Chapter 48
Lean Development: How to Reach Higher Effectiveness and Efficiency

Uwe Dombrowski, Isa von Hoesslin, David Ebentreich and Thimo Zahn

Abstract Over the past years many companies have introduced lean elements to optimize their production and assembly processes. As a result of the achievements of lean production systems the lean elements are also increasingly applied in product development (lean development). So far there is little known about how far the elements of lean development are spread as well as their influence on effectiveness and efficiency enhancement. This article will present the results of a study in which 60 mostly German companies of different sizes and from different industries took part. The study identified which elements of lean development were implemented in the development process and which delivered the greatest benefit to it.

Keywords Effectiveness · Efficiency · Lean development

48.1 Introduction

Due to changed conditions, manufacturing companies have dealt intensively with the implementation of lean production systems (LPS) over the past few years. A LPS is a company-specific, methodological set of regulations for the comprehensive and integrated design of the companies' processes (Dombrowski et al. 2005). Changed conditions not only influence production but also product development. Comparable sets of regulations for product development (lean development) to enhance effectiveness and efficiency as well as to improve employees' and the organization's abilities are more and more focused. Companies such as Toyota that have already implemented the lean philosophy into product

U. Dombrowski · I. von Hoesslin (✉) · D. Ebentreich · T. Zahn
Institute for Advanced Industrial Management, Technische Universität Braunschweig, Braunschweig, Germany
e-mail: i.hoesslin@tu-bs.de

E. Qi et al. (eds.), *International Asia Conference on Industrial Engineering and Management Innovation (IEMI2012) Proceedings*,
DOI: 10.1007/978-3-642-38445-5_48, © Springer-Verlag Berlin Heidelberg 2013

development, generate innovative products and processes of higher quality in significant less time and with fewer resources (Morgan and Liker 2006). Companies following the example of Toyota find plenty of lean development concepts that differ from each other. Furthermore there is a lack of knowledge about the influence of the elements on effectiveness and efficiency enhancement. Therefore the Institute for Advanced Industrial Management, TU Braunschweig revealed in a study which elements of lean development are implemented in companies and which delivered the greatest benefit.

48.2 Methodology

Based on a literature review, 19 lean development elements were identified (Morgan and Liker 2006; Ballé and Ballé 2005; Sehested and Sonnenberg 2011; Ward 2007). This paper uses an industry survey as research method. In a web-based survey the elements were examined towards their distribution with closed questions and their influences on effectiveness and efficiency by a four-stage Likert scale. In this case effectiveness means "developing the right products", e.g. innovative products, low lifecycle costs and high customer satisfaction. The meaning of efficiency is "developing the product right", e.g. low costs, short time-to-market and few changes. In the following the participants of the survey will be introduced before the essential results will be presented.

The majority of the 60 companies is located in the automotive industry (27 %) as well as machinery and plant engineering (22 %) followed by electronic (11 %) and consumer goods industry (7 %). Figure 48.1 shows the annual sales of the

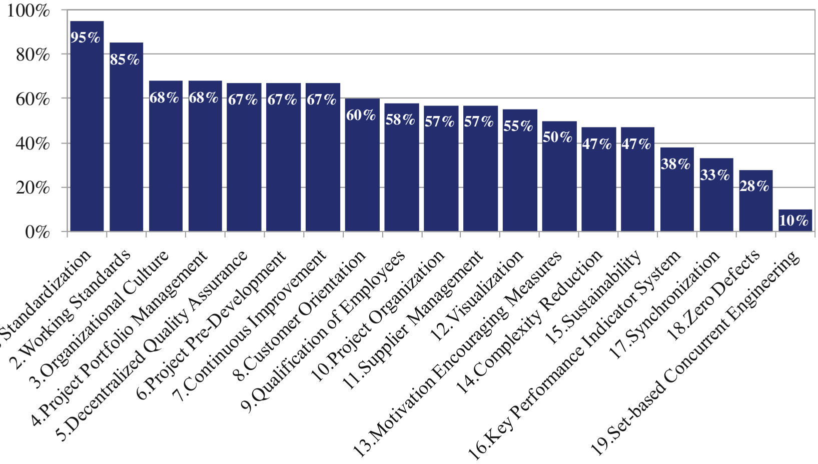

Fig. 48.1 Overview of the diffusion rate of lean development elements

Table 48.1 Annual turnover and number of employees in product development

	Number of employees					
Annual turnover [€]	1–50	50–100	100–500	500–1000	>1000	Sum
<50 m	6	0	0	0	0	6
50–500 m	11	5	3	0	0	19
500 m−1 bn	1	4	3	0	0	8
1–10 bn	3	2	6	2	2	15
10–50 bn	1	1	3	1	3	9
>50 bn	0	0	2	1	0	3
Sum	22	12	17	4	5	60

companies and the number of employees in product development. Moreover it shows that 37 % of the companies have less than 50 employees working in product development (Table 48.1).

48.3 Results

48.3.1 Diffusion Rate of Lean Development Elements

After introducing the group of participants, in the following section the partial results of the study are presented.

1. **Process standardization** involves standardized workflows with defined responsibilities, documents and work instructions within the development process (Morgan and Liker 2006). Standardization supports the reduction of errors, the minimization of variability, the increase of efficiency and the creation of a basis for continuous improvement (Ballé and Ballé 2005; Brown 2007; Schuh et al. 2008). Within the number of participants 95 % already adopt process standardization.
2. **Working standards** are specifications that contain the sequence of work steps, time for an element, cycle time and quantities of inventory (Rother 2010). Working standards increase employee's performances as well as the willingness to perform. Moreover it simplifies measures for employee qualification. Disciplinary (e.g. Methods of Construction, Design of Experiments) and interdisciplinary (e.g. Risk Analysis, Product Life Cycle Calculation) working standards were implemented in 85 % of the companies (Morgan and Liker 2006; Rother 2010)
3. 68 % of the companies started to implement an **organizational culture** of no-blame and problem-solving. This approach is based on openly handling problems and errors. Reasons for problems are assumed in the process. Therefore the focus problem solving shifts from person to process (Rother 2010; Mann 2006).

4. **Project Portfolio Management (PPM)** is an approach that fosters efficiency in the innovation process. On the basis of strategic, technical, economic and organizational criteria as well as objective methods product development projects are evaluated, selected and prioritized. Thereby it supports the selection and initiation of the right projects (Sehested and Sonnenberg 2011). A large number of interviewed companies (68 %) established PPM.
5. **Decentralized quality assurance** contains the analysis, validation and optimization of product and process quality. Methods of the decentralized quality assurance (e.g. Rapid Prototyping, Cardboard Engineering, Checklists, Customer–Supplier Relationship) were implemented by 67 % of the companies (Wiendahl 2008).
6. Compared to the conventional product design **project pre-development** serves to specify product concepts at the beginning of the product design (e.g. Technology, Functionality, Carry-Over-Part, Product Vision, Modularization, Production Concept, Target Costs) (Clark 1989). The majority (67 %) of the companies uses this element.
7. **Continuous improvement** means the simultaneous and day-to-day optimization of processes. There is an unlimited capability for improvements within the processes of a company. The majority of the interviewed companies (67 %) are using continuous improvement in product development (Morgan and Liker 2006; Rother 2010).
8. Requirements engineering identifies, evaluates and prioritizes internal and external product requirements. The intention is to maximize the customer value and to minimize the product and process complexity. Over half of the interviewed companies (60 %) implemented central requirements engineering. Thus the **customer orientation** increases by handling positive as well as negative feedback of internal and external customers (Hull et al. 2011).
9. **Qualification of employees** describes a continuous learning process. It has to match the long-term corporate philosophy and has to be standardized to enable a high as well as homogeneous proficiency level. These specific requirements of lean development are considered in 58 % of the companies by a qualification of employees (Morgan and Liker 2006; Liker 2004).
10. Most of the companies (58 %) adopt a **project organization** in the product development process, where Chief Engineers and Module Development Teams are integrated. The Chief Engineer serves as the voice of the customer. His role is to plan, solve conflicts, support, communicate, monitor and decide. Module Development Teams are independent, interdisciplinary and support the development process among other things by product and process benchmarking (Morgan and Liker 2006; Ward 2007; Liker 2004).
11. **Supplier Management** is an approach for companies to govern the relationship with their suppliers systematically. 57 % of the companies practice a supplier management that considers special requirements of the product development (e.g. Innovative Ability, Personnel Exchange, Communication, Protection of Intellectual Property) (Morgan and Liker 2006).

12. **Visualization** describes the graphical representation of objectives, key performance indicators, problems as well as information about work flow and work results. It facilitates the identification and solution of problem areas and increases the responsiveness (Morgan and Liker 2006; Mascitelli 2011). Fifty-four percent of the companies adopted this element in the product development.
13. The lean element motivation contains different methods to increase the willingness to perform of the employees. The drivers are the corporate image, the attractiveness of work (e.g. Personal Responsibility, Challenges), work environment (e.g. Organizational Structure, Leadership), work-life-balance, career opportunities (e.g. Training Possibilities) and financial incentives (Liker 2004). Half of the number of participants (50 %) is using **motivation encouraging measures**, which consider the requirements of product development.
14. Complexity affects the attainment of quality, cost, time, flexibility, effectiveness as well as efficiency objectives. Among other things the abandonment of a complexity management is the identification, analysis as well as review of complexity driver with the aim to identify an appropriate measure for **complexity reduction** (Schuh 2005). Less than half of the companies (47 %) use the reduction of complexity in the product development process (e.g. Assortment Optimization, Postponement Strategies).
15. The lean element **sustainability** is in charge of the systematic storage of process, product and project information in a knowledge data base. The information can be used for process and product improvements as well as reduction of the time-to-market. In spite of the necessity of a cross-project knowledge transfer, 47 % of the companies indicated that they aim for sustainability through systematic knowledge conservation (Schipper and Swets 2010).
16. Process controlling is a multidimensional approach for planning, control and optimization of business processes. Within the process controlling **key performance indicator systems** are used to reveal weak points, variance and potential for improvement (Liker and Convis 2012). 38 % of the companies use the system.
17. One-third (33 %) of the companies uses Processes **Synchronization** in the product development. The intention is to time and schedule the single work steps to achieve consistent work phases (e.g. Rhythm) (Mascitelli 2011).
18. 28 % of the companies implemented the systematical pursuit of **zero defects** in the product development process e.g. Product Reliability-Test by CAx-Methods. The intention is to decrease the drop-out-rate and the rate of change in the product development process (Linger 1993).
19. **Set-based concurrent engineering** is a new model to structure the process of developing a particular product module. Compared to the point-based approach, set-based concurrent engineering does not only develop a small number of alternative solutions for each concept module, it considers a much larger number of concepts at the beginning of the product development

process. Instead of the quick minimization of alternatives, each concept is designed, tested and analyzed parallel, until one solution is found (Morgan and Liker 2006; Sobek et al. 1999). Within the number of participants only 10 % already adopted Set-based concurrent engineering.

Figure 48.1 shows the diffusion rate of the requested lean development elements.

48.3.2 Effectiveness and Efficiency

In addition to the diffusion rate of lean development elements, the influence of effectiveness and efficiency were queried. The scope of possible answers varied from "very little influence" (1) to "very high influence" (4). The arithmetic mean of the responses was taken and the results are depicted in Fig. 48.2. Moreover there was a distinction between an evaluation, in which the ratings of all companies were considered (Fig. 48.2, Section 1) and an evaluation in which only the ratings were considered by the companies that have implemented the particular elements (Fig. 48.2, Section 2). A different result appears, if only the evaluations of companies are considered, that have implemented the respective element. The diffusion rate (Fig. 48.1) and the impact on effectiveness and efficiency correlate

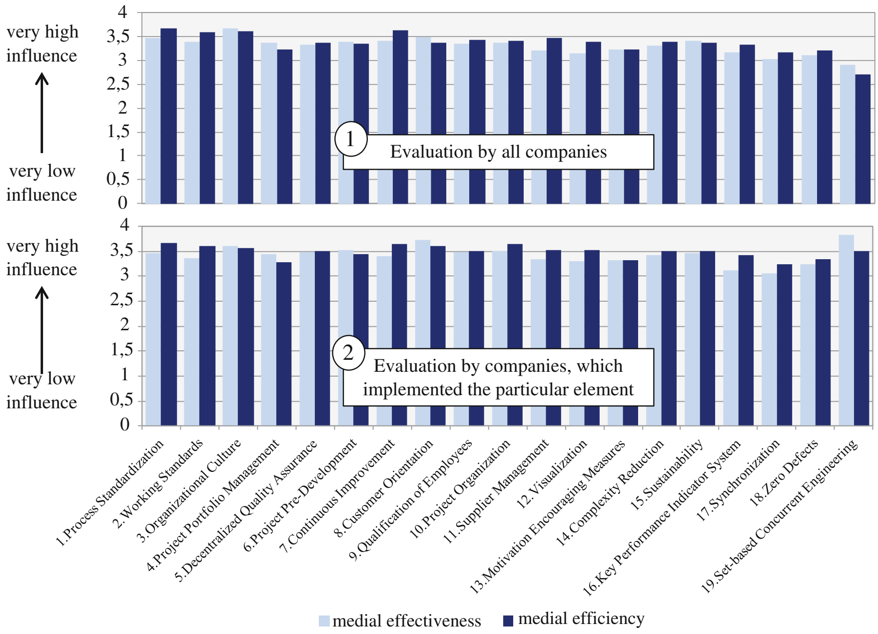

Fig. 48.2 Effectiveness and efficiency of lean development elements

significantly less. Comparing the values of Section 2 with the values from Section 1, it is striking that there is a significant difference between the valuations of some elements. Companies, which have implemented the respective elements already, on average, attach a higher impact on effectiveness and efficiency to the elements of Lean Development. Particularly, in the validation for the set-based concurrent engineering, and for the customer orientation this discrepancy becomes apparent. The set-based concurrent engineering even provides the most powerful influence to increase effectiveness. The efficiency will continue to be affected most by the process standardization. However, the evaluations of customer orientation and continuous improvement have improved significantly. The synchronization of the processes was rated worst in both categories by the companies that have introduced it.

48.4 Discussion

Figure 48.1 shows that the elements key performance indicator system (38 %), synchronization (33 %), zero-defects (28 %) and especially set-based concurrent engineering (10 %) are barely established. This could be reasoned by e.g. the complexity of the implementation or the requirements of other elements (for instance key performance indicator systems require process standardizations).

As mentioned before companies, which implemented the elements already, attach a higher impact on efficiency and effectiveness. Hence, it could be concluded that the actual benefit is higher than the expected influence.

Especially the validation of the elements customer orientation (60 % implementation) and set-based concurrent engineering shows a discrepancy. Therefore companies, which have not established the elements, assume a lower influence of the elements. Probably, the companies do not see the need for the implementation of the element or want avoid the higher effort (time and cost).

Set-based concurrent engineering was mostly established by the companies with the highest number of employees and annual turnover. This could be caused by e.g. the effort of implementation or the high requirement for employee capacity. Furthermore, set-based concurrent engineering, as a lean develop element, does not seem to be lean at first, because of the great amount of considered alternatives at the beginning. In contrast, small and medium-sized companies barely adopt the element. In this field is need for action.

48.5 Conclusion

To increase the effectiveness and efficiency in product development, more and more companies introduce lean development. It can be summarized from the study that 60 companies of varying size and industry already implemented some elements of lean development. Another outcome of the study is that all elements are trusted to have a good to very good influence on the effectiveness and efficiency in product development, regardless whether the ratings of all companies or just of the companies that introduced the element are considered. Nevertheless, the discrepancy between the two analyses is clear. Companies that have introduced elements of the lean development, attach, on average, a higher impact on effectiveness and efficiency to them.

Acknowledgments The authors would like to thank the companies for taking part in the study and making available the data.

References

Ballé F, Ballé M (2005) Lean development. Bus Strategy Rev 16(3):17–22
Brown J (2007) The lean product development benchmark report. Aberdeen Group
Clark KB (1989) Project scope and project performance: the effect of parts strategy and supplier involvement on product development. Manage Sci 35(10):1247–1263
Dombrowski U, Palluck M, Schmidt S (2005) Lean production systems in focus of layout planning (in German), 6. Deutsche Fachkonferenz Fabrikplanung, MIC-Verlag
Hull E, Jackson K, Dick J (2011) Requirements engineering. Springer, London, pp 7–15
Liker JK (2004) The Toyota way: 14 management principles from the world's greatest manufacturer. McGraw Hill, New York, pp 39, 178–198
Liker JK, Convis GL (2012) The Toyota way to lean leadership. McGraw Hill, New York, pp 147–225
Linger RC (1993) Clean room software engineering for zero-defect software. IEEE 2:1–13
Mann D (2006) Creating a lean culture. CRC Press, New York, pp 262–270
Mascitelli R (2011) Mastering lean product development. Technology Perspectives, Northridge, pp 85–89
Morgan JM, Liker JK (2006) The Toyota product development system: integrating people, process, and technology. Productivity Press, New York, pp 29–50, 94–102, 175–215, 287–289
Rother M (2010) Toyota Kata: managing people for improvement, adaptiveness and superior results. McGraw-Hill Companies, New York, pp 28–32, 123–125, 225
Schipper T, Swets M (2010) Innovative lean development. CRC Press, New York, pp 105–117
Schuh G (2005) How to manage product complexity (in German), Hanser, München, pp 34–40
Schuh G, Lenders M, Hieber S (2008) Lean innovation: introducing value systems to product development. Proceedings of PICMET (Portland International Center for Management of Engineering and Technology), Cape Town, pp 1129–1136
Sehested C, Sonnenberg H (2011) Lean innovation—a fast path from knowledge to value. Springer, Berlin, pp 105–127
Sobek DK II, Ward AC, Liker JK (1999) Toyota's principles of set-based concurrent engineering. Sloan Manage Rev 40(2):67–83
Ward AC (2007) Lean product and process development. The Lean Enterprise Institute, Cambridge
Wiendahl H-P (2008) Business organization for engineers (in German), Carl Hanser Verlag, München, pp 110–120