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Lean Design

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Synonyms

Lean design; Lean engineering design; Lean development

Definitions

Lean design is a term increasingly being used by both academics and practitioners to refer to lean principles applied in the context of design. However, as this context is not uniform, the meaning of lean design is not either. Lean design can be used as a *synonym of lean development* (which refers to leaning the processes required to be undertaken for translating a market need into a manufacturable device, as it is used in Ward and Sobek (2014), Ōno (1988), and Bauch (2004)), *as a verb* (referring to having the process of designing being performed in a lean fashion, as it is used by Baines et al. (2006)), and *as a noun* (referring to an object that fulfills a set of desired functions by being lean, as it is used in Johansson and Sundin (2014), Dombrowski et al. (2014), and Gautam and Singh (2008)). All three definitions are intrinsically founded upon the principles of the lean philosophy: eliminating non-value-adding activities (for a process) or sub-functions (i.e., subpart or components for a product) relatively to the needs of the end customer. From the perspective of the consumer of the product or service, the value refers to the expected functionalities of the product or process, according to the amount the customer is willing to pay for. Lean approach preserves value with less work or resources involvement. Based on this, the following definitions can be drawn:

Definition 1: Lean Product Design (*synonym of Lean Product Development*). Is a product development process characterized by reacting to information continually as it is being generated, keeping product options open longer and enabling the engineers' continuous (re)action on new information about customers, markets, suppliers, and production capabilities. Lean product development, as described by Morgan and Liker (Ward and Sobek 2014), refers to the management of (1) skilled people, (2) tools and technologies, and (3) information and decision-making during the phases of product development process (e.g., problem analysis, concept design, layout design, detail design, testing and prototyping, and finally, production ramp-up as described by Ulrich (Ulrich et al. 2011)).

Definition 2: Lean Design (*verb*). Is a design process that focuses on continuous customer value maximization while minimizing all activities and tasks that are not adding value. Lean design deals with a subset of methods and tools of lean product development, targeting the conceptual, layout, and detail design phases.

Definition 3: Lean Design (noun). Lean design can be seen as minimal (lean) functions that fit to the customer's needs, maximizing added value with minimizing materials, energy, and overfunctionalities.

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The difference in meaning of lean design according to its grammatical form (noun vs. verb) is a direct result of the grammatical forms of the term design. In fact, for both the noun and the verb definition of lean design, an adjective (for the first case) and adverb (for the second) provide a more specific meaning of the term design.

Theory and Applications

Lean philosophy originates at the Toyota Production System (initiated by S. Toyoda) in the 1970s. The lean thinking (Womack and Jones 1996) approach initially started for manufacturing and mixing just-in-time tools and Jikoda methods. Companies applying lean principles have a deep understanding of customer value and concentrate its main processes for constant improvement of it. Moreover, the aim of the company is to deliver, to the consumer, the perfect value obtained by the perfect, wasteless process (Jones and Roos 2009). To be able to achieve this goal, thinking in the lean way switches the management attention from single processes, technologies, departments, etc. to product flow through complete value streams (Jones and Roos 2009). The value stream should be as big as possible, which is obtained by setting one by one the steps that add value to the next ones and removing the non-value-adding steps. A significant help here can be received from the visual management, which will support employees and management to instantly see where the process differs from the perfect one and what is working and what is not.

Lean thinking is an "improvement philosophy which focuses on the creation of value and the elimination of waste." Its first focus was on manufacturing, based on the good practices of Japanese automotive industry since post Second World War. Later in the 1990s, tools and methods have been created to support and to spread lean manufacturing to other industries. Lean is not restricted to one single method but to a family of tools and methods. It is now applied as a strategic and management method and can be applied to many systems. However, the definition of lean is drifting. While earlier papers saw lean as a philosophy for waste reduction, the emerging view is one of value creation (Baines et al. 2006). Lean product design and lean products are more recent applications of lean. The analogy between lean attributes in manufacturing and in product development can be found at Baines et al. (2006). Manufacturing has material flow, and product development has information flow. Lean philosophy focuses on three elements: value, knowledge, and improvement.

The improvements expected from a lean product and process development methods are energy, time and resources reduction (for the product or the design process), quality improvement, and innovation increase (Ward and Sobek 2014). As the results of lean product design are in line with resources optimization, comparisons can be made to green product development, as shown in Johansson and Sundin (2014). The authors conclude that lean product development does not ensure green product and that green products do not insure product development process efficiency, but there are potential cross-field learning between fields.

The Lean Product Development (LPD) Approach

As in manufacturing, LPD has the goal of eliminating waste such that value can be maximized. However, as the nature of product design processes is intrinsically different than that of manufacturing ones, the concepts of value have their own particular meaning within the LPD approach. As a consequence, the leaning principles are different than in manufacturing too. According to lean design, the design process results in two different types of value: manufacturing systems and usable knowledge. When these values are created in an efficient and effective manner, profitable operational streams emerge (Ward and Sobek 2014).

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LPD deals with how these activities are organized in time and distributed among different disciplines and people. In this context, LPD is an operations management method. Some of the most common high-level concepts associated with lean product development are:

1. Creation of Reusable Knowledge. As the goal of lean is to maximize value adding by optimizing knowledge translation into operational streams, reusability of knowledge increases both the effectiveness and efficiency.
2. Teams of Responsible Experts. Lean product development organizations develop integrated work teams with multiple competences in each team and reward competence building in teams and individuals.
3. Cadence and Pull. Managers of lean development organizations reject the scientific management notion that managers plan, and workers do. Rather, engineers plan their own work and work their own plans.
4. Visual Management. Visualization is a main enabler of management in lean product development.
5. Entrepreneurial System Designer (ESD). The lean development organization makes one person responsible for the engineering and aesthetic design, and market and business success, of the product.

The Lean Design Approach (Verb)

In LPD, effectiveness and efficiency are achieved by the continuous application of two base principles, namely, just-in-time decision-making (JIT-DM) (as described in Holman et al. (2003)) and set-based concurrent engineering (SBCE) (as described in Raudberget (2010)).

JIT-DM consists on taking decisions proactively by acting on the level of information readiness of a given design phase. JIT-DM rests on the base idea that information processing entities (i.e., engineers) can act the most effectively when the information batches required for carrying out those decisions are fully available. Consequently, efficiency also increases, as the decisions made are more effective, and no time is wasted on readapting afore made erroneous ones.

During the SBCE, designers reason about, develop, and communicate sets of feasible solutions concurrently and with certain independence. Then, as the design process proceeds, solutions are evaluated and dismissed based on additional information coming from different disciplines – for example, simulations and tests from the technical departments and consumer needs from the marketing department.

The most well-known and successful industrial implementation of lean design is done at Toyota automobile company, described in Sobek et al. (1999). Here, designers apply set-based concurrent engineering to generate and evaluate sets of solutions. Then, as the design process progresses, implicit knowledge and new coming constraints are used to narrow the solution space. The application of this principle implies that several options are worked out simultaneously, having the final design selection toward the end of the whole product design process. This encourages just-in-time decision-making.

Approach for Lean Design (Noun)

Lean design as a noun refers to lean product design, in a perspective of eco-design of products and lean function selection or just expected functions and services. Lean design started from the basic idea of lean thinking and focuses on value-adding activities from the perspective of the end customer use. Lean design can be seen as minimal (lean) functions that fit to the customer's needs, maximizing added value with minimizing materials, energy, and overfunctionalities. Lean designed products are mostly driven by cost reduction objective. They can arrive to strategic change such as the switch to product to service. Lean design means lean product and sustainable product.

In order to achieve a product that is lean in its expected function specification, value analysis approaches and value stream serve as important tools. From the design science, the functional analysis

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(Kaufman 1977) and value analysis (Standard (SAVE International, The Value Society 2007) (or value stream) methods help in defining the minimal functions to be delivered. It should be coupled with the establishment of the customer-defined value to separate value added from waste. Life cycle assessment, and life cycle costing approaches, for the designed product, can give the evaluation (at least material, energy, and costs) of the non-value-added save by the leaned designed product. In this sense, Naveen Gautam refers to customer perception on the value of the product and does not only focus on functional answers and minimal function selection to meet the needs.

According to Dombrowski (Dombrowski et al. 2014), the product has different vies:

1. Design View: The product is the sum of parts, their properties, and their relationships.
2. Value View: The product is the sum of functions it performs or properties it offers to create customer value.
3. Waste View: The product is the sum of all life cycle processes.

Lean product design refers mainly to the second point. A well-known example of a design that is lean is the Logan model of Renault (from Renault–Dacia) launched in 2004 and Design from 1999 to 2003, as it has a very restrictive cost objective. The limited set of functions available and the technical solution allow the car manufacturer to propose a cheap and affordable car that meets a huge commercial success.

Cross-References

▶ Conceptual Design
▶ Decision-Making
▶ Design Methodology
▶ Productivity

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