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A conceptual examination of Lean, Six Sigma and Lean Six Sigma models for managing waste in manufacturing SMEs

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Abstract

Purpose – The purpose of this paper is to examine and evaluate various Lean, Six Sigma and Lean Six Sigma (LSS) models proposed by various researchers, which have been implemented in manufacturing organizations.
Design/methodology/approach – The present study has followed three major steps in methodology. In the first step, pooling of various research articles has been done, followed by development of the primary results. At the final step, analysis and development of the LSS model have been performed.
Findings – This paper evaluated and examined various models of Lean Manufacturing, Six Sigma and LSS and developed an advanced LSS model that can be deployed in any manufacturing organization with the purpose of scrap reduction.
Originality/value – The findings of this study will assist shop floor managers to implement an LSS model in their organizations, which can effectively reduce the waste and enhance the overall productivity and quality of the manufactured products.

Keywords Six Sigma, Lean Six Sigma, Lean Manufacturing
Paper type Research paper

1. Introduction

Most of the manufacturing systems of recent times are based upon the input and output models (Vohra *et al.*, 2013). The system receives the input in the form of raw material, processes, signals, etc., and transforms it into the final product (Singh and Sodhi, 2014). Quality and the cost of the final product depend upon the factors that affect the system during the overall processing (Sodhi and Singh, 2013). The ultimate goal of this whole processing is to create a highly reliable and cost-efficient product to get profitability and remain competitive by rapid sales growth. Literature based upon Lean manufacturing, Six Sigma and Lean Six Sigma (LSS) models implemented in various manufacturing industries has been reviewed. Linderman *et al.* proposed a DMAIC model applicable in Brazil and Argentina for industrial and service sectors. Pocha *et al.* implemented an LSS model in health care industries located in the USA. Chugani *et al.* conducted a case study using LSS model for projects in non-profit organizations. Antony and Gijo (2017) worked in the field of proposing an integrated model for LSS application in the airline industry. Timans *et al.* (2018) dealt with projects of LSS in small- and medium-sized manufacturing enterprises in the Netherlands for use and usefulness of LSS tools. Shah and Ishak (2008) in their research proposed that using Lean models improves the quality and productivity of the product. Performance levels are raised when Lean models are implemented in

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organizations. Letens *et al.* (2016) proposed a multilevel Lean model for product development system and designing. As illustrated in Figure 1, there are four critical aspects related to the management of waste in the manufacturing organization. Thorough information has been collected related to these aspects from previous literature and the survey. Sodhi *et al.* (2012) investigated that management of waste in any manufacturing organization revolves around controlling these four critical parameters of any organization, that is men, methods, machines and material. A fishbone diagram, as shown in Figure 1, representing the four Ms indicates the proper utilization of men, machines, methods and materials to achieve perfection in the processes conducted in their organizations to ensure the sustainability in the present competitive world. Numerous literary works demonstrate that LSS includes the use of DMAIC technique with a blend of suitable instruments from the Lean toolbox and Six Sigma at each period of DMAIC. Singh *et al.* (2019), however, contended that LSS utilizes the Six Sigma DMAIC structure as a stage for activities in mix with a Lean standards and devices, thus valuing the DMAIC procedure as a ground-breaking philosophy for LSS ventures. Truth be told, Sodhi *et al.* (2019a) credited the achievement of LSS venture to the executives to the DMAIC technique. Thus, LSS DMAIC procedure expects to be an incredible and fundamental segment of the achievement of LSS ventures, with less significance to its reappearance from its antecedent Six Sigma. Nonetheless, writing additionally demonstrates some analysis and holes in the LSS DMAIC approach.

2. Research methodology

To build up a complete LSS model, the key fixing is to characterize the periods of the model with suitable utilization of instruments at each stage. So as to fortify an applied model advancement under restricted approval requirements, a center gathering study is fundamental. Bringing the aptitude from the two specialists and academicians together in a center gathering offers the chance to accomplish great outcomes inside a constrained time span (De Villiers and Chuntian, 2016; Timans *et al.*, 2016). It has been indicated that "pooling" method allows a gathering to make choice that is more educated than independent choices. As a remedial action individuals have one sided data yet every one of the snippets of data set up together scientist get a fair-minded picture that can be shaped for better choice and options. Anyway the deductions cannot be made dependent on a solitary center gathering alone. In this way, the pooling method begins with an organized writing survey to think about the commitments from different examinations, followed by the center gathering with review

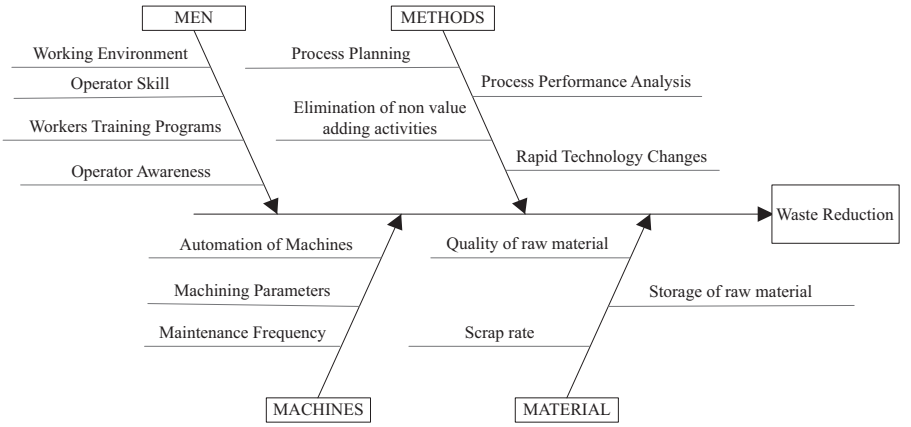

Figure 1.
Fishbone diagram for process improvement

meetings to take in the organizations experience from LSS execution (Laureani and Antony, 2015; Timans *et al.*, 2016).

The methodology adapted in the study comprises of the following sequential steps.

Pooling of relevant data from multiple sources: a structured literature study is conducted with LSS and manufacturing model keywords in four databases. Articles published from 2008 to 2018 in academic journals relevant to the existing LSS framework were identified. Research criteria involving various keywords, search engines, inclusions and exclusions of the study are enlisted in Table I.

A series of focus group followed by retrospective interview method are conducted to identify the drawbacks in the existing DMAIC framework. The participants of the focus group discussions are a mix from both practitioners and academicians groups. The opinions of the participants are captured and then compared with each other for any significant differences in opinion. Wherever there are conflicting opinions conveyed, they are highlighted in the next round of focus discussion, where the groups have heard each other's logical points and arrived at a common agreement resolving the conflicts. The authors of this paper played the role of the facilitators to encourage this analysis-of-opinions process. Based on the literature review and focus group discussions, the drawbacks of the existing model were captured. These techniques also helped to validate the claim that there is need for a comprehensive LSS project management model. In order to create the conceptual model for LSS project management, an online survey questionnaire was rolled out to 650 practitioners across various manufacturing organizations situated across India. A total of 121 participants responded to the survey (57.6 percent response rate). The questionnaire comprises of seven variables measured on a five-point Likert scale. The aim of the questionnaire was to identify the different ways to bridge the gaps of the existing LSS model and to identify what should go into the proposed conceptual model, a comprehensive model for LSS project management. Considering results of all the analytical tools, a LSS model was developed in which the DMAIC approach of Six Sigma was reinforced with tools used in Lean Manufacturing for the purpose of achieving an effective approach toward waste management. At every phase of the proposed model, the existing LSS toolkit is categorized for the appropriate use of the LSS project executors (project managers in general). The study concludes with managerial implications for LSS practitioners and the deployment leadership team as a useful resource for successful LSS deployment (Figure 2).

3. A structured literature search

For the writing study, articles were looked for issues identified with execution in an assembling context. Search included ScienceDirect, Emerald, Taylor & Francis and Springer databases, utilizing the accompanying catchphrase "Six Sigma," "Lean", "Lean Six Sigma", "Arrangement" and "Learning". The pursuit was not confined to articles that explicitly centered around assembling in light of the fact that needed to initially increase a wide picture of arrangement issues. Dissemination of each of the 127 research papers distributed from year 1990 to 2018 has been appeared in Figure 3. At first, the term LSS was seen in year 1990 by Maxwell (2001) as a bit of research work which was coordinated by International Motor

Keywords	Search engines	Inclusions	Exclusions
Lean Manufacturing, Six Sigma, Lean Six Sigma, Systematic Literature Review, Quality Tools, DMAIC, etc.	EBSOC, Science Direct, Emerald, Google Scholar, Elsevier, Taylor & Francis, etc.	Various research and review articles based upon LSS published between years 1990 to 2018. Articles based upon quantitative and qualitative analysis of quality tools	Non-academic database, papers having weak analysis, Books, online sites, etc.

Table I.
Research criteria

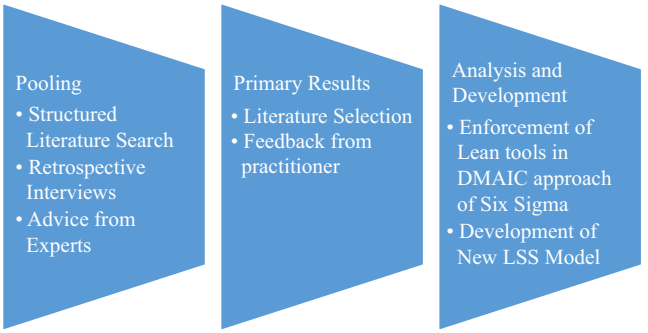

Figure 2.
Research approach and methodology

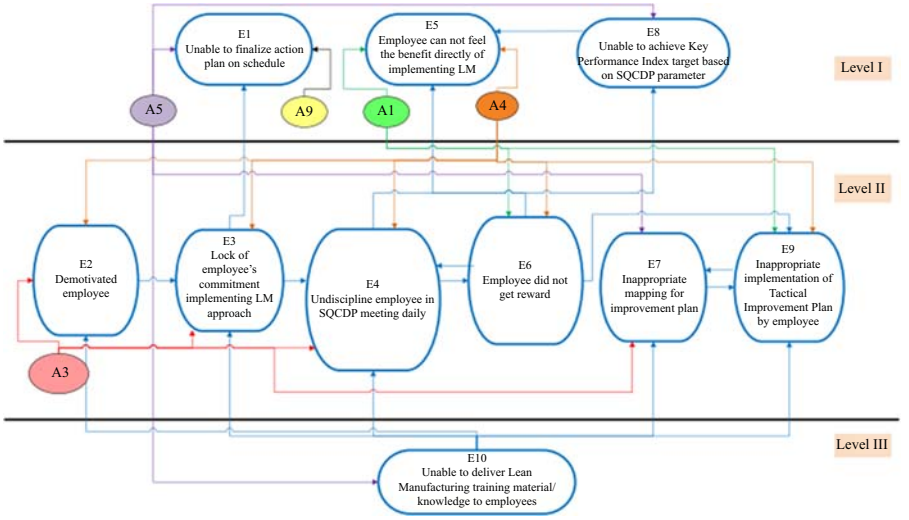

Figure 3.
Lean manufacturing model

Vehicle Program, in the Massachusetts Institute of Technology, it was construed that there was an association among Lean and biological practices. The graphical introduction outlined in Figure 3 reflects distribution of productions every year. Over 80 percent of the articles were seen as distributed in last one and half decade, for example, between years 2003 and 2018. From the number of productions as reflected in the graphical portrayal, it has been seen that the number of distribution in the year 2013 was 18, trailed by the year 2009 in which the number of productions was 17. It has likewise been seen that the examination articles distributed during 1990–2003 were not many, as the recurrence of production of research articles in this time span was in a scope of one to two articles for each year. This pattern mirrors that specialists are all the more thoroughly fixed on LSS as a waste administration strategy in the last one and half decade. Also, the extra condition is that Six Sigma, Lean or LSS be obviously referenced in theory. At that point, rejected papers were not identified with the assembling context and not speaking to any applied models. Table II represents the major outcomes of the reviewed literature.

Hilton and Sohal (2016) proposed a model, as appearing in Figure 3, with regard to improvement of coordinated model for overseeing hazard in Lean assembling usage. The goal of this model is to build up a model to meet difficulties by incorporating a

Quality techniques	Author(s)	Model/Brief description
Lean Manufacturing	Shah and Ishak (2008)	In this research, they proposed that using Lean models improves the quality and productivity of the product. Performance levels are raised when Lean models are implemented in organizations
	Singh and Power (2011)	Implemented a Lean model in the production industry aided by value stream mapping
	Aurelio *et al.*	Proposed a Lean model for enhancing productivity in an auto component industry
	Hoppmann (2015)	Implemented a Lean model for organizing Lean product development
	Letens *et al.* (2016)	Proposed a multilevel Lean model for product development system and designing
	Maxwell (2001)	Implemented a Lean model in service industry
	Pocha *et al.* (2017)	Proposed a Lean model for assessing the use of Lean production practices in manufacturing units
	Nordin *et al.*	Proposed a Lean model for organizational chain management in Lean Manufacturing projects
Six Sigma	Linderman *et al.*	Proposed a DMAIC model applicable in Brazil and Argentina for industrial and service sectors. He noticed a positive and significant impact of Six Sigma methods on project performance
	Chakravorty and Shah (2012)	Proposed a six-step Six Sigma implementation model, which is applicable to a wide spectrum of LSS projects
	Natarajan *et al.* (2017)	Proposed a Six Sigma model for continuous quality and reliability improvement in new product development
	Kumar and Gupta	Proposed a Six Sigma Model for SMEs located in Gujarat (India) to improve productivity
	De Mast *et al.*	Proposed a Six Sigma model for improving top-box customer satisfaction score for a banking call center
Lean Six Sigma	Jeyaraman and KeeTeo (2010)	Implemented a LSS model in a food industry, which adopts Lean and Six Sigma initiatives mainly to increase productivity and to reduce costs and inventory
	Hussain *et al.*	Proposed LSS concepts for sustainable construction and improved quality
	Pocha *et al.*	Implemented a LSS model in health care industries located in the USA
	Cheng *et al.*	Conducted a case study using LSS model for projects in non-profit organizations
	Hilton and Sohal (2016)	Proposed a conceptual LSS model for the successful deployment of Lean Six Sigma in air conditioner industry
	Antony and Gijo (2017)	Worked in the field of proposing ds an integrated model for LSS application in the airline industry

Table II.
Collection of literatures on application of Lean, Six Sigma and LSS

few instruments. This mix is proposed to improve basic leadership by giving quantitative examination at each progression to meet difficulties.

As presented in Figure 4, Linderman *et al.* proposed a conceptual model for evaluating product–service systems (PSS) Leanness in UK manufacturing companies. The reason for this paper is to exhibit a calculated model that can be utilized in estimating the level of PSS Leanness in UK assembling organizations. The model will survey PSS Leanness dependent on five Lean empowering agents (provider relationship, management Leanness, workforce Leanness, process greatness and client relationship), 21 criteria (provider conveyance, culture of the executives, process enhancement and so forth) and finally 73 characteristics. This proposed model will be the base of building up a list utilized as quantitative proportion of the level of PSS Leanness in assembling organizations.

Sreedharan and Li (2017) proposed that a LSS project model consists of eight main phases. Figure 5 shows the different phases of the proposed model.

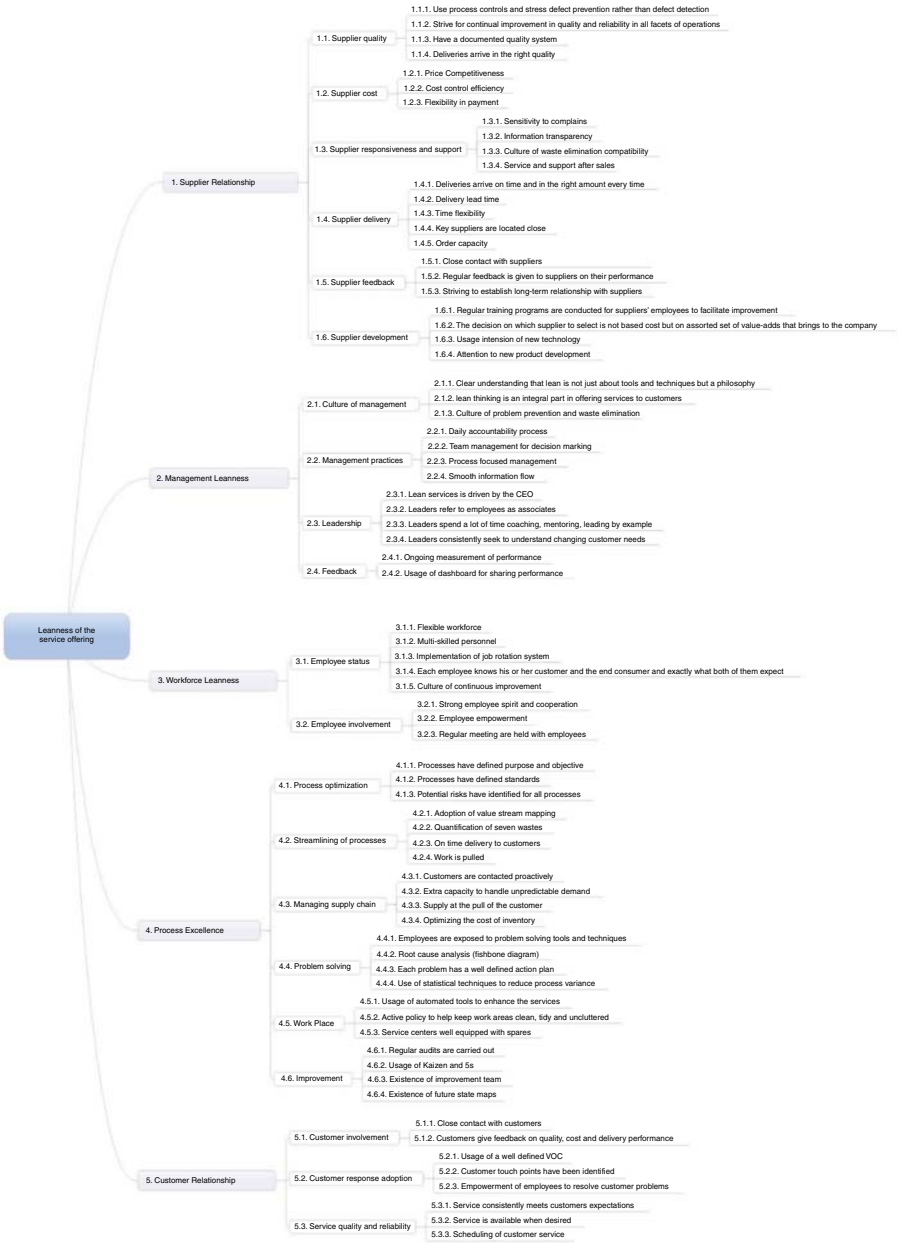

Figure 4.
PSS Leanness assessment model

Barton (2015) prescribed that both Lean and Six Sigma are key business process methodologies that are utilized by organizations to improve their assembling execution. This investigation narrates the plan, advancement and usage of a coordinated LSS model. The work in this examination expands upon the assembling SME's LSS model that has been effectively actualized in various SMEs. The model is in this manner assessed for its

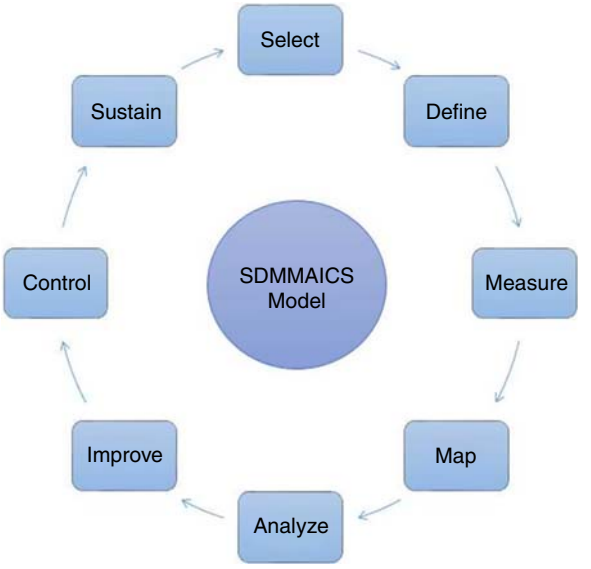

Figure 5.
SDMMAICS – LSS project model

adequacy in the subject organization. It proposes an incorporated way to deal with Lean and Six Sigma model, as presented in Figure 6.

Nordin *et al.*, proposed that LSS models determine the executives improvement model upheld by the DMAIC cycle, coordinating a developed and adjusted arrangement of measurable apparatuses, given the idea of the task, the board primary factors and the included procedures. The proposed model was tried in a Portuguese media transmission

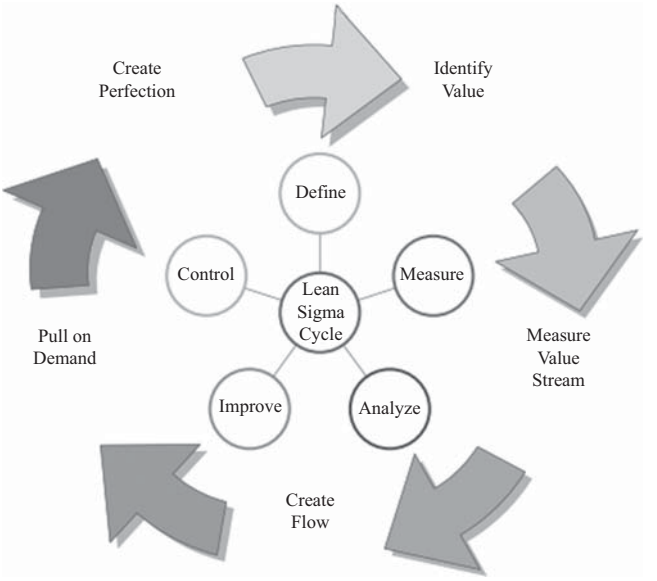

Figure 6.
Lean Six Sigma framework for manufacturing SMEs

organization setting, which undertook the board forms framework depending on Project Management Institute norms. The model permitted recognizing organization's fundamental venture, the board issues and related causes and the determination of the causes to be originally visited. The proposed model likewise allowed to deliberately address the activities and answers for be actualized so as to keep, over the long haul, the nonstop improvement of the task the executives forms in the association. Figure 7 represents the proposed model.

After reviewing the existing models of Lean Manufacturing, Six Sigma and LSS, their outcomes in terms of waste management have been noticed. Many authors have proposed different models for LSS deployment. Critics of Lean Manufacturing and Six Sigma claimed that tools of Lean manufacturing and DMAIC methodology have scope for enhancement, if used in integration (Naslund *et al.*, 2017). Many researchers proposed various models and frameworks of LSS, but they fail to reap best results out of that because of various reasons. Therefore, a modified model related to LSS strategies has been introduced with a purpose of scrap reduction in Indian SMEs. In this model, DMAIC approach of Six Sigma has been reinforced with tools and techniques of Lean Manufacturing. Modified model of LSS is shown in Figure 8.

4. Conclusions

The ideas and uses of Lean Manufacturing, Six Sigma and LSS were considered by exploring the articles found in the diaries. Various specialists had created distinctive sending models of these procedures dependent on their temperament of use. It has been recognized that Six Sigma and Lean frameworks have a similar objective. The two of them look to dispose of waste and make the most effective framework conceivable; however, they adopt various strategies toward accomplishing this objective. In easiest terms, the fundamental distinction among Lean and Six Sigma is that they recognize the main driver of waste in an unexpected way. Lean assembling is a precise method for disposing of waste and making stream in the generation procedure, whereas Six Sigma denotes a lot of strategies that endeavor to enormously decrease the pace of imperfections. Albeit numerous analysts analyze Lean vs Six Sigma, they can frequently be all the more dominant when utilized together. Another fundamental contrast in Lean vs Six Sigma is that Lean is utilized

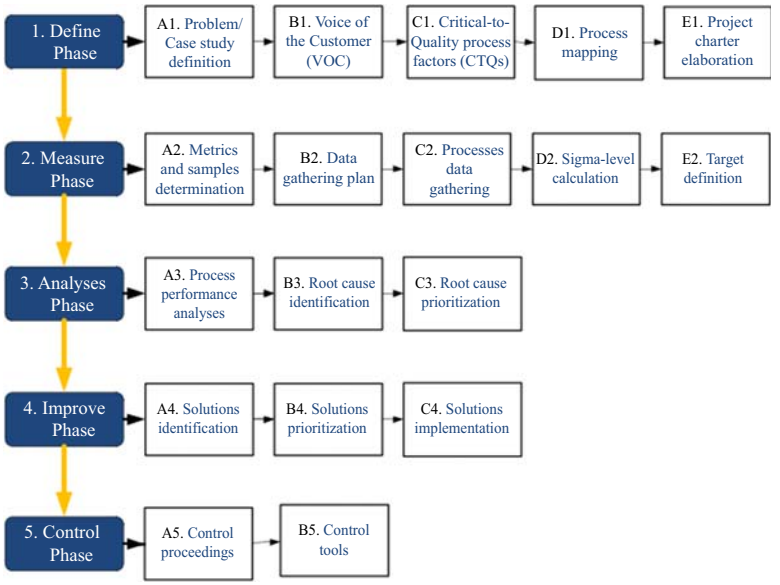

Figure 7.
Lean Six Sigma project management framework

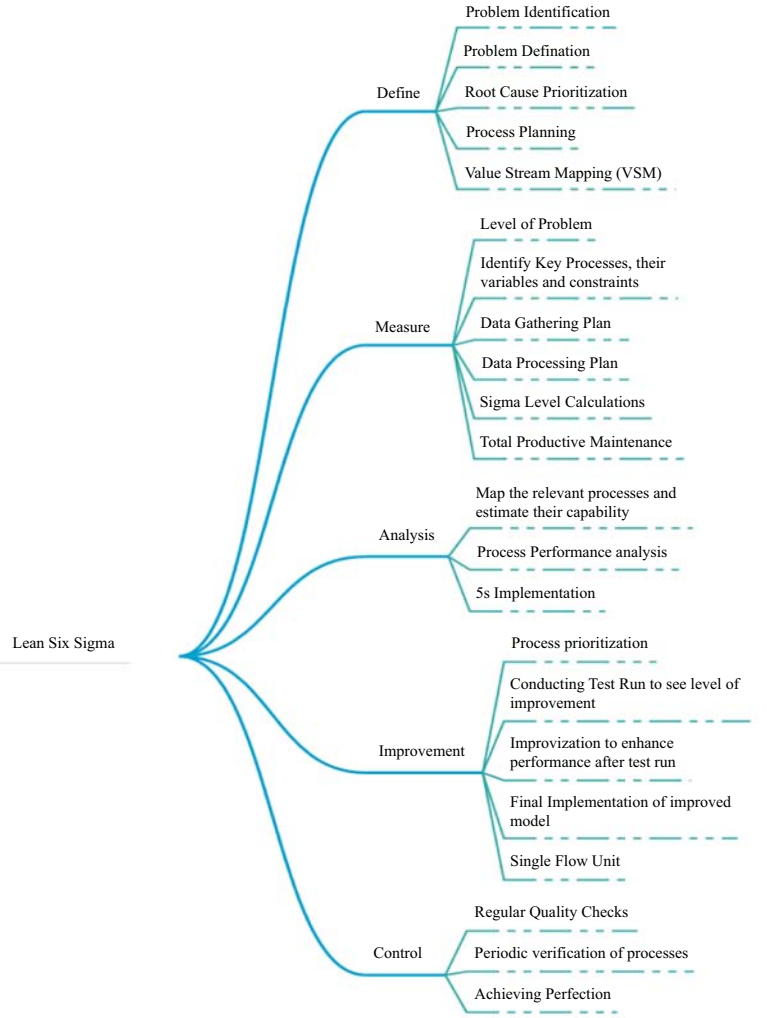

Figure 8.
Improved Lean Six Sigma model

basically underway while Six Sigma can be utilized to lessen mistakes underway just as nonproduction situations. Despite the fact that we are looking at Lean vs Six Sigma, in all actuality, the two of them progress in the direction of a similar extreme objective: wiping out waste and making proficient procedures. They essentially adopt various strategies on the best way to achieve this. Lean spotlights on investigating work process to decrease process duration and dispense with waste. Lean endeavors to amplify an incentive to the client while utilizing a couple of assets, as could be expected under the circumstances. Six Sigma takes a stab at close to immaculate outcomes that will decrease costs and accomplish more significant levels of consumer loyalty. To abridge the primary distinction between Lean vs Six Sigma, Lean sees approaches to build stream, whereas Six Sigma centers around accomplishing reliable outcomes. One closeness between Lean vs Six Sigma is that both have exhibited that it is conceivable to significantly improve the nature of your items and client experience by improving procedures.

References

Antony, J. and Gijo, E. (2017), "Reducing patient waiting time in outpatient department using Lean Six Sigma methodology", *Quality and Reliability Engineering International*, Vol. 30 No. 8, pp. 1481-1491.

Barton, T. (2015), "A review and comparison of Six Sigma and the lean organizations", *TQM Magazine*, Vol. 18 No. 3, pp. 255-262.

Chakravorty, S.S. and Shah, A.D. (2012), "Lean Six Sigma (LSS): an implementation experience", *European Journal of Industrial Engineering*, Vol. 6 No. 1, pp. 118-137.

De Villiers, L. and Chuntian, C. (2016), "New similarity measures of intuitionistic fuzzy sets and application to pattern recognitions", *Pattern Recognition Letters*, Vol. 23 No. 1, pp. 221-225.

Hilton, R.J. and Sohal, A. (2016), "A conceptual model for the successful deployment of Lean Six Sigma", *International Journal of Quality & Reliability Management*, Vol. 29 No. 3, pp. 54-70.

Hoppmann, T.N. (2015), "Future-proofing Six Sigma", *Quality and Reliability Engineering International*, Vol. 30 No. 8, pp. 1389-1392.

Jeyaraman, K. and KeeTeo, L. (2010), "A conceptual framework for critical success factors of lean Six Sigma: implementation on the performance of electronic manufacturing service industry", *International Journal of Lean Six Sigma*, Vol. 1 No. 3, pp. 191-215.

Laureani, A. and Antony, D. (2015), "Strategy through the option lens: an integrated view of resource investments and the incremental-choice process", *Academy of Management Review*, Vol. 18 No. 4, pp. 760-782.

Letens, A., Carsrud, A. and Oflazoglu, S. (2016), "Market, entrepreneurial, and technology orientations: impact on innovation and firm performance", *Management Decision*, Vol. 55 No. 2, pp. 248-270.

Maxwell, J. (2001), "Lean, green, and the quest for superior environmental performance", *Production and Operations Management*, Vol. 10 No. 3, pp. 228-243.

Naslund, D., Vaaler, P.M. and Devers, C. (2017), "Same as it ever was: the search for evidence of increasing hyper-competition", *Strategic Management Journal*, Vol. 24 No. 3, pp. 261-278.

Natarajan, M., Senthil, V., Devadasan, S.R. and Vijay Mohan, N. (2017), "QUARNEWSS: a model for applying Six Sigma framework to achieve continuous quality and reliability improvement in new product development", *International Journal of Productivity and Quality Management*, Vol. 7 No. 1, pp. 44-73.

Shah, K. and Ishak, A. (2008), "Implementing the Lean Six Sigma framework in a small medium enterprise (SME) – a case study in a printing company", *International Conference on Industrial Engineering and Operational Management, Bali*, pp. 387-396.

Singh, B., Taddeo, R. and Morgante, A. (2019), "Value and wastes in manufacturing. an overview and a new perspective based on eco-efficiency", *Journal of Operations Management*, Vol. 4 No. 5, pp. 173-191.

Singh, B.J. and Sodhi, H.S. (2014), "Parametric optimisation of CNC turning for Al-7020 with RSM", *International Journal of Operational Research*, Vol. 20 No. 3, pp. 180-206.

Singh, J. and Power, D.J. (2011), "Use the supply relationship to develop lean and green suppliers", *International Journal of Supply Chain and Management*, Vol. 10 No. 1, pp. 60-68.

Sodhi, H.S. and Singh, H. (2013), "Parametric analysis of copper for cutting processes using turning operations based on Taguchi method", *International Journal of Research in Mechanical Engineering & Technology*, Vol. 3 No. 2, pp. 202-204.

Sodhi, H.S., Singh, D. and Singh, B.J. (2019a), "Developing a Lean Six Sigma conceptual model and its implementation: a case study", *Industrial Engineering Journal*, Vol. 12 No. 10, pp. 1-19.

Sodhi, H.S., Dhiman, D.P., Gupta, R.K. and Bhatia, R.S. (2012), "Investigation of cutting parameters for surface roughness of mild steel in boring process using Taguchi method", *International Journal of Applied Engineering Research*, Vol. 7 No. 11, pp. 23-36.

Sreedharan, T. and Li, C. (2017), "Competence exploration and exploitation in new product development: the moderating effects of environmental dynamism and competitiveness", *Management Decision*, Vol. 49 No. 9, pp. 1444-1470.

Timans, W., Antony, J., Ahaus, K. and Van., S.R. (2016), "Implementation of Lean Six Sigma in small- and medium-sized manufacturing enterprises in the Netherlands", *Journal of the Operational Research Society*, Vol. 63 No. 3, pp. 339-353.

Timans, W., Ahaus, K., van Solingen, R., Kumar, M. and Antony, J. (2018), "Implementation of continuous improvement based on Lean Six Sigma in small-and medium-sized enterprises", *Total Quality Management & Business Excellence*, Vol. 27 No. 4, pp. 309-324.

Vohra, G., Singh., P. and Sodhi, H.S. (2013), "Analysis and optimization of boring process parameters by using Taguchi method", *International Journal of Computer Science and Communication Engineering*, Vol. 6, pp. 232-237.

Further reading

Abdul, S., Albliwi, S., Antony, J. and Vander, T. (2016), "Critical failure factors of Lean Six Sigma: a systematic literature review", *International Journal of Quality & Reliability Management*, Vol. 31 No. 9, pp. 1012-1030.

Albliwi, S., Antony, J., Abdul, S. and Vander Wiele, T. (2014), "Critical failure factors of Lean Six Sigma: a systematic literature review", *International Journal of Quality & Reliability Management*, Vol. 31 No. 9, pp. 1012-1030.

Allen, D., Gutowski, T., Murphy, C., Bauer, D., Bras, B. and Wolff., E. (2005), "Environmentally benign manufacturing: observations from Japan, Europe, and the United States", *Journal of Clean Production*, Vol. 13 No. 1, pp. 1-17.

Andersson, R., Hilletofth, P., Manfredsson, P. and Hilmola, O. (2014), "Lean Six Sigma strategy in telecom manufacturing", *Industrial Management and Data Systems*, Vol. 114 No. 6, pp. 904-921.

Antony, J. (2014), "Some pros and cons of Six Sigma: an academic perspective", *TQM Magazine*, Vol. 16 No. 4, pp. 303-306.

Assarlind, M., Gremyr, I. and Backman, K. (2012), "Multi-faceted views on a Lean Six Sigma application", *International Journal of Quality and Reliability Management*, Vol. 29 No. 1, pp. 21-30.

Augusto, C., Miguel, P. and Marcos., A. (2009), "Benchmarking Six Sigma application in Brazil: best practices in the use of the methodology", *Benchmarking: An International Journal*, Vol. 16 No. 1, pp. 124-134.

Banawi, A. and Bilec, M. (2014), "A framework to improve construction processes: integrating lean, green and Six Sigma", *International Journal of Production Management*, Vol. 14 No. 1, pp. 45-55.

Bhuiyan, N. and Baghel, A. (2005), "Management of continuous improvement: from the past to the present", *Management Decision*, Vol. 43 No. 5, pp. 761-771.

Chandimaet., G. and Shahanaghi., K. (2018), "Determining maintenance system requirements by the viewpoint of reliability and lean thinking: an MODM approach", *Journal of Quality in Maintenance Engineering*, Vol. 16 No. 1, pp. 89-106.

Chen, M. and Lyu, J. (2009), "A Lean Six-Sigma approach to touch panel quality improvement", *Production Planning and Control*, Vol. 20 No. 5, pp. 445-454.

Chiarini, A. (2013), "Relationships between total quality management and Six Sigma inside European manufacturing companies: a dedicated survey", *International Journal of Production Quality Management*, Vol. 11 No. 2, pp. 179-194.

Chugani, S. and Peter, S. (2017), "The human impact on supply chain: evaluating the importance of soft areas on integration and performance", *Operations Management International Journal*, Vol. 14 No. 1, pp. 31-40.

De Mast, J. and Lokkerbol, J. (2012), "An analysis of the Six Sigma DMAIC method from the perspective of problem solving", *International Journal of Production Economics*, Vol. 139 No. 2, pp. 604-614.

Emiliani, M. (2006), "Origins of lean management in America: the role of Connecticut businesses", *Journal of Management History*, Vol. 12 No. 2, pp. 167-184.

Galdino, D. and Gomes., C. (2016), "Impacts of Lean Six Sigma over organizational sustainability: a survey study", *Journal of Cleaner Production*, Vol. 156 No. 2, pp. 262-275.

Garish., A. and Dijkshoorn., J. (2012), "Relationships between solid waste management performance and environmental practice adoption in welsh small and medium-sized enterprises (SMEs)", *International Journal of Production Research*, Vol. 45 No. 21, pp. 489-515.

Garza, J.A. (2015), "Lean and green – a systematic review of the state of the art literature", *Journal of Clean Production*, Vol. 10 No. 2, pp. 18-29.

Gnoni, M.G., Andriulo, S., Maggio, G. and Nardone, P. (2013), "Lean occupational safety: an application for a near-miss management system design", *Journal of Safety Science*, Vol. 53 No. 2, pp. 96-104.

Habidin, F. and Yusuf, M. (2012), "The relationship between Lean Six Sigma, environmental management systems and organizational performance in the Malaysian automotive industry", *International Journal of Automotive Technology*, Vol. 13 No. 3, pp. 119-125.

Hajmohammad, S., Vachon, S., Klassen, D. and Gavronski, I. (2013), "Lean management and supply management: their role in green practices and performance", *Journal of Clean Production*, Vol. 39 No. 2, pp. 312-320.

Handfield, R. and Pannessi, T. (1995), "Antecedents of lead time competitiveness in make to order manufacturing firms", *International Journal of Production Research*, Vol. 33 No. 2, pp. 511-537.

Hussain, K., Hays, C., Center, H. and Daley, C. (2004), "Building capacity and sustainable prevention innovations: a sustainability planning model", *Evaluation and Program Planning*, Vol. 27 No. 2, pp. 135-149.

Linderman, K., Schroeder, R.G. and Choo, A.S. (2006), "Six Sigma: the role of goals in improvement teams", *Journal of Operations Management*, Vol. 24 No. 2, pp. 779-790.

Myrdal, L., Shrivastava, A. and Dinesh., S. (2017), "Critical success factors for Lean Six Sigma in SMEs (small and medium enterprises)", *The TQM Journal*, Vol. 28 No. 4, pp. 613-635.

Nasland, D., Schmidt, F.L. and Rynes, S.L. (2015), "Corporate social and financial performance: a met analysis", *Organization Studies*, Vol. 24 No. 2, pp. 403-441.

Naslund, D. (2008), "Lean, Six Sigma and Lean Six Sigma: fads or real process improvement methods?", *Business Process Management Journal*, Vol. 14 No. 3, pp. 269-287.

Oberoi, J.S., Khamba, J.S. and Sushil, K.R. (2008), "An empirical examination of advanced manufacturing technology and sourcing practices in developing manufacturing flexibilities", *International Journal of Services and Operations Management*, Vol. 4 No. 6, pp. 652-671.

Ohno, S. and Tanner, J. (2007), "A new framework for managing change", *The TQM Magazine*, Vol. 19 No. 6, pp. 572-589.

Shaw, R. (2018), "Implementing Lean Sigma framework in an Indian automotive valve manufacturing organization: a case study", *The TQM Journal*, Vol. 22 No. 7, pp. 708-722.

Singh, D., Oberoi, J.S. and Ahuja, I.S. (2012), "A conceptual examination of impact of dynamic capabilities in managing strategic flexibility in manufacturing sector", *International Journal of Business Continuity and Risk Management*, Vol. 3 No. 3, pp. 187-205.

Singh, D., Singh, J. and Ahuja, I.P.S. (2013), "An empirical investigation of dynamic capabilities in managing strategic flexibility in manufacturing organizations", *Management Decision*, Vol. 51 No. 7, pp. 1442-1461.

Singh, S., Singh, B. and Khanduja, D. (2017), "Synthesizing", *International Journal of Entrepreneurship and Innovation Management*, Vol. 19 No. 3, pp. 256-283.

Snee, R. (2010), "Lean Six Sigma – getting better all the time", *International Journal of Lean Six Sigma*, Vol. 10 No. 1, pp. 9-29.

Sodhi, H.S., Singh, G. and Mangat, H.S. (2013), "Optimization of end milling process for D2 (die steel) by using response surface methodology", *Journal of Production Engineering*, 2014, Vol. 17 No. 2, pp. 73-78.

Sodhi, H.S., Singh, D. and Singh, B.J. (2019b), "Effect of Lean Six Sigma in small and medium enterprises of India: a review", *Adalya Journal*, Vol. 8 No. 8, pp. 57-67.

Tamizharasi, A., Barton, R. and Chuke, C. (2014), "Applying Lean Six Sigma in a small engineering company – a model for change", *Journal of Manufacturing Technology Management*, Vol. 20 No. 1, pp. 113-129.

Tranfield, D., Denyer, D. and Smart, P. (2003), "Towards a methodology for developing evidence-informed management knowledge by means of a systematic review", *British Journal of Management*, Vol. 14 No. 3, pp. 207-222.

Uma, C. (2013), "Dynamic capabilities and the emergence of intra-industry differential firm performance: insights from a simulation study", *Strategic Management Journal*, Vol. 24 No. 2, pp. 97-125.

Vinesh, A. and Geoff, N. (2012), "A fuzzy-logic advisory system for lean manufacturing within SMEs", *International Journal of Computer Integrated Manufacturing*, Vol. 9 No. 6, pp. 839-852.

Vinodh, S. and Balaji, S.R. (2011), "Fuzzy logic based leanness assessment and its decision support system", *International Journal of Production Research*, Vol. 49 No. 13, pp. 4027-4041.

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