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Development of Lean Six-Sigma conceptual implementation model for manufacturing organisations

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Abstract. Due to the importance of manufacturing management models in enhancing the process performance and obtaining continuous improvement, it is apparent that both Six-Sigma and Lean management are two continuous improvement methodologies for improving the operation process and achieving high quality performance. The purpose of this paper is to develop a conceptual Lean six-sigma implementation model (LSS-M) for manufacturing organisations in order to entrench the strategic thinking into long term planning. The paper explores the literature pertinent to the topic and the necessary tools to carry out this research, the study used survey questionnaires to gather practitioners and academic opinion aiming at validating the proposed integrated model, its suitability for manufacturing organisation and identifying the barriers for successful implementation. The results clearly demonstrate that the proposed model is valuable to practitioners and academics and can assist manufacturing organisations to achieve competitive advantage if embedded in their long term strategic thinking.

Keywords Lean Manufacturing, Six-sigma, Organisation Improvement.

1. Introduction

Constant changes in the external business environment driven by increased competition, more demanding consumers and a relatively unstable economic climate in many countries have forced organisations to improve their long term strategic thinking in order to remain in business. Organisations are now required to operate at the lowest cost, with greater speed and reliability, develop a superior ability to change and continuously improve in order to gain competitive advantage [1]. For over a decade, models like Lean Manufacturing, Six Sigma and TQM have been adopted by organisations to simplify the production lines, reduce waste and improve the quality. However, none of these models have been able to solve all the organisation problems when adopted alone, hence the need for hybrid models like Lean Six Sigma (LSS) [2]. LSS becomes able to exceed the improvement rates achieved by Lean Manufacturing or Six Sigma when adopted individually, defeating the purpose of using these models in parallel [3]. LSS improves an organisation's performances in terms of improved quality, reduced cycle time and creates value for stakeholders in all sectors of the organisation [4]. This paper seeks to develop a conceptual LSS implementation model for manufacturing organisations and to help them embed the strategic thinking into their long term planning. The paper shows the literature relevant to the topic, the critical success factors (CSFs) for successful implementation of LSS and the appropriate methodology that leads to the desired result. Furthermore, necessary steps are taken to validate the proposed model.

2. What makes Lean Six-Sigma different?

Lean Six-Sigma is a successful approach due to the use of a disciplined and DMAIC methodology, which is a systematic improvement strategy that leads to rapid project completion in ideal time. This view is supported by [5], who stated that in order to create a tangible improvement methodology the best way is to create an integrated system for management projects, rather than separate systems for Lean or Six-Sigma projects; therefore, Lean and Six-Sigma both have built one system including a business strategy and methodology that increase the process performance, and hence enhance customer satisfaction and the bottom line results) [6]. Also, LSS provides the concepts, strategy and tools that enable the organisation to change from one way of working to a better way.

2.1 The requirements for Lean and Six-Sigma implementation

The overall requirement of the Integration Approach referred to in various literatures as in method engineering [7]. Johannes stated that the main requirements of the Integration Approach are completeness, consistency and intended purpose. Johannes studied these requirements and linked them to the Integration Method in quality management. Johannes concluded that these requirements are considered as the key factors that are required to obtain the synergies between methods and hence success of the Integration Approach. Based on this context [8] stated that Six-Sigma and Lean mutually reinforced and enhanced each other, while DMAIC strategy can be used as a road map work for the process improvement and Value Stream Mapping (VSM), which might be used as a platform for Lean and Six-Sigma tools.

2.2 Critical Success Factors of Lean-Six Sigma

The critical success factors (CSFs) are the key managerial and technical factors in which the organisation must be well identified in order to ensure the success of the process and obtain high performance. Various literatures study the CSFs of LSS such as [9], [10], [11] and others. However, most of them agreed that the following factors are the CSFs for successful implementation of LSS in many organisations:

1. Organisational structure
2. Business plan and vision
3. Link LSS to customers
4. Change management and organisation culture
5. Education and training
6. Top management involvement and participation
7. Effective communication
8. Link LSS to organisation's business strategy
9. Project selection, prioritization, reviews and tracking
10. Link to Suppliers
11. Project management
12. Monitoring and evaluation of performance

3. The proposed conceptual LSS implementation model

The proposed LSS conceptual model developed based on the relevant extensive literature review, however, the model developed is different than the models existing in the literature, where the strategic level and operational level are integrated to simplify the implementation process and enables the manufacturing organisations to overcome the fear of high cost and complexity associated with LSS implementation. The model seeks to utilise the knowledge within the organisation and breaks down the barriers hindering individuals from using statistical problem solving methods by acting as a step-by-step guide. The proposed model is based on DMAIC Approach which is the main strategy enables the implementation processes to identify opportunities for quality improvement, increase process performance and reduce variability and waste in a product or process using statistical tool. However DMAIC phases in this model is integrated to each other to draw the implementation processes and streamline the operating system. Therefore the proposed model in figure 1 below consisting of two main components which are; Strategic elements, comprise the key drivers required for successful implementation of business process. Operation elements, including the key factors for successful implementation of the operation system and obtaining high quality performance, the implementation process of the model is summarised in four sub process as follows:

- i. *Process Planning and Organisation.* In this process the model employs the strategic tools for organising and planning the implementation process, which includes four steps: (1) Analyse the market to capture the Voice of Customer (VOC), evaluate the business process to identify Voice of Business (VOB), and translate VOC and VOB to Critical to Quality (CTQ) in order to improve the quality of products, formulate high level functional team and identify the final vision; (2) Establish the overall improvements including process improvement using Supplier Input Process Output Customer (SIPOC); (3) Create the baseline of LSS metrics and tools and analyse the risk associated with each step by applying Failure Mode and Effect Analysis (FMEA); (4) finally identify the value of LSS by analysing the cost benefits and draw strategic process map.
- ii. *Process Enhancement and Stimulation.* This stage aims to enhance the process and prepare the work environment for improvement. This can be conducted through determination of the area for improvement via VSM and standardise the operating practice using 5S, redesign the system by creating Single Unit Flow (SUF) and evaluate the measurement system and tools by applying Six-Sigma Approach.
- iii. *Process Evaluation and Activation.* The purpose of this step is to apply the proper statistical tools to eliminate the quality problems, identify the gap between the current and desired performance and analyse the root causes to identify the potential improvements by conducting Design of Experiment (DOE).
- iv. *Process Improvement and Verification.* Once the results of DOE are confirmed, then the whole operation process is monitored through controlled plan using appropriate LSS tools to attain sustainable improvement for the operating practice. Finally, the whole process performance is verified via balanced scorecard and KPI to assure whether the organisation meets the business objectives.

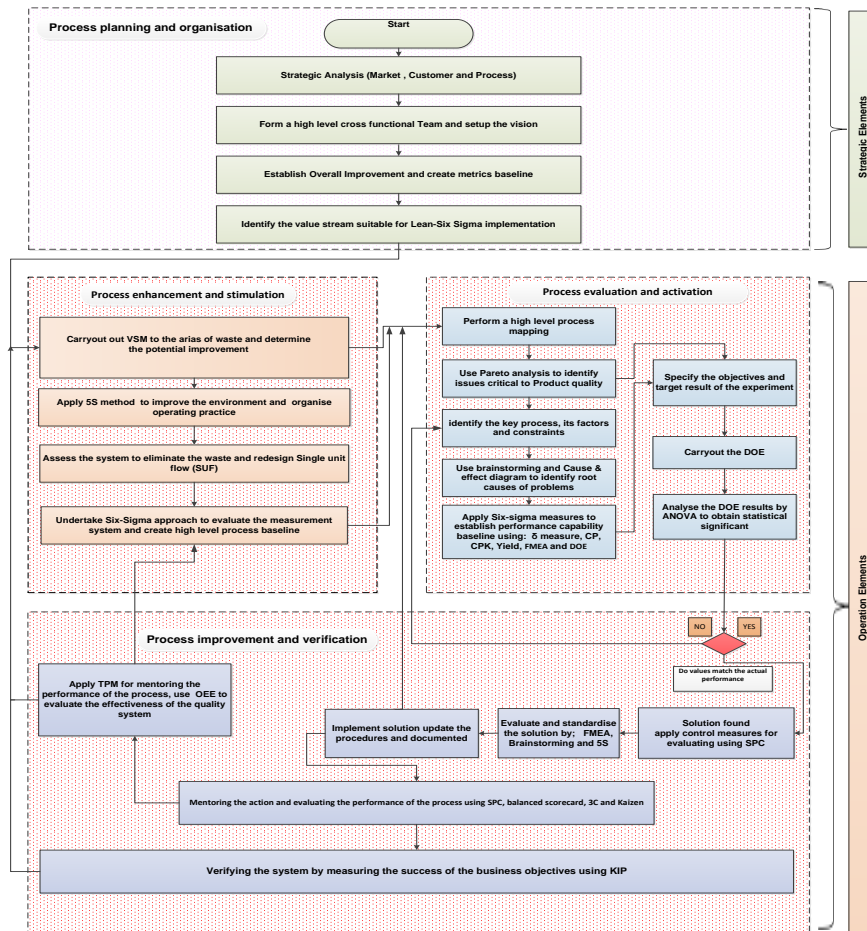


Figure 1. The proposed LSS conceptual model for manufacturing organizations

4. Study Methodology

Questionnaire survey has been developed for this study, and its main aim is to investigate the suitability of the proposed model for manufacturing organisations. The questionnaire consists of five main sections and 24 main questions. The key point of the survey is to identify possible implementation difficulties and reveal the accuracy level of the contents of the proposed conceptual LSS model in helping manufacturing organisations to gain competitive advantage in the long run. 70 questionnaires were sent through email to experienced practitioners and academics across the available manufacturing organisations in different countries. Consequently, 56 valid questionnaires were received making the response rate to be relatively high above the household mediated [12]. Therefore, 56 useable questionnaires were coded and entered to (SPSS 23) software program to carry out basic statistical analysis for the observation of frequencies, percentage, mean and standard deviation to assess the data. (More information about the results will be including the conference presentation).

5. Validation of the proposed conceptual LSS implementation model

The survey investigated the Lean-Six Sigma awareness level, the validity of the proposed conceptual LSS implementation model and the critical success factors for successful implementation in manufacturing organisations. The results of the survey clearly demonstrated that the awareness level of LSS tools is very high, but the usage level in an integrated fashion is still low among manufacturers.

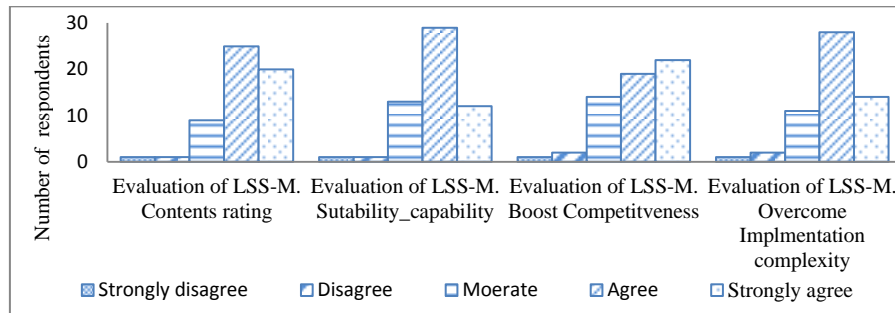


Figure 2. Respondents rate about the evaluation of proposed LSS conceptual model

Although some of the LSS tools listed in the questionnaire are quite familiar amongst managers, many of manufacturing organisations are yet to make use of some of them. The proposed model was evaluated based on four criteria: suitability of the model contents, applicability in practice, ability to boost competitiveness and overcome the implantation complexity. The respondents were asked to indicate the extent to which they agree to the mentioned criteria based on five Likert scales, starting by 1 strongly Disagree and ending by 5 strongly Agree. As it can be seen in figure 2 above the highest rate for the entire criteria falls respectively in favour of agree, strongly agree and moderate. Therefore, the results clearly demonstrate that the proposed developed model is a workable model and can help manufacturing organisations to achieve competitive advantage if embedded in their long term.

5.1 Reliability and validity analysis

Cronbach's (α) employed to check the internal consistency of the measurements used as reliability test, the results show that the overall Cronbach's (α) is 0.91, which is greater than 0.7 see [13] As a result, it is concluded that these instruments have high internal consistency and reliability as shown in table 1.

	Model contents rating	Suitability/ Capability of the model	The ability of the Model to competitiveness	Control LSS Application difficulty	Difficulty applying the model	Any missing in contents of the model
Chi-square	42.929 ^a	44.09 ^b	30.96 ^a	42.75 ^a	15.68 ^c	1.50 ^d
df	4	4	4	4	1	1
Asymp. Sign. (P)	.000	.00	.000	.000	.000	.000
Cronbach's' (α)	0.911					

Chi-Square Goodness of fit (X^2) is also used to examine the validity of the measures, as can be seen in table 1. The results of X^2 demonstrated that P values are less than 0.05, which means that the results are significantly different from the actual observed values and expected values of the entire statements used to evaluate the proposed model. Due to space limitation, the rest of the results will be presented in the conference.

6. Conclusion

The paper demonstrated: 1) the output of the research question, 2) the development of the proposed conceptual Lean Six-Sigma implementation model and 3) LSS implementation, which should be integrated into the organisations long term strategic thinking. These will shape the management strategies and vision to which the managers have to commit and also guide the employees to achieve improved processes, reduce variations, reduce waste and meet or exceed customers' expectations. The study concluded that LSS implementation in manufacturing organisations are still at the early stage, although a good number has at least used most of the 26 LSS tools and techniques presented in this paper. The majority are yet to adopt Lean and Six-Sigma as an integrated approach, hence the need for the developed conceptual model. Most of the organisations already have the required culture that will make the implementation process easier, but a lot has to be done in terms of training and education so that most managers will fully understand LSS and the potential benefits.

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