Proposal for a Conceptual Model for Evaluating Lean Product Development Performance: A Study of LPD Enablers in Manufacturing Companies

2016 IOP Conf. Ser.: Mater. Sci. Eng. 114 012047

(http://iopscience.iop.org/1757-899X/114/1/012047)

IOP Conf. Series: Materials Science and Engineering **114** (2016) 012047 doi:10.1088/1757-899X/114/1/012047

Proposal for a Conceptual Model for Evaluating Lean Product Development Performance: A Study of LPD Enablers in Manufacturing Companies

Daniel Osezua Aikhuele[1*], Faiz Mohd Turan[2]
[1,2]Faculty of Manufacturing Engineering, Universiti Malaysia Pahang, 26600 Pekan, Pahang, Malaysia

Email: [1]danbishop_22@yahoo.co.uk, [2]faizmt@ump.edu.my

Abstract. The instability in today's market and the emerging demands for mass customized products by customers, are driving companies to seek for cost effective and time efficient improvements in their production system and this have led to real pressure for the adaptation of new developmental architecture and operational parameters to remain competitive in the market. Among such developmental architecture adopted, is the integration of lean thinking in the product development process. However, due to lack of clear understanding of the lean performance and its measurements, many companies are unable to implement and fully integrate the lean principle into their product development process and without a proper performance measurement, the performance level of the organizational value stream will be unknown and the specific area of improvement as it relates to the LPD program cannot be tracked. Hence, it will result in poor decision making in the LPD implementation. This paper therefore seeks to present a conceptual model for evaluation of LPD performances by identifying and analysing the core existing LPD enabler (Chief Engineer, Cross-functional teams, Set-based engineering, Poka-yoke (mistake-proofing), Knowledge-based environment, Value-focused planning and development, Top management support, Technology, Supplier integration, Workforce commitment and Continuous improvement culture) for assessing the LPD performance.

1. Introduction

The instability in the global market and the ever emerging demands for mass customized and hybrid products by customers, are driving companies to seek for cost effective and time efficient improvements in their production system and this have led to real pressure for the adaptation of new developmental architecture and operational parameters to remain competitive in the market. Among such developmental architecture adopted, is the integration of lean thinking in the product development process, this is as a result of the realization by manufacturing firms of the potential of an effective lean product development process management, in reducing developmental cost, time to market of new products, engineering hours, ease in manufacturability, process control, flexibility, and increased in the quality of products.

The lean approach which is an improvement philosophy is aimed at providing a new way of thinking, with the view to delivering more benefits and value to the individuals while eliminating waste. The ideas behind the lean thinking philosophy can be traced back to great industrialists like

Henry Ford and management thinkers like W. Edwards Deming [1] who contributed to the expansion of the original ideas developed by Taiichi Ohno in the Toyota motor company during the post Second World War manufacturing operations.

Many organization have attempted the integration of lean principle in the product development process, but mostly have failed due to the lack of clear understanding of the lean performance measurements [2], and the near absent of a holistic and unifying measuring method. However, without a proper performance measurement, the performance level of the organizational value stream will be unknown and the specific area of improvement as it relates to the LPD program cannot be tracked, hence, it will result in poor decision making in the LPD implementation effort [3]. Few research contributions have been made over the years on the development of an assessment model for the LPD performance. Among such effort includes, [4] who applied Key Performance Indicators (KPIs) for measuring the performance of organization by monitoring the successes of the organization. [5] Develop a Balanced Scorecard (BSC) as a management decision tool which provides framework for a balanced set of measures for strategy and operational performance. [6] In their exploratory research study developed a maturity model - SMART (Start, Motivate, Apply, Review and improve, and Transform) for the assessment of the current and desired maturity level of the organization as it relate to LPD process. [7] Present a model for the assessment of information waste during information transfers between team members using a paper based value stream map.

[8] Develop an assessment tool for defining the lean status of an organization using a customized five-level scale for rating the readiness levels of the organization in a radar chart. [9] Proposed a fuzzy model for the evaluation of variant solutions in the PD process and for diminishing the uncertainty in the product developmental process. [10] Present a model for the evaluation and the prioritization of new products development ideas using a fuzzy multi-criteria decision making methodology (FMCDM), the final result of the evaluations compared the proposed model with a traditional existing AHP model to assess the compatibility and reliability of the model in the evaluation of PD process. [11] Develop a decision support (DS) tool using fuzzy logic algorithm for the assessment of the maturity level of a software product, where the DS tool was use in assisting organizations in making crucial decisions and for ensuring the knowledge and information generated during the early stages of product development process are not lost.

As demonstrated in the literatures reviewed, certain contributes has been made in the development of tools and models for the assessment of the LPD performance, however mostly have been concentrated on some aspects of the lean performance, most especially the financial aspect using quantitate metrics, hence measuring only the results from the company and neglecting the actual LPD process which are summarized in the following areas; the lean implementation strategy, innovation and learning, cultural assessment, assessment of product and information value, and the assessment of waste in the product development process. Also, very few researchers have contributed to the approach in assessing the LPD process. In order to fill this gap, this study therefore describes a preliminary study for the development of a conceptual model that can be used in the evaluation of LPD performance thereby addressing issues surrounding the lean evaluation approach.

2. Methodology

In constructing the conceptual model, the study starts with a thorough literature review of the LPD practice as well as the existing LPD performance model, where the existing and current model for LPD performance assessment were identified and studied. However, to stay in line with the objective of the research study, more emphasis was placed on the identification and analysis of the lean practices or lean enablers for the implementation and evaluation of the LPD performances. Following synthesis of the literature reviewed, a semi-structured interview were conducted to get the opinions of academics experts and researchers with special interest in lean management, lean design and development, performance assessment, multi-criteria decision making and process modelling on the feasibility of using the identified lean enablers for the assessment of the LPD performance in an industrial environment. Although the semi-structured interview was conduct with very few respondents participating and within Malaysia only, however the aim of the interview was achieved, since is a preliminary study and a work in progress.

3. Conceptual Model

The conceptual performance evaluation model has been designed with reference to literature [8]; [12]–[14]; [15] and have been verified through a semi-structured interview of Academic experts and Researcher. Although the model is still a work in progress as is yet to get approval or validation for its efficacy in assessing LPD performance in the industrial environment, however the preliminary conceptual model have been presented as shown in Table 1. The model consists of two levels, where the first level consists of ten (10) lean enablers and the second, thirty-three (33) lean attributes. The model have designed such that it can capture all aspect of the LPD performance areas mention in the previous section, hence it can be said to be very comprehensive, as all the lean enablers in the model has been reviewed from various perspectives. As a sample, three of the core lean enabler and their attributes are explained.

Set-based engineering: The set-based engineering which is potentially one of the main underlying cause for the successes recorded in the Toyota Motor Company [16] is an organized group of principles that allows design practitioners to reason, develop, and communicate about a sets of solutions in parallel, and gradually narrow them down based on the knowledge and information gained through customers relations and interaction, communication with the manufacturing departments, tests/design of prototypes, and other sources [15],[17]. The set-based engineering as a lean enabler has been reviewed from its five different major perspectives (i.e. Principles), and they are used as factors and sub-factors in the evaluation of the LPD performance, the five principles includes;

- Strategic value research and alignment,
- Mapping the design Space,
- Create and explore multiple concepts in parallel,
- Integrate by intersection and
- Establish feasibility before commitment.

Knowledge Based Engineering: Knowledge Based Engineering which is an innovative method allows businesses including design practitioners to capture product and process information and to reuses such information in automating all or part of the process. The main objective of this lean enabler is to reduce time to market for new product and for the reduction of product development cost. This is achieved through the automation of repetitive design tasks while capturing, retaining and re-using of the gain design knowledge [18]. The Knowledge Based Engineering as a lean enabler is based on the following;

- Knowledge Identification
- Knowledge Representation
- Knowledge Capturing
- Knowledge Re-Use

Supplier integration*:* In the LPD context, the suppliers of the parts for the manufacturing of the product are actively involved in all aspect of the PD, right from the early stages of the Design through to the product lunch, this is to avoid misunderstanding and rework, also the involvement of the supplier in the PD process will help in speeding up the process. This is in contract to the traditional product development practices where the suppliers only get involved when the detailed design specifications have been developed. Supplier integration as a lean enabler is based on the following;

- Supplier feedback
- Supplier development

- Supplier support/involvement
- Supplier quality

Table 1. Conceptual model for LPDD performance evaluation

	LPD Enabler	Lean Attributes
1	Chief Engineer	• Cross-functional module development teams • Manufacturing involvement
2	Cross-functional teams	• Work experience • Work capability • Specialized knowledge • Communication and corporation
3	Set-based engineering,	• Strategic value research and alignment • Mapping the design Space • Create and explore multiple concepts in parallel • Integrate by intersection • Establish feasibility before commitment
4	Poka-yoke (mistake-proofing),	• Mistakes Elimination in Product Design Parameters Identification • Mistakes Elimination in Process Parameters Selection • Mistakes Elimination in Manufacturing
5	Knowledge-based engineering	• Knowledge Identification • Knowledge Representation • Knowledge Capturing • Knowledge Re-Use.
6	Supplier integration,	• Supplier feedback • Supplier development • Supplier support/involvement • Supplier quality
7	Value-focused planning and development	• Voice of the Customer (customer needs/wants) • Value-stream mapping • Multi-project plan and strategy
8	Top management support	• Organization structure • Nature of organization
9	Workforce commitment	• Employee involvement • Employee status
10	Continuous improvement (Kaizen) culture	• Employee empowerment/individual responsibility • Lessons learnt reflection process • Standardization of processes, skills, and design methods • Separating research from development

4. Conclusion

The aim of the study was to design a conceptual model that can be used in the evaluation of LPD performance in the manufacturing industry. This was done, first by identifying the issues with existing performance evaluation methods as it relates to LPD. Secondly, a ten (10) core lean enablers were identified and analysed with reference to literature, and the lean enablers were verified by a group of Academic experts and Researchers as a possible means for assessing the LPD performance, since it will not only be based on quantitative measure but on the qualitative aspects, also it will not rely only on the result from the company for it measurement like the presently existing methods that are based on quantile matrices but will be based on criteria and attributes hence it can be used measuring the actual LPD process. The developed conceptual model in this research study however, is still a work in progress as is yet to be validated in the industrial environment, hence is term a preliminary study.

Reference

[1] R. J. Zarbo, "Creating and sustaining a lean culture of continuous process improvement," *Am. J. Clin. Pathol.*, vol. 138, pp. 321–326, 2012.
[2] F. Behrouzi and K. Y. Wong, "Lean performance evaluation of manufacturing systems: A dynamic and innovative approach," *Procedia Comput. Sci.*, vol. 3, pp. 388–395, 2011.
[3] H. Wan, "Measuring Leanness of Manufacturing Systems and Identifying Leanness Target by Considering Agility Measuring Leanness of Manufacturing Systems and Identifying Leanness Target by Considering Agility," *PhD Thesis*, 2006.
[4] V. Jovan and S. Zorzut, "Use of key performance indicators in production management," *2006 IEEE Conf. Cybern. Intell. Syst.*, pp. 1–6, 2006.
[5] R. S. Kaplan and D. P. Norton, "The balanced scorecard: Measures That drive performance," *Harv. Bus. Rev.*, vol. 83, 2005.
[6] A. Sopelana, M. Flores, L. Martinez, K. Flores, and M. Sorli, "The Application of an Assessment Tool for Lean Product Development : An exploratory study in Spanish Companies," *Int. Conf. Eng. Technol. Innov.*, no. 1996, pp. 1–10, 2012.
[7] M. Graebsch, W. P. Seering, and U. Lindemann, "Assessing Information Waste in Lean Product Development," *Proc. Int. Conf. Eng. Des.*, no. August, pp. 1–12, 2007.
[8] A. Al-ashaab, A. Andino, and M. Summers, "Lean product development performance measurement tool," *Proc. 11th Int. Conf. Manuf. Res. Adv. Manuf. Technol. XXVII 19-20 Sept. 2013. Cranfield, Bedfordshire, UK.*, no. September, pp. 19–20, 2013.
[9] M. R. Vladu, G. Dobre, and R. F. Miric, "Application of the fuzzy logic in the evaluation of solution variants in the product development process," *1ssn 1454-234x*, vol. 75, no. 1, 2013.
[10] a Badizadeh and S. Khanmohammadi, "Developing a Fuzzy model for assessment and selection of the best idea of new product development," *Indian J. Sci. Technol.*, vol. 4, no. 12, pp. 1749–1762 ST – Developing a Fuzzy model for asses, 2011.
[11] F. Ahmed, "A Decision Support Tool for Assessing the Maturity of the Software Product Line Process," *Int. J. Comput. Inf. scinences*, vol. 4, no. 3, pp. 97–113, 2006.
[12] J. Hoppmann, E. Rebentisch, U. Dombrowski, and T. Zahn, "A Framework for Organizing Lean Product Development," *Eng. Manag. J.*, vol. 23, no. 1, pp. 3–16, 2011.
[13] M. Khan and a Al-Ashaab, "Towards lean product and process development," *… J. Comput. …*, vol. 26, no. 12, pp. 1–27, 2013.
[14] W. Ahmad, "Cost modelling system to support lean product and process development," *PhD Thesis*, no. September, p. 258, 2012.
[15] M. Khan, A. Al-Ashaab, A. Doultsinou, E. Shehab, P. Ewers, and R. Sulowski, "Set-based concurrent engineering process within the LeanPPD environment," *Adv. Concurr. Eng.*, no. July, pp. 433–440, 2011.
[16] D. K. S. I. Allen Ward, Jeffrey K. Liker, John J. Cristiano, "The second toyota paradox: how delaying decisions can make better cars faster," *Sloan Manage. Rev.*, vol. 36, no. JANUARY, pp. 43–61, 1995.
[17] D. S. Raudberget, "Enabling Set-Based Concurrent Engineering in Traditional Product Development," *Proc. 18th Int. Conf. Eng. Des. (ICED11), Vol. 1*, no. August, pp. 45–56, 2011.
[18] W. J. C. Verhagen, P. Bermell-Garcia, R. E. C. Van Dijk, and R. Curran, "A critical review of Knowledge-Based Engineering: An identification of research challenges," *Adv. Eng. Informatics*, vol. 26, no. 1, pp. 5–15, 2012.