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# OPTIMIZED NEW PRODUCT DEVELOPMENT STRATEGY

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## Abstract

New product development is a key element of sustainable business. Although mass production brings both excellent and cheap products, overproduction has become a difficult problem for enterprises. Enterprises must develop appropriate new products, and must have a systematic thinking design strategy. The ability of enterprises to develop appropriate products will be a key advantage for sustainable business. Although many tools for product development are getting better (6σ, TRIZ, DFM, DFA), most tend to improve product stability. Some tools propose comprehensive management thinking (DFSS, PLM, QFD), but still neglect key product design strategies. This study is mainly to construct an optimal new product development design strategy matrix. Its purpose is to explore how to meet the needs of the consumer market under technical constraints when developing new products, in order to reduce the loss of design and the loss caused by overproduction. The design strategy matrix can sequentially view relevant design parameters (users, competing products, third-party information and design decisions); then compare with competing product CP values. It is expected that at the beginning of the design, product design specifications with market competitiveness and technical feasibility can be confirmed to propose an optimal product design strategy, and then continue the new product development process.

Keywords: New product development, design strategy matrix, sustainable business

## Introduction

New product development is an issue that must be faced by enterprises for sustainable operation. For the product, whether it is the magnitude of the change or the speed of change, the product life cycle is a problem that needs to be concerned. In the process of product development, the product should be continuously improved. At the same time, it is necessary to evaluate the competition, technology and resources to adjust the development strategy, in order to effectively pursue profit and survival. For new product development with mass production scale, development costs include pre-market development and design, as well as late investment in molds, tools, testing, and production equipment. Once the development fails, the inventory generated by mass production and related equipment investment may become idle. Although the new product development success rate is low, the company is mostly conservative and cautious about new product development. However, enterprises still have to continue to develop new products for profit-making. Therefore, how to improve the success rate of new product development will be an important goal of the enterprise.

In the relevant technical part of product development, from single-purpose that includes reverse engineering, concurrent engineering (CE), design for assembly (DFA), and design for manufacturing (DFM), to focus on functional stability that includes axiomatic design, Taguchi method, and TRIZ. Now the NPD develops into a comprehensive management thinking, design thinking, and lean thinking, such as design for six sigma (DFSS) and product lifecycle management (PLM). These technologies have gradually matured to improve product stability. For product development design strategies, from preliminary specification design, cost-effectiveness testing, market competitiveness, confirmation of new product development feasibility, prototype completion and testing, to mass production marketing confirmation. The main purpose is to achieve a long-lasting design. However, enterprises must understand and recognize, the design decisions in the previous paragraph have irreversible characteristics. If the future needs to be revised, it is usually only possible to relocate the original design, which will lead to a reduction in the optimal design of the product and an increase in the cost of production. Therefore, competitive product design must evaluate the comparative advantage under the market. Build a new product development process with "customer and market-oriented product design thinking" and a "design strategy" that enables new product designs to meet consumer requirement.

With the development of science and technology, products are becoming more and more complex. Innovation is also becoming more and more important in product design and development. Product innovation is mainly in conceptual design (Assink 2006; Li et al. 2007). From abstract concepts to functional structures, products need to choose the right engineering concepts and combinations and find a reasonable solution. The main incentives for innovation and product development include:

1. Although the success rate of new product development is very low, once it is successful, the rewards obtained are quite considerable and the profit is usually several times. Therefore, product innovation is often the key to creating competitive advantage.

2. Design strategies often relate to the future quality of the product and the cost of the production. The cost of the product in the design phase is about 5%, but the design activity has often determined 70% to 80% of the product cost (Cooper et al. 2005; Saravia et al. 2008).

However, what consumers really think about is the overall optimal mix, including product characteristics (quality, appearance, function, price, service) and comparison with the relative interests of competitive products. That is, the consumer will consider the CP (capability / price) value, and then select the product that the consumer thinks is the most suitable.

Therefore, the optimal design is difficult to achieve through the traditional step-by-step division of labor, especially the design strategy and functional design of the previous paragraph. In order to obtain the most suitable products, the design information of specification and function should be integrated at the beginning of the design stage, and the irreversible design link should be reviewed to achieve the optimal design. The "design strategy" proposed in this study is aimed at mass production products, and proposes an optimal new product development analysis matrix in response to the trade-off between technical limitations and consumer diversification needs. This new product development analysis matrix will be able to construct a marketable and feasible product design strategy to enhance the CP value of the product to ensure the competitiveness of the product launch.

## Evolution Of New Product Development Tools

In different technologies and competitive environments, enterprises have different considerations for the introduction of new products, and also produce product development analysis tools for various purposes. Tables 1 to 5 address the different development directions and development stages of new product development, and the derived product development methods and their objectives.

### *Conceptual Guidance Tool*

Provide the principle of guiding theory for product design and propose a more stable and reasonable solution based on design theory. Axiomatic design is a tool that is usually used. For the specific principles of detailed design, TRIZ theory (9 box solution map, 40 Principles, contradiction matrix, 39 engineering parameters, and 40 innovation rules) is usually used to improve and solve problems.

Table 1. Conceptual Guidance Tool

| tool | core strategy | tool limitations | purpose description | reference |
|---|---|---|---|---|
| axiomatic design | customer, function, prototype, process | independent axiomatic and information axiomatic.<br>a generalized rational design is available but the operation is still slightly rough. | beyond the limitations of experience and tools | Arcidiacono et al. (2017) |
| TRIZ | design parameter, prototype | engineering parameter selection, complete prototype | provide principles and design guidance for structural and detailing | Belski and Belski (2015) |

### *Coping With Strategic Tools*

The product design task is mainly to imitate existing products for quick listing (reverse engineering), focusing on shortening the time-to-market and R&D costs (concurrent engineering). The application of tools mainly focuses on competition and enhances efficiency-oriented design thinking (DFM, DFT, DFC, DFQ, DFA, DfDA) and mature products to improve reliability of design and engineering techniques.

Table 2. Coping With Strategic Tools

| tool | core strategy | tool limitations | purpose description | reference |
|---|---|---|---|---|
| reverse engineering | imitate, speed | the latter part of the project to the completion of R&D | imitation fast listing | Roxana et al. (2013) |
| concurrent engineering | speed, cost | design, engineering to the completion of R&D | quick listing | Loch and Terwiesch (2000) |
| DFM DFT DFC DFQ | quality, cost | design, engineering, quantity management | technical implementation | Bargelis (2007) |
| DFA DfDA | quality, cost, speed | design, engineering, quantity management | technical implementation | Bargelis (2007) |
| reliability engineering | quality, cost | quality from the later stage of the project to the completion of research and development | stable quality | Zio (2009) |

### *Stable-Oriented Tools (Product Quality)*

When the product has entered mass production, the stability of manufacturing should be mastered.

TQM and 6σ are the main tools. Collaborative design and lean thinking reduce communication errors when designing more mature products, and improve the competitiveness of production and sales.

Table 3. Stable-Oriented Tools

| tool | core strategy | tool limitations | purpose description | reference |
|---|---|---|---|---|
| 6σ | ensure quality management thinking | control defective products at 3.4ppm level | measurement guarantee quality | Pande et al. (2000) |
| TQM | comprehensive quality assurance management thinking | concept and practice from top to bottom | total quality | Anvari et al. (2012) |
| collaborative design | the overall benefits are optimized | design front to quality management of mass production | reduce wear and stability | Kamrani (2008) |
| lean thinking | reduce waste (quality, flexibility, customization) | design front to quality management of mass production | reduce waste, stabilize quality and comprehensive effects | Womack and Jones (2003) |

### *Customized Tools*

When production quality tends to stabilize, how to get the customer's approval design will become the key. As technology matures, companies need to integrate comprehensive design processes to get information on product cost, manufacturing quality, marketing, and flexibility. The QFD, TRIZ, DFSS, PLM, lean thinking, and design thinking are the main tools.

Table 4 Customized Tools

| tool | core strategy | tool limitations | purpose description | reference |
|---|---|---|---|---|
| QFD | customization, cost | subtractive thinking, unable to handle the needs that customers cannot express | customized design strategy: optimization of technology and customer needs | Akao and Mazur (2003) |
| DFSS | integrate QFD and competitive thinking | comparing the relative factors of competitors | customized design with competitive thinking | Pande et al. (2000) |
| PLM | manage thinking after product design | lack of design strategy thinking in the previous paragraph, focusing on the retrospective design of the latter paragraph. | quality assurance and control in the latter stage | Corallo et al. (2013) |
| lean thinking | reduce waste (quality, flexibility, customization) | design front to quality management of mass production | reduce waste, stabilize quality and comprehensive effects | Womack and Jones (2003) |

| | | | | |
|---|---|---|---|---|
| design thinking | customization and optimization are the guiding objectives; the latter paragraph is based on this concept to modify the design, manufacturing, and service processes. | prospective customization, design, engineering to mass production and service | prospect customization priority and prototype realization thinking。 | Brown (2010) |

*System-wide integrated tools*

From the beginning of the design, comprehensive and systematic thinking about the design and production links to obtain the best design choices (DFSS, PLM), avoid remediation of difficult design (collaborative design), find the expected variables of engineering and marketing (lean Thinking), obtaining engineering and achievable engineering decisions with relative cost, quality and market advantages (design thinking).

Table 5. System-Wide Integrated Tools

| tool | core strategy | tool limitations | purpose description | reference |
|---|---|---|---|---|
| DFSS | integrate QFD and competitive thinking | comparing the relative factors of competitors | customized design with competitive thinking | Pande et al. (2000) |
| PLM | manage thinking after product design | lack of design strategy thinking in the previous paragraph, focusing on the retrospective design of the latter paragraph. | quality assurance and control in the latter stage | Corallo et al. (2013) |
| lean thinking | reduce waste (quality, flexibility, customization) | design front to quality management of mass production | reduce waste, stabilize quality and comprehensive effects | Womack and Jones (2003) |
| design thinking | customization and optimization are the guiding objectives; the latter paragraph is based on this concept to modify the design, manufacturing, and service processes. | prospective customization, design, engineering to mass production and service | prospect customization priority and prototype realization thinking。 | Brown (2010) |

The above five categories of new product development tools can only play a part of gradually improving functions for new product development issues with diverse decision-making factors and environmental changes. For overall product development, there are still some limitations, including:

1. Management limitations: the lack of innovation and customization based on the principle of stability, usually suitable for the extension of existing products.

2. Marketing limitations: The description of the segmentation and positioning is abstract and difficult to specifically present on the design prototype. The specific effective presentation of differentiation is unpredictable. The gap between the actual design and marketing communication of professional design engineers.

3. Design limitations: Detail design and customer strategy parameters depend on the subjective experience of the design engineer. Tool applications such as axiomatic design, TRIZ or design thinking can only be used as an auxiliary reference.

The spirit of optimal design lies in the matching combination of consumer requirement, resources and competitive market. That is, consumers will choose products with relatively high CP values.

Therefore, when designing the product:

1. For products with alternative technical conditions: less innovation competitors or large gaps, the CP value comes from the customer's perception of the value of the product, the importance of solving the problem and the cost (price and learning cost).

2. For products with technical choices (oligopoly): limited technical capabilities, innovation competition comes from design strategies, CP values come from customer comparisons and individual needs, and design costs (prices paid by customers and learning costs).

3. Products that are increasingly competitive and mature in the market (imperfect competition): reducing costs and improving quality and service are key, and the rest of the factors will not be of comparative advantage. Usually the price drop CP value rise is the normal state of competition. Focus will be transferred to quality and service improvement.

The way to adjust the CP value can be divided into the following six categories: (1) cost (price); (2) popularity (appearance); (3) brand (advertising); (4) quality (process); (5) function (design); (6) service (aging). The method of adjusting the CP value includes: (1) improving performance, the price is constant or the difference is not large; (2) the price is lowered, the performance is unchanged or the difference is not large; (3) the CP is improved by the inductive factors, and the feeling is improved; (4) reduce learning costs and increase the perceived CP value.

## Design Strategy Matrix

At the beginning of development, appropriate product design should consider both customer needs and competitive markets. Design decisions often come from senior design engineers and their teams, so they can search for information and countermeasures, and eliminate professional biases. Develop an effective analytical and integrated design strategy, construct a more forward-looking analysis model for new product development, and improve the effectiveness of product innovation and development. This study reorganizes the spirit of optimal design based on the analysis of past tools. This study emphasizes the connotation of optimal design, the combination of elements of new products in the face of the choice between the target customer and the competitor for the design strategist. In the process of seeking to design the optimal product, construct a more comprehensive design strategy matrix as shown in Figure. 1.

The optimization of the product can generally be explained from the dimension of quality, including: 1. transcendent, 2. product-based, 3. user-based, 4. manufacturing-based, 5. Value-based (Garvin 1984). The meaning of the optimal design of this study is: 1. Design strategist's choice of new product element combinations in the face of target customers and competitors; 2. Conduct comprehensive product cost comparisons (including price, learning and dedication) with competitors and target customers to find the biggest design benefits; 3. The optimization of the design output should have an optimum design with comprehensive benefits and cost, and usually presents a state of superior value to the competitive product (the only suitable combination of VC values, even the best or the cheapest, usually not optimum choice). In summary, the optimization emphasized in this study is based on a quality with substantial competitive significance. It should be a contingency perspective under factors such as cost and risk. Optimization requires the construction of multi-dimensional VP values to have practical meaning.

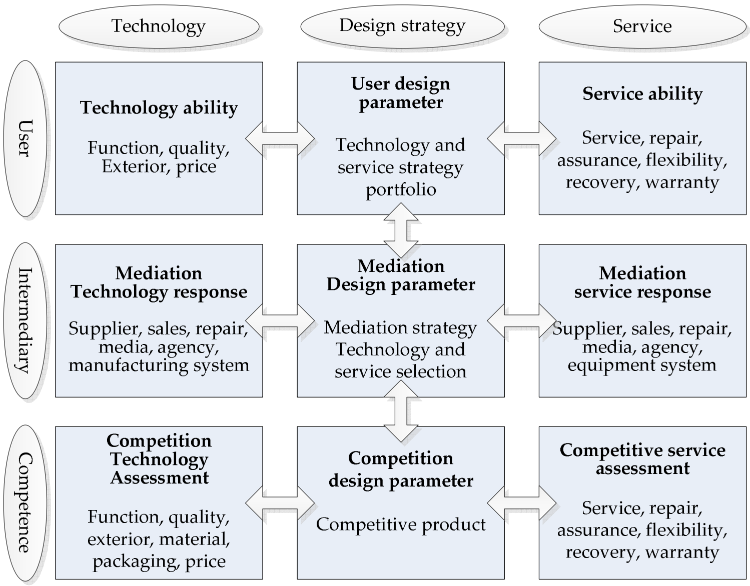


Figure 1. Optimal Product Design Strategy Matrix

In this 3*3 design strategy matrix, the vertical axis mainly describes the source of new product development, including design options that are generated by the customer, generated by the intermediary, and generated by the competitor. The description is as follows:

1. Customer: The design requirements provided by the user, including the technical parameters and service parameters to be resolved or expected. Currently, analytical tools for customer needs should be representative of QFD.

2. Intermediary: Design requirements provided by the intermediary, such as maintenance, distribution, research units, and other markets, including design parameters for technical functions and services to be improved. The mediator's information processing usually takes:
   (1) Mandatory factors such as laws, patents, and common specifications.
   (2) Semi-mandatory such as cultural factors, regional or professional particularities.
   (3) Passive response with targeted improvements or responses, such as DFA, DFC, DFM or technical equipment limitations.

3. Competitor: Observe the design of the competitive end with or possible, including technical functions and services, or strong or weak clever design and relative cost parameters. Currently, analytical tools for customer needs should be more representative of DFSS.

The horizontal axis of the matrix

mainly describes the design options in the three directions of the customer, the intermediary and the competition, including the actual or possible options of the technology and service. These three policy options can be used as design strategy options for integrating decision design strategies. And retain factors that are not included in the design strategy, such as estimates of competitor strategies. This result can be used as a resource for future changes. The description of these three design options is as follows:

1. Design strategy: presenting the thinking logic of the choice and matching of technology and service.

2. Technology: Provide complete function, quality and appearance information to the product, and correspond to the design and manufacturing process to solve the actual needs of customers.

3. Service: Thinking about how to provide sales and after-sales services, such as packaging, advertising, branding, and guarantee, to meet the customer's needs.

For technology and service available resources that are not included in the strategy options of the design strategy matrix, they can be retained in the final design to flexibly adjust the CP value of the marketing portfolio. Through the analysis of the design strategy matrix to obtain the optimal specifications, and then through the CP worth comparing to obtain the optimal CP value, complete the construction of the optimal product design. When the product is ready to go on the market, it can obtain a competitive product portfolio and obtain parameters that dynamically adjust the CP value, so that it can be adjusted according to environmental changes, especially for competitors facing similar product positioning.

Application Of Design Strategy Matrix

*Design thinking in the stage of production orientation*

This type is mainly generated by a combination of functions, services and customer needs (Figure 2). In the early stage of product development, when competition is less intense, you only need to consider the top information. In the early stage of industrialization, when the market is still in the production-oriented stage, it is more suitable.

A. The intersection of functional design and customer needs, with original technology in the market, usually unique or strategically unique; mainly for customer needs and the quality and service assurance. Usually customized a small number of products, such as special machines, architectural design.

B. The intersection analysis of service design and customer needs is applicable when there is an absolute advantage in research and development of new technologies, design innovations, patents or market management. Usually customized a small number of services, such as consulting services, or single-person event design, catering design.

C. Both functions and services need to be balanced. In addition to the functions, the products also need service-supported products to cope with possible competition conditions, such as skin care products, home appliances, or items that require constant adjustment.

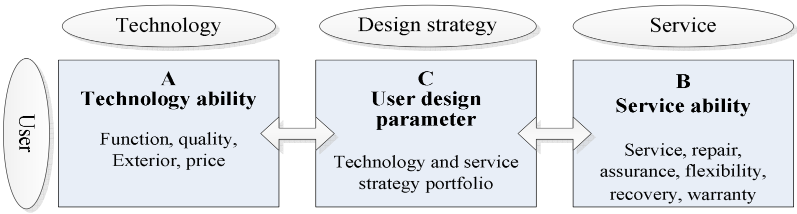


Figure 2. Design Thinking In The Stage Of Production Orientation

*Design Thinking In The Sales Orientation Stage*

This type is mainly generated by the combination of functions, services, customer needs, and competitive products (Figure 3). In the mid-term of product development, when the market competition is relatively mature, it is necessary to consider the information of the competition layer. In the middle stage of industrialization, the market is more suitable in the production-oriented and sales stages.

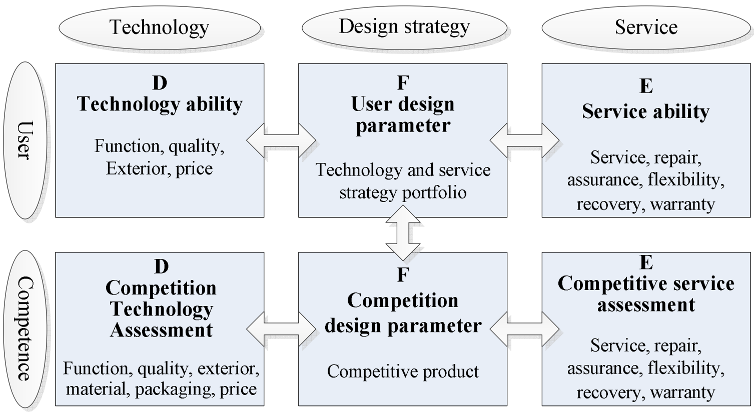


Figure 3. Design Thinking In The Sales Orientation Stage

D. The intersection of functional design and customer needs, and comparative analysis with competitors. Applicable to oversupply in the market, oligopolistic or only competitive advantage. The main strategy is to maintain a comparative advantage in terms of functionality, quality, and service for customer needs and competitive products.

E. The intersection of service design and customer needs, and comparative analysis with competitors. Mainly focus on the cost-effective regulation design, in addition to cost, function, quality, but also marketing methods and market flexibility.

F. Both functions and services need to be balanced. Existing products also require additional service products and must be compared with competitors, such as cosmetics, home appliances or items that require frequent adjustments.

*Design Thinking In The Stage Of Marketing Orientation*

When the product market develops to maturity, the market competition is fierce (Fig 4). Products must consider competition and innovation to win. In the mature stage of industrialization, the market is more suitable in the marketing-oriented stage.

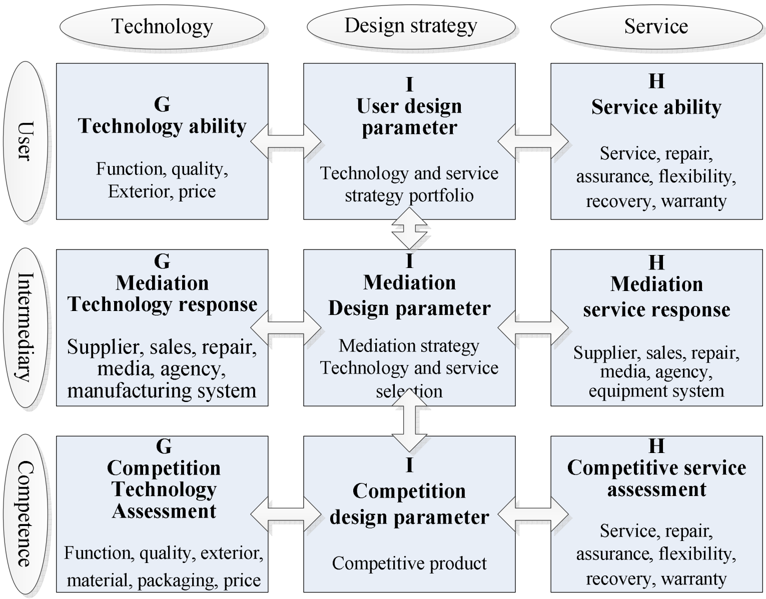


Figure 4. Design thinking in the stage of marketing orientation

G. After the intersection of functional design and customer needs, consider the intermediary factors and competitive products for comprehensive comparative analysis. For example, cosmetics, home appliances, or items that require constant adjustment. Applicable when the market is oversupply and close to a fully competitive market. Product advantages are built primarily in function, quality, and service. The strategy is to pre-evaluate and create differences and uniqueness while continuing to innovate to maintain sustainability.

H. The integration of service design and customer needs is integrated, considering the intermediary factors and competitive products for comprehensive comparative analysis. For example, cosmetics, home appliances, or items that require constant adjustment. The strategy emphasizes the control of cost performance, marketing methods, brand and emotional value creation.

I. Functional and service needs to be balanced, existing products also need to be accompanied by service products, and must be compared with competitors. Respond to future innovation and marketing positioning while sensitive observation and response.

*Innovative Marketing Stage, Possible Random Combination Status*

After the maturity of the product market, the factors of product competition are complex and diverse. In addition to considering competition and innovation, it is also necessary to adapt resources to meet the needs of the market and customers in order to maintain flexibility and speed of strategy. In the mature industrialization, the marketing technology in the market is at the mature stage. Strategic adjustment is needed to achieve the possible degree of optimization. The product mix will be generated with market conditions and subjective creativity. The law of product mix is relatively unstable, but the management principle is still the pursuit of optimization.

## Conclusion

There is no way for business management and product development, and it must be reflected in the changes in the market environment. This study constructs a design strategy matrix model of three-layer information and three-layer design strategy, and examines the feasible alternatives for layer-by-layer visualization. The initial design thinking is generated by functions, services and customer needs; the comparative thinking of gradually adding competitive products, and the comprehensive thinking of third-party information and designers' insights. The analysis of the design strategy matrix provides analysis from simple to complex, with a full range of competitive thinking to avoid design flaws that cannot be compensated afterwards due to limited thinking.

In the design strategy matrix, the analysis model integrates tools of QFD, DFSS (6σ design), and PLM, and theory of product customization, market economy, competitive thinking and consumer behavior, in order to construct an analytical model with validity and feasibility. This design strategy matrix can fully express the design concept and integrate the communication effects of different expertise. The design strategy matrix analysis model will embody the design parameters related to customers and competition. The inclusion of intermediary design parameters covers the interpretation of ideas and other information. This design strategy matrix analysis model considers both normative induction and narrative recommendations. Through the comparison of customer demand practices and competitive products, CP values will provide evidence of specific market acceptance as a reference for design decisions.

## References

Akao, Y. and Mazur, G. H. 2003. The Leading Edge QFD: Past, Present, and Future. The International Journal of Quality & ReliabilityManagement, 20(1), 20-35.

Anvari, A. R., Sorooshian, S. and Moghimi, R. 2012. The Strategic Approach to Exploration Review on TQM and Lean Production. International Journal of Lean Thinking, 3(2), 13-26.

Arcidiacono, G., Matt, D. T. and Rauch, E. 2017. Axiomatic Design of a Framework for the Comprehensive Optimization of Patient Flows in Hospitals. Journal of Healthcare Engineering 2017, ID 2309265, 9 pages.

Assink, M. 2006. Inhibitors of disruptive innovation capability: a conceptual model. European Journal of Innovation Management, 9(2), 215-233.

Bargelis, A. 2007. Design for process capability and capacity at the product conception stage. 19th International Conference on Production Research, Chile.

Belski, I. and Belski, I. 2015. Application of TRIZ in Improving the Creativity of Engineering Experts. Procedia Engineering 131, 792-797.

Brown, T. 2010. Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation. Harperbusiness, NY.

Cooper, R., Aouad, G., Lee, A., Wu, S., Fleming, A., Kagioglou, M. 2005. Process Management in Design and Construction. Blackwell Publishing Ltd, Oxford, UK.

Corallo, A., Latino, M. E., Lazoi, M., Lettera, S. Marra, M. and Verardi, S. 2013. Defining Product Lifecycle Management: A Journey across Features, Definitions, and Concepts. ISRN Industrial Engineering 2013, ID 170812, 10 pages.

Kamrani, A.K. 2008. Collaborative Design Approach in Product Design and Development. Collaborative Engineering. Springer, Boston, MA.

Li, Y., Wang, J., Li, X. L., and Zhao, W. 2007. Design creativity in product innovation. The International Journal of Advanced Manufacturing Technology, 33(3-4), 213–222.

Loch, C.H. and Terwiesch, C. 2000. Product Development and Concurrent Engineering, Innovations in Competitive Manufacturing. ch.22, 263-273, USA.

Pande, P.S., Neuman, R. P. and Cavanagh, R. R. 2000. The Six Sigma Way: How GE, Motorola, and Other Top Companies are Honing Their Performance. McGraw Hill Professional.

Roxana, P., Gheorghe, O. and Luminita, P. 2013. Parts in CATIA Based on Reverse Engineering Technique. Applied Mechanics and Materials, 371, 544-548.

Saravia, M., Newnes, L., Mileham, A. R. and Goh, Y. M. 2008. Estimating cost at the conceptual design stage to optimize design in terms of performance and cost. Collaborative Product and Service Life Cycle Management for a Sustainable World. Proceedings of the 15th ISPE International Conference on Concurrent Engineering (CE 2008), 123 – 130.

Womack J. P. and Jones D.T. 2003. Lean thinking: Banish waste and create wealth in your corporation. New York: Free Press.

Zio, E. 2009. Reliability engineering: Old problems and new challenges. Reliability Engineering & System Safety, 94(2), 125-141.