Figure 2 represents that casting, aerospace, metal industry, supply chain, hospitals, textiles machine tools and auto components clusters usually have the application of lean manufacturing. From reviewed literature, it has been observed that 11% casting sector usually uses lean manufacturing technique for waste management whereas aerospace sector have 5% application of this technique. 15% of metal industry is also applying lean systems for waste management. At the same 12% of time supply chain industry is using

lean systems and 8% of hospitals are also using tools and techniques of lean systems in order to well manage their systems. Textile sector is also applying Lean manufacturing techniques for the waste management and from reviewed literature it has been found that 8% of textile industries are using this technique. 19% of the machine tool industry is using tools and techniques of lean manufacturing systems for the purpose of waste management and 22% application of lean manufacturing systems is also noticed in the auto components sector as well (Emiliani, 2019).

2.3 History and growth of Six Sigma

The main focus of Six Sigma is on reducing the variation in the process for improving the consumer's experience. An industrial organisation adopting the standards of Six Sigma does not makes more than 3.4 defects per million opportunities (Chugani and Peter, 2017). In 1980s, Six Sigma was introduced by the engineer of Motorola named Bill Smith. Smith was having a strong belief that reducing the variations in the process will definitely going to improve the experience of the customers and by getting rid of the variations in the processes and will enhances the overall earnings and profits of the manufacturing organisation. As a result of implementation of the Six Sigma practices results in saving the millions of dollars to Motorola (Chiarini, 2013). After witnessing the great success of Motorola other companies also started adopting the techniques of Six Sigma for waste management in their organisations (Chandimaet and Shahanaghi, 2018). The Six Sigma approach follows the systematic approach of define, measure, analyse, improve and control (i.e., DMAIC). This approachis discussed in detail in the next section of this article.

2.3.1 DMAIC

Six Sigma incorporates the DMAIC approach to get control over the processes (Handfield and Pannessi, 1995). Six Sigma is one of the most powerful tool used for the improves in the process and to get the maximised profits. Here is a more in- depth look at each step of the process:

- Define: Define is the first step in the implementation of Six Sigma, it signifies the effectively defining the problem of the organisation.
- Measure: In the measure step, the current data is measured and analysed by identifying which parameters are significant and having effect on the overall process for the purpose of making the improvements.
- Analysis: After measuring the data, the data is being analysed in order to get the root cause of the existing problem.
- Improvement: In improvements stage the solutions to the existing problems are proposed to get rid of the problems
- Control: Once the improved process have been implemented its required to maintain the same process on the similar note so proper control is one of the most important aspect of the implementation of Six Sigma.

2.3.2 Critical success factors of Six Sigma

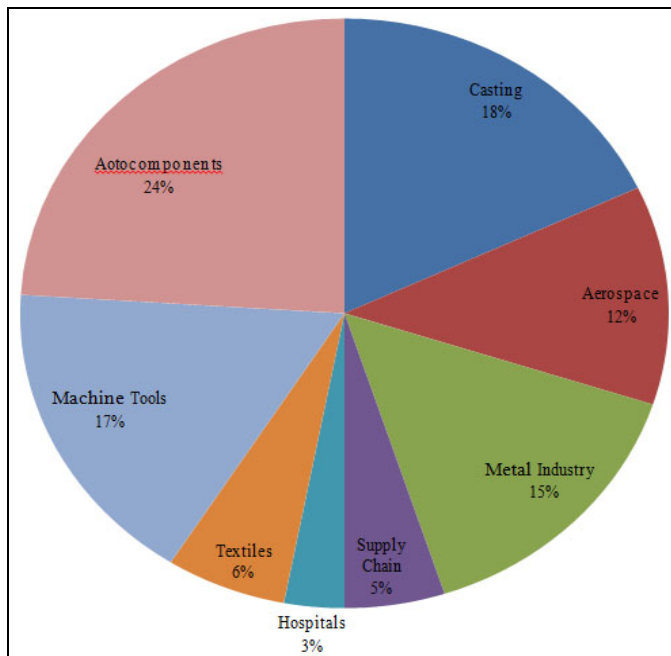
Various critical success factors for the implementation of Six Sigma are listed in the Table 2.

Table 2 Critical success factors for the implementation of Six Sigma

S. no.	Critical success factors of Six Sigma	Cronbach's alpha
1	Vision of management	0.69
2	Employees involvement and skill set	0.78
3	Understanding of Six Sigma	0.66
4	Training programs	0.84
5	Infrastructure and technology	0.91
6	Error proofing analysis implementation	0.72
7	Customer management systems	0.81
8	Process management system	0.69
9	Bench marking system	0.88

Source: Garish and Dijkshoorn (2012)

Figure 3 Cluster wise implementation of Six Sigma techniques (see online version for colours)



Source: Naslund et al. (2017)

2.3.3 Cluster wise implementation of Six Sigma

Six Sigma finds its wide applications in different industrial clusters. Figure 3 represents that casting, aerospace, metal industry, supply chain, hospitals, textiles machine tools and

auto components clusters usually have the application of Six Sigma (Garish and Dijkshoorn, 2012). From reviewed literature, it has been observed that 18% casting sector usually uses Six Sigma technique for waste management whereas aerospace sector have 12% application of this technique. 15% of metal industry is also applying Six Sigma for waste management. At the same 5% of time supply chain industry is using Six Sigma and 3% of hospitals are also using tools and Techniques of Six Sigma in order to well manage their systems (Naslund, 2018). Textile sector is also applying Six Sigma techniques for the waste management and from reviewed literature, it has been found that 6% of textile industries are using this technique. 17% of the machine tool industry is using tools and techniques of Six Sigma systems for the purpose of waste management and 24% application of Six Sigma systems is also noticed in the auto components sector as well.

2.4 History and growth of lean Six Sigma

Lean Six Sigma is a method that relies on a collaborative team effort to improve performance by systematically removing waste and reducing variation. It combines lean manufacturing/lean enterprise and Six Sigma to eliminate the eight kinds of waste (muda): defects, over-production, waiting, non-utilised talent, transportation, inventory, motion, and extra-processing (Sodhi et al., 2020a).

Lean Six Sigma not only reduces process defects and waste, but also provides a framework for overall organisational culture change. By introducing Lean Six Sigma, the mindset of employees and managers change to one that focuses on growth and continuous improvement through process optimisation. This change in culture and the mindset of an organisation maximises efficiency and increases profitability.

In order to successfully implement Lean Six Sigma, a combination of tools from both lean manufacturing and Six Sigma must be used. Some of these tools include kaizen, value-stream mapping, line balancing, and visual management.

The first concept of Lean Six Sigma was created in 2001 by a book titled *Leaning into Six Sigma: The Path to Integration of Lean Enterprise and Six Sigma* by Barbara Wheat, Chuck Mills, and Mike Carnell. The book was developed as a guide for managers of manufacturing plants on how to combine lean manufacturing and Six Sigma in order to dramatically improve quality and cycle time in the plant. Wheat, Mills, and Carnell narrate the story of a company who was skeptical about implementing Lean Six Sigma, but as a result of doing so was able to successfully improve the quality and efficiency in all aspects of business.

In the early 2000s, Six Sigma principles expanded into other sectors of the economy, such as healthcare, finance, supply chain, etc. While different sectors of the economy sell different 'products' and have different 'customers', Lean Six Sigma principles can still be applied with slight alterations in wording and processes (Lozzi and Hurry, 2008).

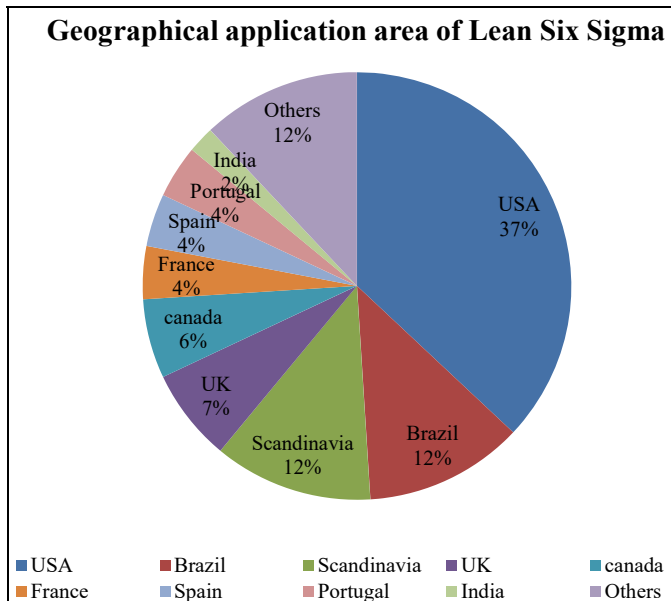
Lean Six Sigma is a synergised managerial concept of lean and Six Sigma. Lean traditionally focuses on the elimination of the eight kinds of waste/Muda classified as defects, over-production, waiting, non-utilised talent, transportation, inventory, motion, and extra-processing. Six Sigma seeks to improve the quality of process outputs by identifying and removing the causes of defects (errors) and minimising variability in (manufacturing and business) processes. Together, lean aims to achieve continuous flow by tightening the linkages between process steps while Six Sigma focuses on reducing process variation (in all its forms) for the process steps thereby enabling a tightening of those linkages. In short, Lean exposes sources of process variation and Six Sigma aims to

reduce that variation enabling a virtuous cycle of iterative improvements towards the goal of continuous flow.

Lean Six Sigma uses the DMAIC phases similar to that of Six Sigma. The five phases include DMAIC (Tamizharasi et al., 2014). The five phases used in Lean Six Sigma are aimed to identify the root cause of inefficiencies and works with any process, product, or service that has a large amount of data or measurable characteristics available. The DMAIC toolkit of Lean Six Sigma comprises all the lean and Six Sigma tools (Chandimaet and Shahanaghi, 2018).

The different levels of certifications are divided into belt colours, similar to judo. The highest level of certification is a black belt, signifying a deep knowledge of Lean Six Sigma principles. Below the black belt are the green and yellow belts. For each of these belts, levels skill sets are available that describe which of the overall Lean Six Sigma tools are expected to be part at a certain Belt level (Garza, 2015; Vinesh and Geoff, 2012). These skill sets provide a detailed description of the learning elements that a participant will have acquired after completing a training program (Sodhi et al., 2019). The skill sets reflect elements from Six Sigma, lean and other process improvement methods like the theory of constraints (TOC) total productive maintenance (TPM). In order to achieve any of the certification levels, a proctored exam must be passed that includes various questions on Lean Six Sigma and its applications (Gnoni et al., 2013).

Figure 4 LSS implementation status in SME’s at international level (see online version for colours)



Source: Myrdal et al. (2017) and Sodhi et al. (2019)

Manufacturing SMEs in advanced countries are having higher output because of better implementation of waste management techniques (Sodhi et al., 2020b). From literature, it has been observed that developed nations like the USA is highly using this technique in their manufacturing SMEs and service sector and they are also reaping good results in terms of waste management (Habidin and Yusuf, 2012). At the same time, nations like

Brazil and Scandinavia are also using this technique up to a great extent (Hajmohammad et al., 2013; Vinodh and Balaji, 2011). From our survey, we had noticed that underdeveloped and developing nations are quite rarely utilising this technique in their industrial organisations. Figure 4 shows the usage of LSS internationally in the SME sector for ensuring sustainability across the various developed, developing and underdeveloped nations (Uma, 2013). It has been observed that only 2% of industrial organisations in India are using LSS as a waste management technique. This review reflects that advanced nations are quite depending upon LSS for their sustainability and it's becoming important that developing and underdeveloped nations should also incorporate LSS strategies in their manufacturing SMEs for reaping better results and to remain competitive and sustainable (Ohno and Tanner, 2007).

2.4.1 *Critical success factors of Lean Six Sigma*

Critical success factors for the implementation of Lean Six Sigma are identified and listed in Table 3.

Table 3 Critical success factors for the implementation of Lean Six Sigma

<i>S. no.</i>	<i>Critical success factors of lean Six Sigma</i>	<i>Cronbach's alpha</i>
1	Effectiveness of LSS training program	0.85
2	Workflow analysis	0.81
3	Material flow analysis	0.76
4	Standardisation of processes	0.92
5	Project prioritisation, selection, reviews, and tracking	0.78
6	Value analysis implementation	0.83
7	Standardisation of processes	0.92
8	Elimination level of minor stoppage in the workflow	0.67
9	Competency level of master black belt/black belt	0.82

Source: Bhuiyan and Baghel (2005) and Chugani and Peter (2017)

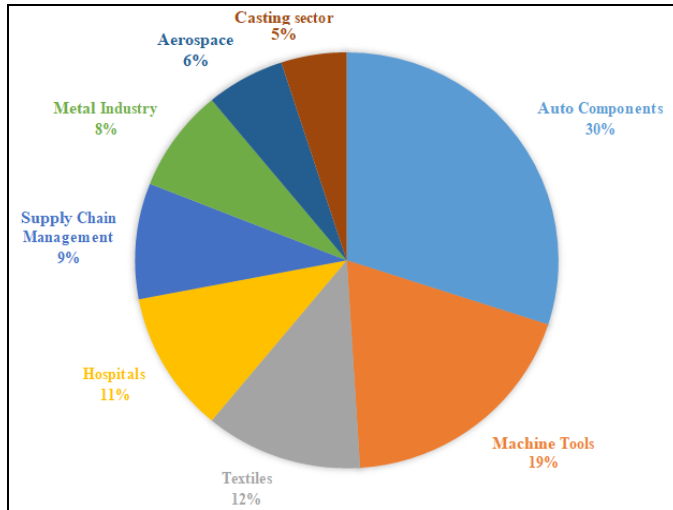
2.4.2 *Cluster wise implementation of Lean Six Sigma*

Cluster-wise distribution of various research papers published during the last one and a half-decade is represented in Figure 5. It has been noticed from the survey that 30% of an industrial cluster of automotive components is implementing LSS approach in their organisations followed by the cluster of machine tool industry in which 19% of implementation of LSS techniques is noticed (Snee, 2010). The distribution also reveals that the application of LSS is 12% and 11% in textiles and hospitals clusters respectively. Supply chain management and metal industry are also using LSS by 9% and 8% respectively. Whereas the application of LSS in aerospace and casting sector is just 6% and 5% respectively. From this cluster-based review, it has been observed that LSS strategies can contribute significantly both in the industrial sector as well as the service sector.

2.4.3 Comparison of Lean Manufacturing, Six Sigma and Lean Six Sigma

Lean manufacturing and Six Sigma were considered as two different techniques ever since the 1980s, when the terms were first defined and applied in 1913 at the Ford plant in Michigan, USA. Later, the Japanese perfected it using the Toyota Production System, while the dawn of Six Sigma began in the USA in the Motorola Research Centre. Lean is a methodology to improve the process which delivers the products and services in a better format at a lower price. Lean thinking provides the tools and techniques of doing more with lesser efforts (human effort, human equipment, time, and space), while moving towards customer’s needs. Six Sigma methodology is based on a data-driven approach, used to stabilise the process and get predictable results by reducing variations and defects in the process involved. Lean cannot address the issues related to variations in the process statistically and Six Sigma cannot remove waste from the process. In real life, data is messy and does not always fit into normal statistical distributions in industries where the variables are dynamic and measured by the yardstick of constantly changing needs of customers, as the scope and deepness of tools available have increased. The impact of lean in different places within the USA and explained how lean provides opportunities for improvement for both the employee and organisational culture. Managed a scientific research project by employing LSS and project management. They point out to a need to integrate Lean and six sigma, to demonstrate how to integrate a suite of tools, making sense of an unstructured problem and focus on what is critical to customers. Two popular process improvement methodologies viz., lean and six sigma, to compare and contrast the differences and common factors which could lead to a successful continuous improvement program. It was found that no standard framework for Lean Six Sigma and its implementation exists. Therefore the study emphasises the need for an integrated Lean Six Sigma model. Existing models that explain how Six Sigma and lean work well in combination; and highlighted the benefits of the integration of Lean and six sigma. A Comparison of Lean Manufacturing, Six Sigma and Lean Sox Sigma is shown in Table 4.

Figure 5 Cluster wise implementation of Lean Six Sigma (see online version for colours)



Source: Kocak et al. (2017), Singh et al. (2017) and Sodhi et al. (2020a)

Afterwards in order to make a more detailed comparison between lean manufacturing, Six Sigma and Lean Six Sigma a questionnaire on a liker scale of five has been prepared and sent to more than 650 manufacturing organisations. Responses have been received and the mean score of all the asked questions for different manufacturing techniques has been recorded in Table 5.

Table 4 Lean principle vs. Six Sigma principle and synergy

<i>Principle</i>	<i>Lean</i>	<i>Six Sigma</i>	<i>Lean Six Sigma</i>
Origin	Toyota (Toyoda, Ohno, and Shingo;	Motorola and General Electrics	–
Applicability structure	1 Specify the value 2 Identify the value stream 3 Flow 4 Pull 5 Search for perfection	1 Define 2 Measure 3 Analyse 4 Improve 5 Control	Robust structure focused on the elimination of wastes and problem solving
Focus	On the flow	On the problem	Simultaneous focus on eliminating problems and
Theory	Elimination of wastes and profit increase	Reduce variation and increase profit	Increased margins, return on investment and value of the company stock in the stock
Target	Maximise productivity	Maximise business results	–
Assumptions	The reduction of wastes increases the business Performance	There is a problem to be solved; Statistical tools can help to solve the problem by the reduction of variability in the processes.	Simultaneous focus on reducing wastes and on the solution of a specific problem that might be a loss generator

Source: Shaw (2018) Singh et al. (2013), Yang and Li (2011), Sodhi et al. (2020b)

A graphical representation of mean scores of lean manufacturing, Six Sigma and Lean Six Sigma has been presented in Figure 6.

Figure 7 represents the interval plots of Lean Manufacturing, Six Sigma and Lean Six Sigma practices. After analysing the data it has been observed that Lean Manufacturing is having a mean score of 3.7 for all the asked questions in the questionnaire on a liker scale of five. Whereas the mean score of Six Sigma technique is found to be 3.8 for all the asked questions in the questionnaire on a liker scale of five.

After analysing the Lean Six Sigma it has been analysed that the mean score of all the asked questions in questionnaire on is 3.6.

Table 5 Question wise mean score of waste management techniques

S. no.	Questions	Question wise mean score of waste management techniques		
		Lean manufacturing	Six Sigma	Lean Six Sigma
1	Level of reduction in operating cost achieved.	3.4	3.6	3.3
2	Awareness level of workers about waste management technique implemented in your organisation.	3.8	4.2	3.7
3	Level of scrap reduction after implementation of waste management technique.	4.2	4.2	3.8
4	Level of increase in profitability due to the implementation of a waste management technique.	4.0	4.0	3.5
5	Level of work flow balance by implementing waste management technique.	3.7	4.1	3.7
6	Level of improvement in customer order compliance.	3.7	3.6	3.8
7	Level of reduction in defects.	3.7	3.7	3.9
8	Level of reduction in machine breakdown time.	3.7	3.9	3.6
9	Level of reduction in inventory.	3.5	3.4	3.4
10	Level of increase in production capacity of your organisation.	3.2	3.5	3.5

Figure 6 Mean score comparison between lean manufacturing, Six Sigma and Lean Six Sigma (see online version for colours)

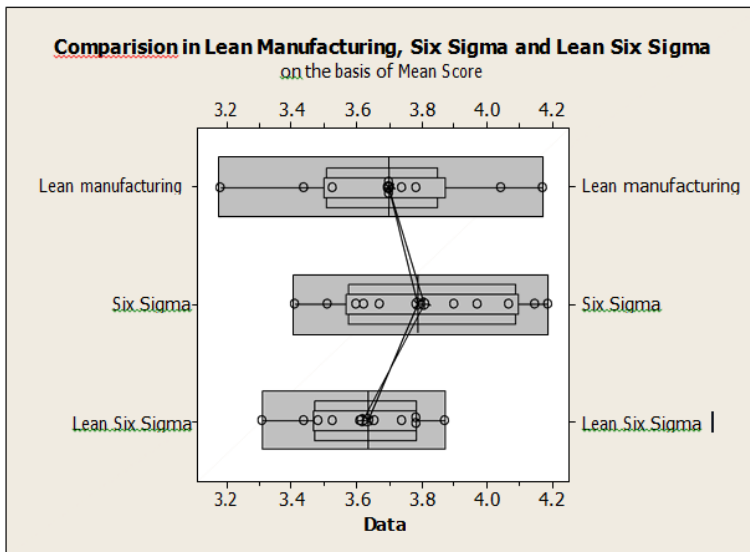


Figure 7 Interval plots of lean manufacturing, Six Sigma and Lean Six Sigma practices (see online version for colours)

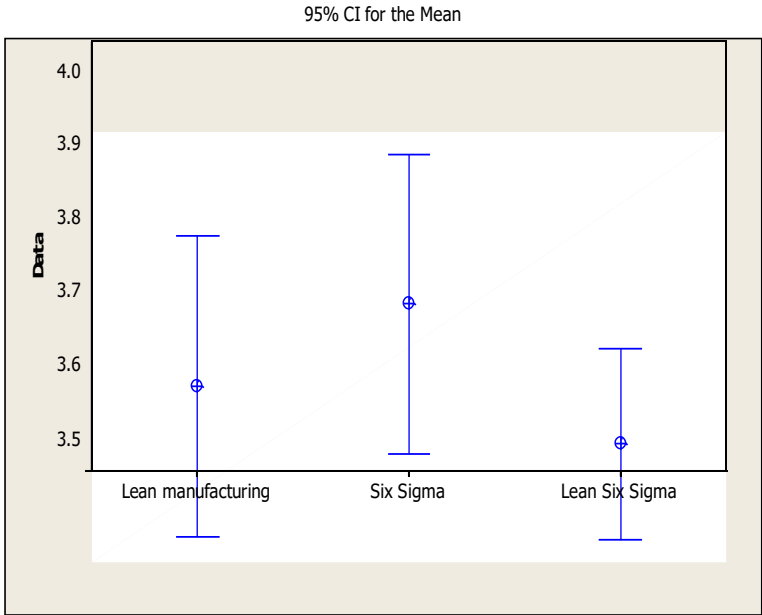
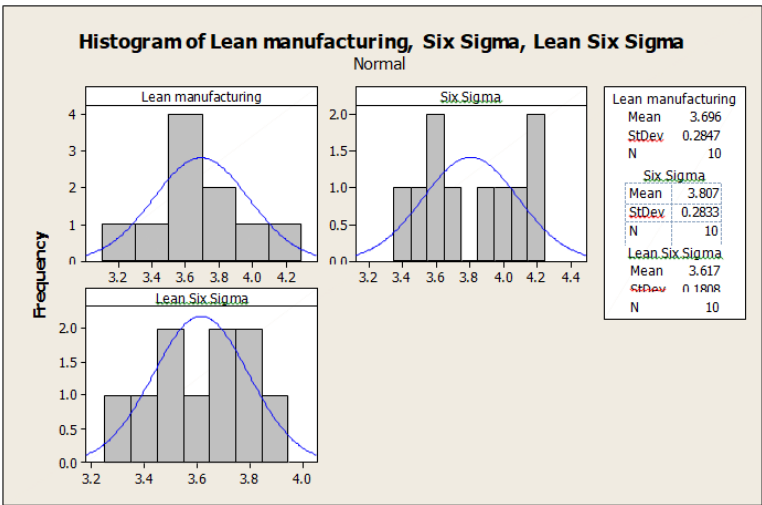


Figure 8 Histogram plot of lean manufacturing, Six Sigma and Lean Six Sigma (see online version for colours)

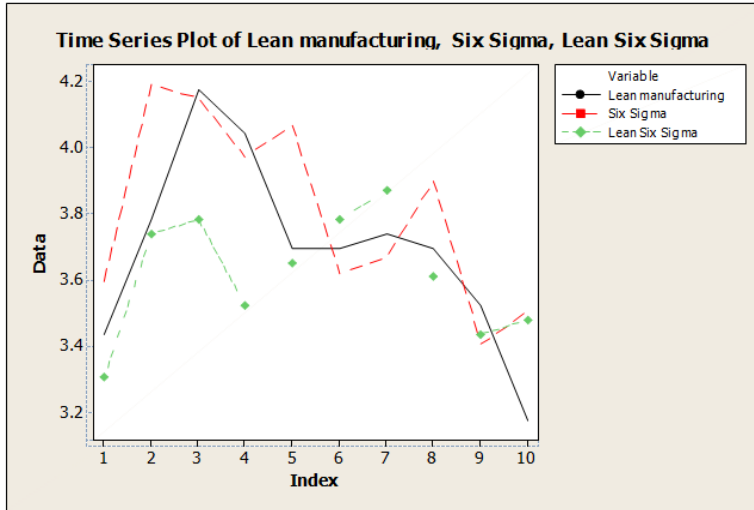


In Figure 8, a histogram plot in lean manufacturing, Six Sigma and Lean Six Sigma has been plotted in order to compare these techniques. A question wise histogram is plotted for each individual technique representing the effect of individual question on these considered techniques individually for making a systematic comparison among these. Standard deviation for the asked question for lean manufacturing is analysed as 0.2847

where as the standard deviation for Six Sigma is 0.2833. Standard deviation calculated for Lean Six Sigma is 0.1808 for all the asked questions.

A Time series plot lean manufacturing, Six Sigma and Lean Six Sigma is shown in Figure 8. Time series of lean manufacturing, Six Sigma and Lean Six Sigma is plotted individually in figure.

Figure 9 Time series plot (see online version for colours)



3 Result and analysis

In the present study, a systematic analysis of various waste, management techniques has been done along with this a comparative analysis of all major waste management techniques. In order to make a more detailed comparison between lean manufacturing, Six Sigma and Lean Six Sigma a questionnaire on a liker scale of five has been prepared and sent to manufacturing organisations. Responses have been received and the mean score of all the asked questions for different manufacturing techniques has been recorded. the interval plots of lean manufacturing, Six Sigma and Lean Six Sigma practices. After analysing the data it has been observed that lean manufacturing is having a mean score of 3.7 for all the asked questions in the questionnaire on a licker scale of five. Whereas the mean score of Six Sigma technique is found to be 3.8 for all the asked questions in the questionnaire on a licker scale of five. After analysing the Lean Six Sigma, it has been analysed that the mean score of all the asked questions in questionnaire on is 3.6.

A histogram plot in lean manufacturing, Six Sigma and Lean Six Sigma has been plotted in order to compare these techniques. A question wise histogram is plotted for each individual technique representing the effect of individual question on these considered techniques individually for making a systematic comparison among these. Standard deviation for the asked question for lean manufacturing is analysed as 0.2847 where as the standard deviation for Six Sigma is 0.2833. Standard deviation calculated for Lean Six Sigma is 0.1808 for all the asked questions.

4 Conclusions

This section presents the conclusions, in light of research objective and various issues and as a result of the detailed study carried out through survey and qualitative modelling. Present study presents a systematic comparison of lean manufacturing, Six Sigma and Lean Six sigma practices followed for the waste reduction in manufacturing industries. A thorough review of literature has been done and these practices are compared from their origin and growth. Afterwards various critical success factors of all these studies have been identified from reviewed literature. After identifying the critical success factors a questionnaire has been sent to various industrial organisations which were following these practices for the waste reduction and validated was done through calculating Cronbach's alpha of all critical success factors individually. Cluster wise implementation of all these techniques has also been presented in a section separately. A comparison in a tabular form is presented keeping various aspects in mind such as origin of these techniques, Applicability, Structure, Focus, theories, targets and assumptions of these individually. In lean manufacturing practices it has been observed that Specify the value; identify the value stream; flow; pull; and search for perfection are the important aspects. Where as in Six Sigma define, measure, analyse, improve and control are the essential aspects. In Lean Six Sigma practices synergy of lean manufacturing and Six Sigma is used in which Robust structure focused on the elimination of wastes and problem solving is focused upon Simultaneous focus on eliminating problems and improving the production flow Increased margins, return on investment and value of the company stock in the stock market.

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