Lean Product Development and the Role of PLM

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Monica Rossi[1], Laura Cattaneo[1], Julien Le Duigou[2], Stéphane Fugier-Garrel[3], Sergio Terzi[1], Benoît Eynard[2]

[1]Politecnico di Milano, Department of Management, Economics and Industrial Engineering
Piazza Leonardo da Vinci, 20133, Milano, Italy
monica.rossi@polimi.it
laura1.cattaneo@polimi.it
sergio.terzi@polimi.it

[2]Sorbonne Universités, Université de Technologie de Compiègne, Department of Mechanical Systems Engineering, UMR CNRS 7337 Roberval, CS 60319, 60203 Compiègne Cedex, France
julien.le-duigou@utc.fr
benoit.eynard@utc.fr

[3]KLManagement 30 rue Vincent Moris, 92240 Malakoff, France
sfugier-garrel@klmanagement.fr

Abstract. Lean Product Development (LPD) promises high product development success by strongly relying on knowledge. Though, despite many IT-based knowledge management tools exist to support and enable knowledge capture, use, formalization and reuse in product development, such as Product Lifecycle Management (PLM) systems, their use within the LPD context is either low or not discussed. This research aims at starting a debate on the role such technologies could have in LPD applications and product development success. The study involves two independent empirical research initiatives, one in France and one in Italy, and launches a discussion on the role of PLM in *customer value definition* in LPD initiatives.

Keywords: Lean Product Development, Product Lifecycle Management, Value Definition, Industrial Survey, Open Questions.

1 Introduction

Traditional product development experiences many problems such as mismanagement of tasks and activities, resources overload, frequent reworks and delays

[1], [2]. Lean product development (LPD) proposes a consistent change in the traditional product development paradigm to entail such criticalities and today it is widely acknowledged that LPD represents one of the most critical and challenging area in the lean management field, affecting the success of the whole enterprise [3]–[7]. One of the main challenges comes from the nature of product development. While manufacturing deals with physical products, product development deals with untouchable flow of data, information and knowledge and this makes the development process uncertain, complex, and unpredictable [7], [8]. Moreover, work in progress in product development is mainly constituted of information and data stored in computers. Theoretically, Product Lifecycle Management (PLM) systems -that aim at providing the right data to the right person at the right time- have the potentialities to increase efficiency of product development process [9] and to emphasize the LPD intent of promoting effective and efficient knowledge management and learning. Though not many evidences exist yet about the enabling role of PLM to successful LPD applications and this research aims to encourage this debate. Starting from a background overview, the authors give some insights on the current understanding and challenges of both LPD and PLM.

The contribution to the debate comes through different levels. First of all the aim of the research is to understand the current level of diffusion of both LPD and PLM systems within industry. The authors conducted and compared two independent empirical researches run from 2012 to 2015 in Italy and France, involving a total of about 150 enterprises. Also the main challenges faced by companies when developing new products in today's market are mapped. The role of the use of PLM and LPD towards such problems is assessed, too. Finally, preliminary discussion on the role of PLM as enabler of the LPD process outcomes is proposed, that will hopefully stimulates further research, applications and debates.

2 Background

2.1 Lean Product Development

Lean Product Development is about creating value through a process that builds on knowledge and learning, enabled by an integrated system of people, processes, and technology [8] [5] [7]. The core of LPD, and its more paradoxical aspect, is the so-called *Second Toyota Paradox* of Set-Based Concurrent Engineering (SBCE) [10], [11]. SBCE bases on its three main principles of *exploration, communication* and *convergence*. *S*tarting from broad design space and driven by customer value, SBCE evaluates different alternatives that are progressively eliminated as soon as technical information becomes available. Main lessons from SBCE are to delay design decisions as much as possible and rely on proven knowledge, often represented in the form of trade-off curves [7], [11].

The attention posed to the system of people, process and technology [8] guarantees that different enterprise aspects are taken into considerations simultaneous-

ly to enable value creation. Visual management, Obeya, cross-functional team, design for-x techniques, people empowerment through training, just some of the several LPD practices that are leading Toyota, and many more, to successful stories. Though, given to the fairly new discipline and the uncertain nature of product development due to the abstraction and complexity of knowledge management and people empowerment, LPD still represents a true challenge for both practitioners and scholars.

2.2 Product Lifecycle Management

PLM is often seen as an extensive and comprehensive concept [12], [13], which defines the integration of different kind of activities that from a technical, organizational and managerial point of view are performed by engineering staff along the entire ideal lifecycle of industrial products, "from cradle to grave" [14].

However, in its practical essence, PLM defines the adoption of several software tools and platforms for supporting innovation and engineering processes[15]. According to the main business analysts, PLM is a leading global market of IT solutions, mainly segmented in two branches: (i) Authoring and Simulation tools and (ii) Collaborative Product Development plaforms and environments. The first segment, includes virtual prototyping solutions (from CAD 3D and PDM, to Computational Flow Dynamic, etc.). The second branch develops collaborative functionalities supporting effective file sharing, document vaulting, work flow automation, team management, on distance working, etc. This last branch could help and support the LPD intent of promoting effective and efficient knowledge management and learning [16].

3 The Empirical Research

Two independent researches, both part of bigger research initiatives still running respectively in France and Italy, contribute to this study. Although independently designed, the studies investigate a large number of similar variables (in term of LPD practices, product development problems, and PLM adoption) that contribute to the same research objectives, and could hence be effectively compared, benchmarked and broadly discussed.

3.1 The French Investigation

The French study is the result of collaborative work between a French consultancy company KLManagement (KL), the French university Université de Technologie de Compiègne (UTC) and R&D managers of large French and foreign companies. This study, conducted in 2015, fits into the bigger on-going research within the platform KL-UTC to develop an innovative approach to manage R&D performances.

This specific study is taken via an online questionnaire that involved R&D Directors and CEOs from large groups operating in France and abroad. The surveyed companies come from various sectors, described in Table 1.

Table 1. The French Sample

Sector	Number of enterprises
Automotive/aeronautical industry	10
Chemical and pharmaceutical industry	6
Agro-food	2
Business services	1
Others	5

3.2 The Italian Investigation

The Italian study have been conducted under the GeCo Observatory Initiative, a broader study started in 2012 at the School of Management, in Politecnico di Milano, and still on-going. The study considered in this paper analyzes the data collected for about a year across 2012 and 2013, through face-to-face interviews to over 100 companies.

Each interview involved a project manager, a technical director, and/or a team of engineers working in product development. An average of 2.5 hours have been spent in each company for each interview, based on a semi-structured questionnaire. The sample in term of companies' size and sector is described in Table 2 and Table 3, respectively.

Table 2. The Italian Sample: *Size*

Size (number of employees)	N° of companies	Class	N° of companies
Micro (<10)	4		
Small (10>employees<50)	13	SMEs	38
Medium (50>employees<250)	21		
Big (250>employees<1000)	29	LARGE	65
Macro (>1000)	36		

Table 3. The Italian Sample: *Sector*

Sector	Mechanics	Electrics	Electronics	Other
N° companies	44	27	18	14

4 Results and Discussion

This research investigates (i) the *problems* encountered in product development; (ii) the adoption of *LPD practices* and *PLM system*; and (iii) their mutual

correlations. In the specific results are shown for the two separate studies (French and Italian) and then compared and discussed.

4.1 Problems in Product Development

Both researches identified -from literature and from discussions with experts- a list of common problems affecting product development, which could be classified in: *product quality not compliant with customers' expectations, too many and too late reworks, unneeded activities that generate delays, resources overload, management problems* (such as *unclear roles, inflexible resources, lack of resources*), *poor knowledge management,* and *others* (such as *high cost of projects, abandoned projects, loos of technical skills*). Problems are evaluated according to a Liker-type scale, where 1 means the problem never occurs, and 9 means the problem always occurs.

Problems in Product Development: French Research

The main problem affecting the French sample is in term of *resources overload*, indeed companies declared they *find problems when managing projects without exceeding* or *because using non-planned resources*. Secondly, companies sometimes encounter *delays* problems, since *the Time To Market doesn't meet clients expectations, it is too long*. Also *projects errors/mistakes are reproduced, few lessons learned are undertaken and best practices are not formalized*, and *once defects are known or chronic, employees are not able to find solutions* determine a *poor knowledge management*. Results on the problems in product development experienced by the French sample are summarized in Figure 1.

Figure 1. Problems in Product Development: the French Sample.

Problems in Product Development: Italian Research

The main product development criticalities encountered in the Italian sample are in terms of *management problems*, happening when *in the development process the responsibilities are not well defined, as a result, the process is chaotic; the projects are very complex to be adequately managed and designers get lost in their activities;* and *the development process involves too many signatures and bureaucracy is a norm*. Secondly the *designers are overloaded and cannot keep up with the overload*. Also *designers often are asked to do many changes during the design process that frequently result in design reworks*. Data are in Figure 2.

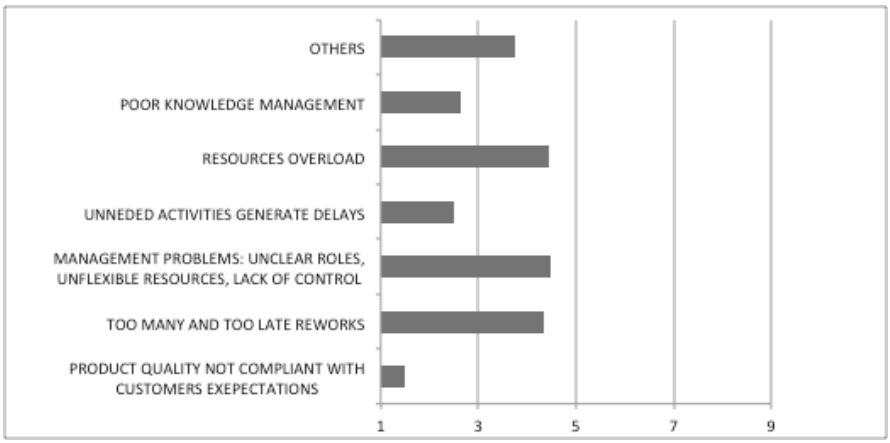

Figure 2. Problems in Product Development: the Italian Sample.

4.2 LPD practice and PLM

LPD practices adopted within the companies belonging to the 2 samples and the use of PLM are investigated in this section. LPD Practices includes *design methods* (such as *Design for X, Variety Reduction Program*); *visual management* tools; *SBCE*; *standardization*; *quality function deployment* (*QFD*); *knowledge management methods*; *training and competencies development*; *multifunctionality* and *globalization of the project team*.

LPD Practice and PLM: French Research

Each LPD practice, as well as PLM, where assessed in the French sample with a Boolean yes/no answer (companies could declare whether they use or not each of the LPD practice and PLM). Figure 3 shows the % of companies adopting the LPD practices and PLM. Most diffused LPD practices, used by more than 50% of companies are *visual planning and management, lean engineering* and *management competences enhancement*. A bit less then 50% of companies adopt PLM system.

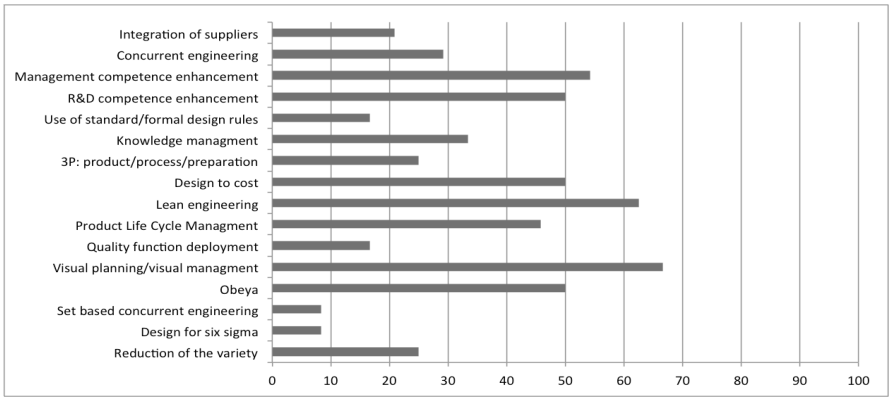

Figure 3. Adoption of LPD Practices and PLM: the French Sample.

LPD Practice and PLM: Italian Research

Within the Italian sample, the use of LPD practices and PLM has been assessed using a Likert-type 5 points scale, where 1 means *the practice is never used*, 9 stands for *always*. Figure 4 displays the diffusion of LPD practices and PLM within the sample. PLM is averagely used (more then 50%), as data and knowledge management system. In term of LPD practises it looks that companies are quite often adopting *SBCE*, in the specific for *evaluating more initial design alternatives*, *defining clear customer value*, and *highly relying on previous knowledge*. Other diffused LPD practices are the *use of standards and design* rules, and *concurrent engineering*.

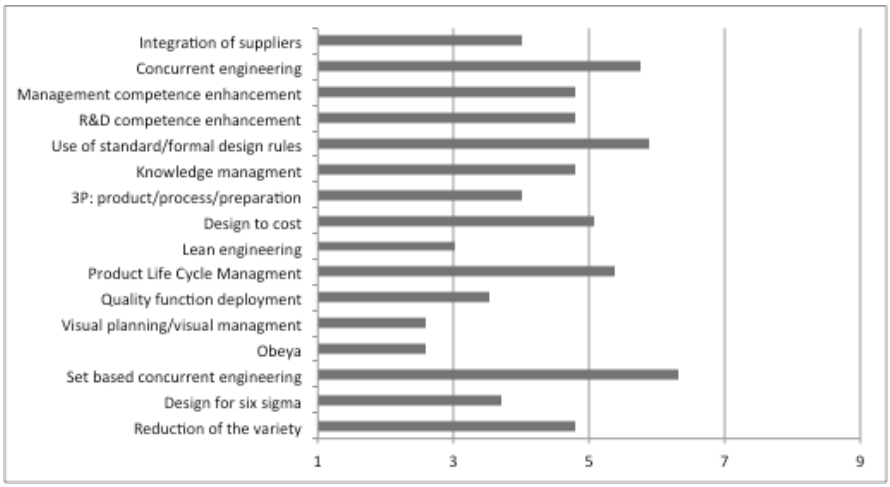

Figure 4. Adoption of LPD Practices and PLM: the Italian Sample.

4.3 Correlations between Problems, LPD Practices, PLM

This section analyses the correlations found between the use of practices (both PLM and LPD practices) and the existence of problems. Also it considers the correlations between the use of PLM and certain LPD practices, to give preliminary understanding on an eventual role of PLM as enabler of product development success (problems are used as a proxy of success) through LPD practices implementation.

Correlations between Problems, LPD Practices, PLM: French Research

Only few significant correlations have been found in the French research, maybe due to the small sample dimension. In the specific it looks like the most a company is able to embrace *SBCE*, the lower the *reworks problems* and *management problems* (*inflexible resources, lack of control*) (see Table 4).

Table 4. Significant correlations between PLM, LPD practices and problems: French Sample. Rho symbol represents the Kendall correlation coefficient.

Variable 1	Variable 2	ρ
LPD Practices vs Problems		
SBCE	TOO MANY AND TOO LATE REWORKS	-0.23
	MANAGEMENT PROBLEMS: UNCLEAR ROLES, UNFLEXIBLE RESOURCES, LACK OF CONTROL	-0.29

Correlations between Problems, LPD Practices, PLM: Italian Research

Some significant correlations have been found in the Italian research. Particularly, lowest project *reworks* are linked to higher use of *SBCE* (in term of *final design choice, customer value definition,* and *knowledge from previous projects*) and higher use of *PLM*. Higher use of *PLM* is enabling the ability of companies to implement *Modularization and Standardization* and *QFD*. Finally it is interesting to notice how the importance of proper *customer value definition* leads to a overall problems reduction (see Table 5).

Table 5. Significant correlations between PLM, LPD practices and problems: Italian Sample. Rho symbol represents the Kendall correlation coefficient.

Variable 1	Variable 2	ρ
LPD Practices vs Problems		
SBCE (Includes: *Final design choice, Customer value definition, Knowledge from previous projects*)	TOO MANY AND TOO LATE REWORKS	-0.24
Customer value definition	TOO MANY AND TOO LATE REWORKS	-0.41
	MANAGEMENT PROBLEMS: UNCLEAR ROLES, UNFLEXIBLE RESOURCES, LACK OF CONTROL	-0.27
	POOR KNOWLEDGE MANAGEMENT	-0.28
	DUCT QUALITY NOT COMPLIANT WITH	-0.18

	CUSTOMERS EXEPECTATIONS	
PLM vs Problems		
PLM	TOO MANY AND TOO LATE REWORKS	-0.17
PLM vs LPD Practices		
PLM	Design method: modularization/standardization	0.25
PLM	QFD	0.27

5 Conclusions, Limitations and Future Work

This preliminary exploratory research indicates companies in France and Italy present commonalities in term of problems encountered in their product development, as well as adopted LPD practices. There is certain level of correlation between the use of some LPD practices and product development problems, in the specific *customer value definition* resulted to be the main driver for success.

Though a clear and extensive role of PLM as enabler of LPD practice usage and as directly linked to higher product development success (measured through product development problems) can't be strongly inferred. The use of PLM per se brings advantages in terms of reducing *reworks* –and this is not at all insignificant, given the weight reworks have in companies, together with *resources overload* and *poor management problems*- and, from the Italian sample, relations are showed between the use of *PLM* and *QFD* (actually very important in the customer value definition process) and *modularization and standardization* methods.

Some limitations apply to this research. First of all, the research wasn't initially designed to cover such a broader international scope and some misalignments between the two research streams apply. Though, even if designed separately the two researches have a high level of similarities that makes the analysis significant. More companies should be analysed, especially within the French context. Also, as typical in qualitative analysis, the subjectivity of the respondents is always a factor that lowers the results validity. This could be improved by increasing the number of companies within the samples. Also to extend the research towards other countries (either European or extra-European) could be beneficial.

This study moves the authors to stimulate the discussion towards this direction: *lean management states the importance of customer value above everything. Indeed better customer value definition enables product development success. Still problems remains, not all companies pay enough attention on proper customer value definition, and PLM is underused. Future debates should discuss the role of PLM as enabler of the customer value definition process (some initial results show its support in QFD and some design methods), and hence key for product development success.*

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