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Integrating lean principles into new product development projects

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Abstract

New ideas generation and their development into competitive innovative products or services became the foundation for genuine success in competitive marketplace. However, this process is very complex, especially in view of the complexity of today's fast changing environment and unique challenges different to other processes within an organization. The product innovation in industry is experiencing a big change in last few decades. This can be closely connected to the changes in ICT tools that are likely to be a subject of further evolution. Consequently, today's models for new product development – NPD, bear little resemblance to the original ones. Progressive companies have modified, adjusted and adapted their models for new product development by embedding different approaches and principles which made them better, faster and more productive. This models, whose typical representative is Stage-Gate, now are scaled to suit different sizes, and types of development projects; adaptable – include spiral or agile development; seek for ideas, technology solutions and even finished products outside the firm, thus implementing open innovation; introduce lean production principles in order to eliminate waste and bureaucracy from the system. Having in mind the importance of model improvement, in this paper we will deal with lean product development which offers very good techniques, principles, and methods for removing waste from innovation process. More precisely, the focal point will be how lean principles are being embedded all along the phases of the new product development process. This is of great importance for contemporary innovation models, since lean approach in product development is being widely implemented, from the start-ups to the largest global organizations.

Key words: *Innovation models, Lean thinking, New product development*

1. INTRODUCTION

The need for lean, rapid and profitable new product and service development has never been more apparent. Nowadays product life cycle is shorter, the competition is fierce, users are more demanding, so companies that do not innovate slowly going downhill. Introduction of new products to the market is of big importance for continuing business success. It enables creation of job opportunities, increases the competitiveness of enterprises in global markets, improves the quality of life and contributes to more sustainable economic growth [2][22].

Studies conducted by European Commission showed that companies that prioritise innovation are experiencing the highest increase in turnover. Some 79% of companies that introduced at least one innovation since 2011 experienced an increase of their turnover by more than 25% by 2014 [9]. According to the Eurostat research during the period of 2012-2014, in the EU-28, more than one quarter (27.3 %) of all enterprises reported organisational innovation. The second most common type of innovation concerned product innovation (innovation that encompasses new or significantly improved goods or services), which took place in 23.9 % of all enterprises, followed by marketing innovation (22.8 %) and process innovation (21.6 %) [10].

Accordingly, most of today's companies, even countries and beyond (European Union), with great concern talk about improvement of their innovation performance. They are developing innovation strategies and policies in order to deliver sustainable growth and significant competitive differentiation [9]. Nevertheless, everyone should be aware that attaining competitive advantage by offering new product is not easy. In fact, it is

estimated that about 46% of the funds invested in the development and launch of new products are related to unsuccessful projects [18].

Having this in mind, the world's leading companies and researchers in the field have been revising the process of product innovation through constant research of best practice, trying to recognize critical success factors. Consequently, one of the recognized factors that enables success is to integrate innovation process with lean as a philosophy that in focus put waste reduction and reduction of everything else that doesn't bring value to the customer. Customer orientation, which is one of the basic postulates of lean, should ensure that innovation, in this case new product, is successful "from the first time" (that is, the value delivered is something that someone really needs). Waste reduction, representing characteristic of the lean, should ensure that the innovation itself is done as efficiently as possible, and that the innovation reaches the customer as soon as possible, with the desired quality and minimum costs. The focus on continuous improvements, also lean characteristics, should ensure the establishment of learning organization.

According to the aforementioned, the aim of this paper is to present the importance of new product development for the company, to show how lean principles are being embedded into process of new product development and to show how model Stage-Gate can be made lean.

2. NEW PRODUCT DEVELOPMENT

New products are one of four/five main categories of innovation according to Oslo Manual (2005). New products are goods and services that differ significantly in their characteristics or intended uses from products previously produced by the firm [16].

New product development is one of the riskiest, but, in the same time, one of the most important endeavours of the modern company. Big money is being spent on new product failures in different companies and industries, but, as well, big money is being earned as a reward. More than one quarter of the companies' revenues are coming from products three years old or newer [5]. The message is simple either innovate or die.

NPD covers a large number of topics and challenges in a firm, such as strategy formulation, deployment, resource allocation, and coordinated collaboration among people, and systematic planning, monitoring, and control. What is more, this field has long been an important topic for several business research disciplines, certainly economics, marketing, organizational theory, operations management, and strategy [11].

New product before being introduced to the market passes through a sequence of stages, starting with an idea that is evaluated, developed, tested and finally launched on the market. The process of NPD differs from industry to industry and from company to company, and it should be adapted to each company in order to meet specific needs and resources [3].

The biggest challenge, when it comes to this innovation category, is to design the best process of new product development, a process by which these projects can move from the idea stage through to commercialisation, quickly and effectively. Today's theory and practice recognize eight critical drivers that separate successful innovation projects from the failures. This critical success factors make the difference between winning and losing (Figure 1).

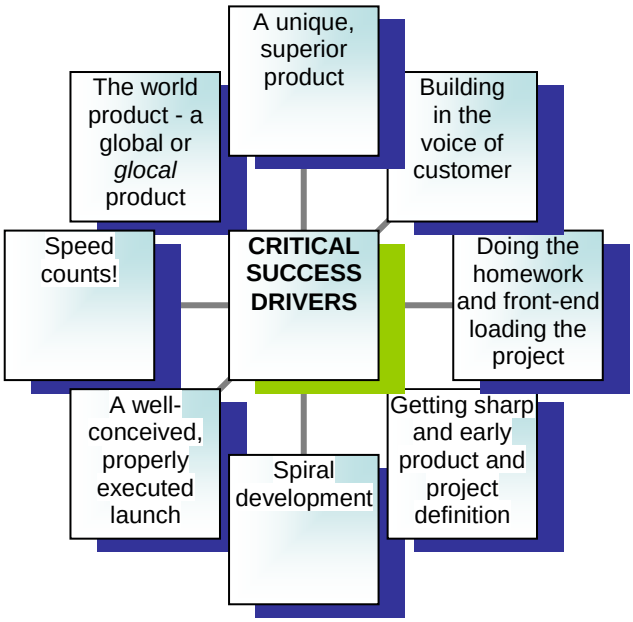

Figure 1. Eight critical success drivers (adapted from [5][11])

Delivering products with unique benefits and real value to users separate winners from losers. This can be confirmed by the fact that such superior products have five times the success rate, over four times the market share, and four times the profitability of products lacking this ingredient. *A systematic understanding of customers' or users' needs and wants*, the competitive situation, and the nature of the market is an essential component of new product success. In opposition, a failure to adopt a strong market focus in product innovation, an unwillingness to undertake the needed market assessments, to integrate the voice of the customer, and to leave the customer out of product development causes disaster. *Doing the homework and front-end loading the project* is the key to success. Due diligence done before product comes to the development stage, is very important. *Providing sharp, early, stable, and fact-based product definition*, before development stage begins, is one of the most critical drivers of cycle-time reduction and product success. Such product definition assumes clearly defined benefits to be delivered to the customer, clearly identified market, the product concept, product features, attributes, and specifications. *Spiral development* is the way for handling the dynamic information process with fluid, changing information. Earlier NPD models used to be rigid and linear processes. Today's models, more

precisely, project teams and businesses practice use spiral development, which assume interaction with the customers through a series of iterative steps or loops, whereby successive versions of the product are shown to the customer to seek feedback and verification (Figure 2).

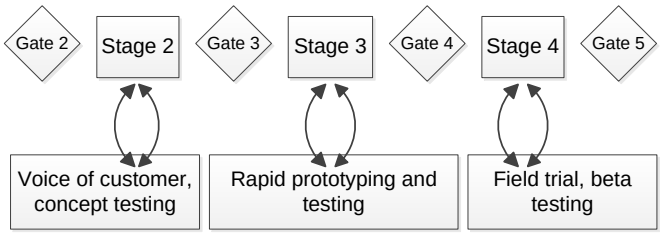

Figure 2. Spiral development

The benefits of superior new product must be communicated and marketed aggressively. So, it requires a well-conceived and properly executed launch. Such a launch does not occur by accident, it is the result of a fine-tuned marketing plan. *Speed to market is of big importance* and there are many valid reasons that cycle-time reduction should be a priority. *The world product - a global or glocal product* (global concept, locally tailored) targeted at international markets, is far more profitable than the product designed for to meet one-country needs [5][11].

There are many components of new product development which can be observed as critical, but the most common organizational traits, found in companies with a successful new product introduction process, are the use of cross-functional teams, management support, and a supportive organizational structure [21].

The multi-functional co-operative approach using cross-functional teams is recognized as the most important factor in improving development processes. These teams are often the only means of developing complex products, and they are very difficult to be managed but their combination of differing skills allows them to solve complicated problems.

Senior management commitment has also been identified as important for successful process of new product development. Support, coming from senior management, improves project team performance reducing the duration to make key decisions. Management planning and reviews ensure that human and financial resources are available and set the criteria as gatekeepers which enable the evaluation of the product or service.

Proper organizational structure must be in place to support successful new product development. Organizational structure is very important because it has a continuous, daily influence on the team and mediates the environmental factors in which the team operates. Communication is a key factor both within the team and between the team and the others, including management, suppliers and the customers and is aided greatly by an appropriate organizational structure.

All of previously mentioned critical factors should be somehow embedded into one model for NPD. Many researchers and practitioners have tried to develop a model that encompasses relevant stages of the NPD process [3][5][23], and many of them have been developed over the years. The well-known between those models is the Stage-Gate model. Today's models for NPD bear little resemblance to the original ones. Progressive companies have modified, adjusted and adapted their models for new product development by embedding different approaches and principles which made them better, faster and more productive. Some of those new practices built in the model are [5][11]:

- Adapting the process for open innovation, meaning inclusion of ideas, intellectual property, R&D work, and even fully developed products from outside the firm;
- Making the process scalable. For example, *Lite* and *XPress* versions of Stage-Gate for lower-risk and smaller projects;
- Making the Stage-Gate system part of the total Product Life Cycle Management System, from idea to product exit many years later;
- Building in tough gates or gates with teeth, in order to focus scarce development resources on the highest value projects;
- Making the system more adaptive and agile by using spiral development, and accelerating the process through overlapping activities and even stages, meaning moving forward with partial information;
- Creating a leaner idea-to-launch system, meaning removing all waste and factoring in continuous improvement, by utilizing lean manufacturing principles;
- Automating the idea-to-launch system via new software products that handle everything from idea management to the development process and even resource management.

3. LEAN THINKING AND NPD

Lean thinking is derived from Toyota production system (TPS) during the late 1980s at MIT's International Motor Vehicle Programme (IMVP). The TPS, often called lean manufacturing system or Just-in-Time (JIT) system, is a systematic approach to waste (jap. *Muda*) elimination in order to increase productivity and create value for the customer" [14]. The TPS permeates all aspects of production in pursuit of the most efficient methods.

The idea of lean is a better way of organizing and managing customer relations, supply chain, product development and production operations, applying identified principles (Figure 3) which can ensure, as the authors said, more and more with less and less [24].

Figure 3. Lean principles

As it can be seen from the previous definition lean philosophy can be a part of product development, and very important one. The ability to innovate, to generate new products, is only worth something if those innovations generate value. A lot of great ideas never reach more than concept development (second stage of NPD process), lose the battle with competitors (competitors arrive first to the market), or lose all their profitability to post-launch quality problems. The solution to these problems may be found in applying lean product development that can ensure for ideas to get to market faster, by maximizing value and minimizing waste. The specific benefits that companies reported after applying this approach include: greater schedule predictability, shorter development time, increased R&D capacity, lower costs throughout the product life cycle, less uncertainty, products that meet customers' needs more completely [19].

In product development process lean thinking is more than systematic waste reduction and the application of lean manufacturing techniques. To allow lean product development, the project plan must allow value creation while providing for waste reduction. To ensure the value creation in NPD or to provide what the customers exactly want, and to create actions against waste, five lean principles, initially proposed by Womack and Jones (2003), have to be implemented (Table 1).

Table 1. Lean principles in NPD ([19][24])

Lean principles	Lean principles in NPD
Specify value by specific product	This principle underlines that value can only be defined by the customer, and that the value is meaningful only if it represents a specific product which meets the customer's needs at a specific price and time. In a project or product development program, the value is the purpose of the project team, which means they must understand all the required product or service characteristics regarding the value that all stakeholders of the program expect to receive during the product life cycle. The value identification, therefore, is a critical development success factor and it is in line with critical success driver of NPD *delivering products with unique benefits and real value* (Figure 1).
Identify the value stream for each product	The next step is identification of the set of all the specific actions required to bring a specific product. There are three types of actions that can occur along the value stream: troubleshooting, which includes everything from concept to product launch, through detailed design and process engineering; the information management task running from order-taking through detailed scheduling to delivery; and the physical transformation task proceeding from raw materials to a final product that ends up in the hands of the customer. The value stream represents sequence of exclusively value-added tasks, where a value-added activity transforms the deliverables of the project in such a way that the customer recognizes the transformation and is willing to pay for it. Thus, the idea is to make the product development process simpler with highlighted key dates and responsibilities and optimized information flows with the intention of preventing excessive data traffic and efficient communication.
Make value flow without interruptions	All the value-added activities should be conducted without interruption. The idea is to assemble value-creating steps which enable value to flow quickly through the system. The ideal product development process should be harmonized with the single-piece flow in manufacturing, that is, a value should flow from ideation to production, without stops due to bureaucracy and loop backs to correct errors. Hence, the process should not include any obstacle coming from functional departments, executive gate meetings, freighting, changing requirements, management interference.
Let the customer pull value from the producer	As value starts to flow, value is pulled through the system ideally by the customer and at the rate of customer demand. Such a system enables reduction of a lead time, onetime cash windfall from inventory reduction, rapid return on investment. It represents a pull system and the customer is the one who pull the product from the company when there is a need, instead of product being pushed onto the customer by the company. Pull system secures the value flow, make quality problems visible, and create knowledge.
Pursue perfection	This principle assume that there is no end to the process while there is still a chance of reducing effort, time, space, cost, and mistakes in the process. The main idea is to repeat the previous four steps until all waste in the system is removed. The continuous improvement of the product/service development process is achieved by the capability of the process and effective knowledge management. The knowledge is systematically being documented and spread so everyone can access and use it. Therefore, the perfection is pursued by persistent continuous improvement which represents the motor that sustains and evolves the lean philosophy.

Having in mind the aforementioned, if companies want to apply lean product development they have to simplify the process by removing all the activities that do not add value, to enforce the activities of prototyping and testing, moreover to maximize experimentation and learning, to encourage creativity of each team member, to build a culture that supports innovation, excellence and relentless improvement. The first two principles guarantee the value delivery, while the remaining three work on waste reduction. Actually, the application of lean philosophy has three core elements to the new product development [17]:

1. Do the right thing, meaning to create product families and projects that create value for all stakeholders.
2. Do the thing right, meaning to eliminate waste and improve cycle time and quality engineering.
3. Continuous improvement, meaning to be a learning organization and keep improving every day.

Considering this, lean innovation or lean new product/service development is being incorporated by a wide range of entities, from the start-ups to the large global companies. Large numbers of today's well-

known companies are trying to maximize value and minimize waste in product development [1].

Google has developed unique methods for beta testing new ideas with customers and tracking online behaviour to understand how well these concepts have been received. These tools facilitated the integration of customer and technical knowledge into new products/services and ensured that customer's needs are being met.

Facebook eliminated waste in an internet user's value stream for connecting with friends, sharing photos, and spreading news within social networks. In the process, the company developed an advertising platform and marketing engine that help companies reach the specific users most likely to want their products.

Amazon eliminated waste in the online shopper's value stream with the introduction of the e-commerce platform that company uses to sell its own products and to facilitate online sales from other merchants.

4. LEAN STAGE-GATE

Stage-Gate®, a trademark of R.G. Cooper & Associates Consultants, stands for industry standard for excellence in new product/service development. This advanced, widely applied and recognized process, integrates new product development best practices in an easy to understand recipe for success. A Stage-Gate system is a conceptual and operational roadmap for moving a new product from idea to launch. It divides the product innovation process into series of stages, separated by gates in which the decision is being made [5]. This model is being continuously improved and ever since it is experiencing modifications presented through different model generations (1st, 2nd,…, next generation).

But aside that it stands for industry standard for new product development, Stage-Gate have many critiques (Table 2).

Table 2. Critiques to Stage-Gate

[15]	Model doesn't pay attention to links between technology and business opportunities, projects are usually extensions of existing products. Model doesn't have a strong connection to the strategy, suffers from fragmentation and its resources are scattered. It is limited by looking at a pre-defined market and is in nature market-driven and not market-driving.
[4]	Model is not suitable for new product development and that it can only be used as a milestone control point. Gates are focused on searching flaws that lead to excluding radical ideas and potential innovations.
[13]	Model has linear approach and lack in rapid feedbacks throughout innovation process.

Considering critiques and today's fast changing environment most of the companies have modified, adjusted and adapted Stage-Gate and have implemented next-generation of the model that is more flexible with less strict stages and gates. The main purpose of this model generation is to speed up the idea to launch process and to overcome delays, which is the idea of the lean philosophy. According to this model every project should be aligned regarding risk level, meaning that only new to the world or new to the company products may require the rigor 5-stage process [7]. Since 60-80% of new products present improvement of the existing products, the biggest number of companies should implement it with less stages and gates (Figure 4). Applying this approach to new product development is very useful for most companies since the re-investment in existing products is required to extend their market life, thereby, to keep the cash cows alive for longer [20].

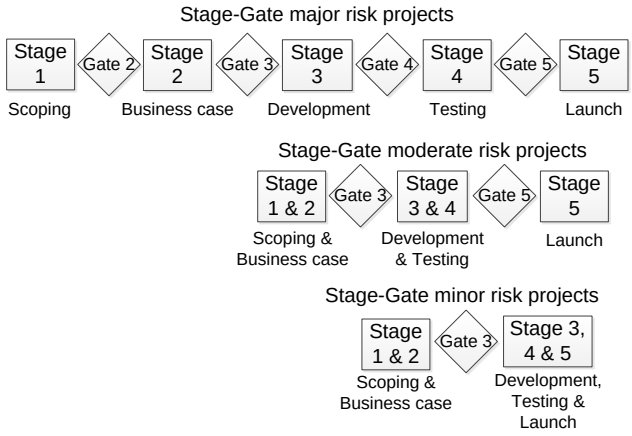

Figure 4. Next-generation Stage-Gate

One of the improvements embedded into next-generation model is spiral development which states that model can be managed better with iterative development activities (Figure 2) [5][11]. Spiral development starts with voice of the customer and concept testing in the stage 2. Team members contact customers in order to better understand unmet needs, problems and benefits of new product (in that period new concept) and show them the concept (virtual, hand-made model). During the stage 3 the testing on customers is continued, but now the prototype is being tested. Customers test more versions of prototypes, giving feedback to the company about their required features [7]. NPD process like this ensures that customers recognize the transformation they propose through testing and they are willing to pay for the value created (lean principle).

Furthermore, progressive companies are trying to make their next-generation Stage-Gate process even leaner, with all waste removed, no bureaucracy and no unnecessary activities in the system. They have used value stream analysis or maps - lean principle, to enhance the NPD process, accelerating the system and improving work efficiency. As it is mentioned earlier, this principle is used to identify and document the value added and non-value added activities. It is a simple connection of all the process steps with the aim of maximizing customer value. In a typical project all stages (from ideation to full production and launching to the market), gates and key activities should be mapped out, with defined timetable for each activity and decision [6].

Of big importance is to outline all major milestones, checkpoints that project team must and should meet, and overview of the key decisions for the project which are put in a sequence and relation to each other to build the development logic [19]. Defining measurable and strict milestones can make decision making process within the gates faster and easier. Such milestones can be control points within the stages, so if they are met, the gates can be fictive.

Kennedy, Harmon and Minnock (2008) emphasize the existence of knowledge value stream which role is to capture and enable reuse of the knowledge flow about customers, markets and technologies. The importance of this stream lies in collecting knowledge from different projects which can be reused for the future projects.

It is of vital importance to build in post-launch reviews, where, besides financial results, the steps and missteps of the project are reviewed and assessed in order to make next projects even better, to have continuous improvement [6].

6. CONCLUSION

New product is significant not only for company but also for the customers and wide society. First and the most important, it provides new value to the customer. On the other side, even if it is very risky endeavour the introduction of new product ensures the existence and competitive advantage to the company.

The product development process has lots of places where errors might happen and if errors happen, especially, in the later stages of development, the opportunities for improvement are fewer and less likely to have an impact. Therefore, it is of big importance to address the significance of well-defined and effective new product development process, and to identify all critical factors which can impact the process.

One of the ways to bridge these problems is to apply lean philosophy into new product development process. This approach can ensure increased customer collaboration which enables market success, transparent and effective customer-developer interaction, increased cross-functional collaboration, higher flexibility in the design process, increased team productivity, lower incidence of changes at later development stages, successful final products/solutions, faster development → reduced lead time → shorten time to market, and many other.

Above all, future research should involve wider approach to integration of lean philosophy into NPD and integration of agile principles.

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