The Concept of Product Design

Adherbal Caminada Netto
University of São Paulo
adherbal@usp.brr

Paulo Carlos Kaminski
University of São Paulo
pckamins@usp.br

Abstract: This paper addresses the fact that design and project, although related, are not conceptually identical. It is pointed out that nowadays both terms are loosely employed even in technical and scientific environments, and that in the Portuguese language spoken in Brazil this fact is made worse by confusions created when translating from English texts. In order to make their point, the authors lead the reader through a brief account of the recent evolution of definitions for both terms in national and international standards related to quality. Finally, it is remarked that both terms stand at the same level when related to the concept of process.
Key Words: Product design and development, Project, Quality Standards.

1. Introduction

The words project and design are nowadays quite frequently used in every day language with a somewhat loose meaning, even in technical and scientific environments. Therefore, although it may be regrettable to loose all the emotional wealth contained in phrases such as *life project* or even *research project*, by the very reason that they have broad meanings and are not precise, it seems often advisable to define as precisely as possible what one means by product design.

Having been involved with the application and evolution of Quality principles and concepts for the last twenty years, one of the authors had the opportunity to follow the great effort which was developed in order to arrive at definitions such as those shown in Figure 1. Particularly during the RIO'97 meeting of the ISO Technical Committee 176 ¾ held in November 1997 in the city of Rio de Janeiro and closed in the Parliament of Latin America in the city of São Paulo, Brazil ¾ he had the chance to witness the international community's accentuated preoccupation with the need to come up with definitions that not only would be acceptable to all concerned parties, but also could be consistently translated into the several languages spoken in some 150 countries interested in the drafts which, three years later, would become what we now know as the ISO 9000:2000 series of standards (ISO, 2000).

2. The Evolution of Concepts

The difficulty in obtaining good definitions ¾ which includes the very perception of the necessity and convenience of definitions ¾ in a field of knowledge such as Quality Engineering and Management, which has been evolving in a unceasing and accelerated way for the last thirty years, can be exemplified by the recent evolution of the definitions of **design** and **project** within the ISO standards related to quality. Thus ISO 8402 (ISO, 1994), which was probably

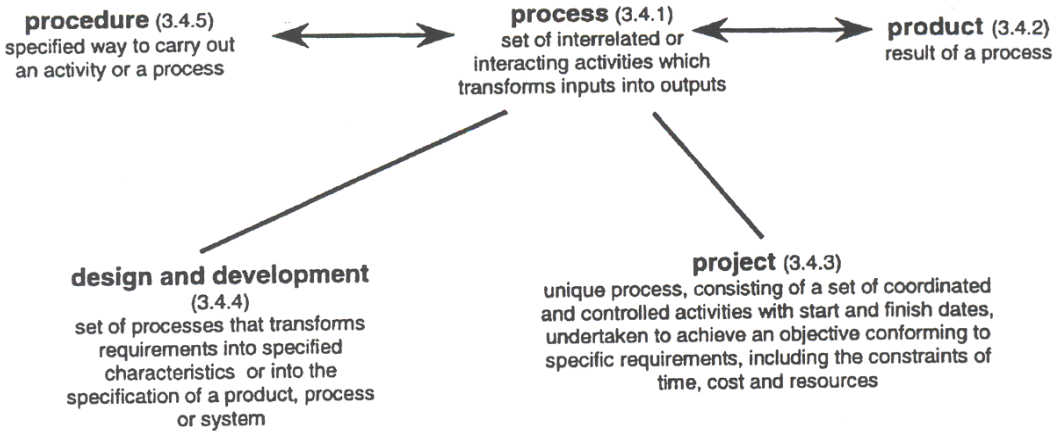

Figure 1: Concepts relating to process and product.. Source: ISO 9000:2000 (ISO, 2000).

the terminology standard most widely used by quality professionals since its publication in 1994, until it was superseded by ISO 9000:2000 (ISO, 2000), simply did not contemplate such terms, although it contained the definition of "design review" since this was one of the requirements included in the contemporary certification standards.

Before the publication of the aforesaid ISO 8402 Standard it was necessary to refer to national standards or glossaries in order to check what was meant by the terms under consideration. Particularly important were those texts published by the *American Society fort Quality Control - ASQC*[1] (1987), both because they divulged the terminology contained in the ANSI/ASQC standards (1987) and due to their international repercussions. It is easy to perceive, however, that what was taking place in the international arena was eventually bound to influence national standards. As an example thereof one verifies that the 1979 edition of British Standard BS 4778 (BSI, 1979) still included item ***7.1 design***. However, in 1987 as a first step of a revision destined to make this Standard into a multiple document its international part was published (BSI, 1987) ¾ equivalent now to the 1986 edition of the international Standard ISO 8402, equivalence that was maintained between the respective following editions ¾ no longer showing said definition of **design**. As for the national part of BS 4778, the revision of which was only to be published some years later (BSI, 1991), it also no longer included that definition. At the same time in the USA the glossary compiled by Bemowski (1992) for ASQC, for instance, equally failed to present definitions either for design or for project.

In the period following 1994 one can detect two facts worth remarking. First, the commencement of a perception of the need to include definitions for the terms design and project in the International Standards related to Quality. Second, as already previously remarked, the persistent difficulty in arriving at satisfactory definitions. As an example of such difficulty one has only to remember that during the revision process of the ISO 9000 series of Standards, Draft ISO/CD2 9000:2000 (ISO, 1999) included the following versions:

> *4.1.20*
> *design*
> ***process** (4.3.1) that transforms **requirements** (4.1.7) into a set of product **characteristics** (4.4.1).*
>
> *4.1.21*
> ***development***
> ***process** (4.3.1) to specify the product realization process.*
>
> *4.3.2*
> *project*
> **process** (4.3.1) to achieve a given objective within a unique, specific set of conditions.

It is also interesting to note that the term **project** was presented within the group of "concepts related to process and product", while the terms **design** and **development** were separately included within the group of "concepts related to management".

In the following revisional step of the ISO 9000 series of International Standards, Draft ISO/DIS 9000:2000 (ISO, 1999) already shows all three terms within the group of "concepts relating to process and product". However, although the term **project** appears with its present definition shown in Figure 1, the definition for the terms **design** and **development**, now united in one single concept, shows some differences to the present one: "... set of processes that transform requirements into specified characteristics **and** – *instead of* ***or*** – into the specification of **the product realization process** – instead of **a product, process or system**".

Finally, on the penultimate stage of development of the 2000 edition of the ISO 9000 series of Standards, document ISO/FDIS 9000:2000 (ISO, 2000) consolidates the definitions under consideration in the way they are presented today in Figure 1.

3. Sources of Misinterpretation

Nevertheless, in spite of the effort to arrive at such definitions accepted by the international community, it is curious to note that the Brazilian Standards Association (ABNT) published, in December 2000, Standard NBR ISO/ 10006:2000 including the following superseded definition:

> ***3.1 Design:** Unique process, consisting of a set of coordinated and controlled activities with start and finish dates, undertaken to achieve an objective conforming to specific requirements, including the constraints of time, cost and resources.*

From what we saw previously, this definition, when given in a Standard in force, may create great confusion among users if they are not careful enough to read on the upper part of the first page the following remark: "This Standard is

[1] Now American Society for Quality - ASQ.

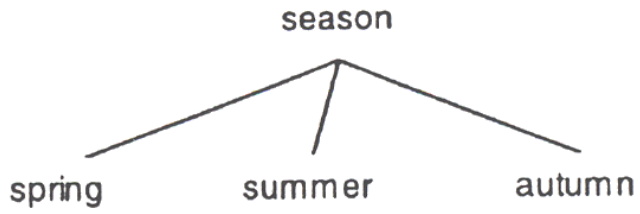

Figure 2: Graphical representation of a generic relation. Source: ISO 9000:2000 (ISO, 2000).

equivalent to ISO 10006:1997(E)"[2], therefore prior to the publication of ISO 9000:2000. By the way, this is the reason that in the definition of the term project in item 3.4.3, the Brazilian NBR edition of ISO 9000:2000 (ABNT, 2000) translates NOTE 4 as "Adapted from NBR ISO 10006:2000", instead of "Adapted from ISO 10006:1997", as it appears in the official English language version (BSI, 2000).

Such comments do no purport to convey negative criticism, nevertheless, they try to call the reader's attention to the frequent confusion made in this country between the terms design and project, in considerable part due to the translation of their English versions[3]. Such confusion is not restricted to the spoken language but appears frequently also in written texts. As a matter of fact, several Brazilian authors avoid using the term *empreendimento*[3], leaving to context or to *ad hoc* explanations the task to establish the distinction between concepts. This can be seen for instance in Thiry-CHERQUES (2001) and PRADO (2000 e 1998) and also holds true for translations of foreign texts, such as for instance PMIMG (2002) and VERZUH (2000).

Adds to this confusion the fact that the English word *design* is nowadays currently used in Brazil, as in the original language for that matter, to mean activities related to the early stages of design generally necessary to plan and fashion artistically or skillfully the desired product. Thus, the terms designer and *projetista* are employed today in the language spoken in Brazil to designate professionals who are involved with design phases which are meant to be distinct in nature.

4. Noteworthy Aspects of Present Definitions

In the present group of definitions from ISO 9000:2000 shown in Figure 1, it is interesting to remark three aspects.

Firstly, as previously remarked, one notices that the definition given for design and development unites both terms in one single concept, with the following note by way of clarification: "The terms 'design' and 'development' are sometimes used synonymously and sometimes used to define different stages of the overall design and development process." (ISO, 2000).

The second aspect concerns the fact that "a qualifier can be applied to indicate the nature of what is being designed and developed (e.g. product design and development or process design and development)" (ISO, 2000). In other words, the concept does not apply only to products. Therefore, if one is concerned with product design and development, as in this paper, then the qualifier **product** should de added in order to avoid confusion.

Thirdly, it may be remarked that both the concepts of design and development and of project are related to that of process through a generic type relation such as the one shown in Figure 2, where "subordinate concepts within the hierarchy inherit all the characteristics of the superordinate concept and contain descriptions of these characteristics which distinguish them from the superordinate (parent) and coordinate (sibling) concepts" (ISO, 2000).

As a matter of fact, seeing product design and development as a process is now current in the literature, such as used by SILVA (2002) in the title and summarized in the justification for his work: "In several theoretical approaches on PD[4] ... it is clearly important to see PD as a process". As to projects, PMBOK in item 3.1 (PMI, 2000) presents a state-of-the-art synthesis for the subject: "Projects are composed of processes". Therefore, although this paper has been primarily concerned with the concept of design and development proper, and in spite of the need to take into consideration the essential differences between concepts, the authors believe that it seems reasonable to say that in many instances what can be applied to the concept of design and development may also be judiciously extended, *mutatis mutandis*, for application to what, on the same level, is conceptualized as project and *vice versa*.

5. Closing Remarks

Basing their reasoning ultimately upon the ISO 9000 series of International Standards, which embody the state-of-the-art consensus on quality matters of representatives from some 150

[2] Now American Society for Quality - ASQ.

[3] In the Brazilian version of ISO 9000:2000 Standard the word projeto stands for design not project. Project is translated by empreendimento for lack of a better word.

[4] Product Design.

countries, the authors hope to have made the point that the terms design and project, although related, are not conceptually identical. And that this should be always taken into consideration whenever talking or writing about those subjects.

The reader, however, may be wondering about their motives for such an effort to be so scrupulously accurate, bearing in mind that one deals here with oddities of the Portuguese language which can be accommodated in most instances. The answer is simple: although there may be many similarities between the concepts under consideration, the authors believe that the differences, however small, play an important role when attempting to come up with a methodology for assessing the efficiency of design and development processes as opposed to project processes.

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Book review

The Lean Design Guidebook, by Ronald Mascitelli, 2004. Northridge: Technologycal Perspectives. ISBN: 0-9662697-2-1.

The title contains the faddish term "lean". After the success of the books "The machine that changed the world" and "Lean Thinking", lean is as modern as Six Sigma. The author is quite forthright when he states that "The "lean" I mean has a very specific and positive connotation: the act of eliminating non-value-added waste throughout the organization to enable higher productivity, increased profits and improved overall competitiveness". But some of these goals are identical to those of Just in Time and Simultaneous Engineering.

The first book, "The machine that changed the world", put emphasis on product development. The publications and further works, however, involve production planning. Today, lean thinking is one of the most important concepts used on the shop floor. In product development (PD), the main dimensions of cost, time and quality are addressed through simultaneous engineering and integrated product development. Many PD consultants and specialists consider lean design something new, which is not entirely true. Some methods, such as quality function deployment (QFD), value engineering and portfolio analysis, are very well known.

But the book has its merits, which we will discuss below. Firstly, the book gives a good description of lean design for product development professionals. This is important for lean specialists who try to apply suitable shop floor techniques to product development, like value stream analysis.

The book also offers useful guidelines for PD practitioners. Personally, I disagree with the focus on cost, since the tools presented in the book go beyond this dimension and can create value and benefits in the dimensions of quality and time-to-market. The author mentions he will publish new books focusing on the other dimensions. Clearly, these tools can also be applied in integrated product development that embraces complementary tools.

Part I presents the basics of the book, beginning with the meaning of the term "lean". It briefly discusses product cost, which is useful for the reader unfamiliar with the alternatives available. The author shows how to create a cost model for monitoring the product's target cost. The end of part I describes twenty levers for product cost, which are, quoting the author, "possible tradeoffs that the designer might consider when attempting to meet the target cost". Helpful are the "at a glance" boxes in which the impact of each tool on the twenty levers is pointed out. This didactic style focusing on practical application and the simplification of techniques proves very pragmatic for practitioners.

Part II discusses how to capture and prioritize customer requirements. It is organized in a structured and didactic way, including many examples and a simpler, redesigned QFD tool. Therefore, it is called lean QFD (sic). However, the creator of QFD, Akao, proposes another approach for improving QFD efficiency. It is the conceptual model that defines what QFD matrixes need to be defined and how they relate to each other for specific deployments. For prioritization, the author mentions the Kano model, which is not new. However, these tools are classical and their efficiency has been proven by many cases, so their inclusion at the beginning of a guideline on product development is a must.

Part III also presents well-known concepts and strategies, such as the concept that one should develop a product line rather than single products, thereby promoting synergy among products of the same line based on sharing solutions and parts. In this context, the author describes the role of the product platform from which many new products can be derived. He also explains that the development of modular product architecture contributes to the creation of robust platforms and product lines, and discusses the main concepts of modularity and of mass customization.

Consolidated tools used for product development are presented in part IV. The main tool is value engineering and analysis, which is a procedure to systematically generate lower-cost solutions. Value engineering is discussed in detail and includes examples, useful checklists and ready-to-use templates. The last section deals with Pugh's method for solution selection. This is a classical method to qualitatively evaluate alternative solutions based on user-defined criteria. At that point, the author describes a really new lean design tool called Set-Based Concurrent Engineering (SBCE), which is not commonly found in others books on product development. This tool was proposed by Toyota, whose PD

engineers create concurrent concepts and solutions for some phases of the development, but before deciding which one to actually use, they go to the next phases of detailed design and make the decision only when they have more information in hand.They discard solutions at a later stage of the process than is normally done in traditional product development processes. They also support the so-called lean design challenge, which stimulates the generation of new ideas, rewarding the team that proposes the most suitable idea.

Part V introduces new tools. In the first section, the author describes the main concepts of a lean factory, which foresees the possible compatibility between product and process development. He presents the concepts of Just in Time, pull system, flow lines, work cells and one-piece flow, as well as Toyota's production preparation process (3P). This process belongs to the broader scope of product development, whereas set-based concurrent engineering and the 3D process must run parallel to each other. Also discussed is integration with factory design aimed at achieving a lean factory. This means defining the manufacturing process in accordance with the selected solutions and vice versa. Mr. Mascitelli points out the seven alternative processes, proposing that no less than seven alternatives should be defined for further analysis so that the best option to manufacture a specific product can be chosen.

The tools presented in part VI are applied to detailed design. The first section discusses the traditional process capability. This is followed by the basics of Six Sigma focusing on the Tagushi method. A few minor examples of tolerance variation are illustrated, but the author fails to offer more important and detailed concepts of Six Sigma (it is also a fashionable term related to Design for Six Sigma – DFSS – which presents many traditional PD tools interrelated sequentially, with emphasis on the application of statistical tools and critical parameter design). The focus of this section is the Tagushi method and its integration with FMEA (failure mode and effect analysis) for defining problems, factors that must be analyzed by DOE (design of experiments). The DFMA (design for manufacturing and assembly) method is discussed in the context of DfX (design for "x", where "x" can have many meanings). The main literature references are listed here. The author presents a DfX checklist called design for excellence. He proposes the definition of a best practice guideline, which goes beyond a simple checklist and documents the lessons learned involving any DfX application. This is similar to the patterns one finds in software development, where best-proven solutions and tips for software development are documented for future reuse.

In the last section of this part, the author proposes a method for continuous cost improvement. This method is useful, but the reader may fail to see Mr. Mascitelli's focus on cost, as I mentioned earlier, since the tools Mr. Mascitelli presents are also suitable for reducing time-to-market and increasing product quality and reliability. According to the author, this continuous cost improvement is a Kaizen approach to lean design deployment. He recommends that any organization should select the most appropriate tools for its goals in order to implement them. An additional innovation of the book is the maturity model for application of the 18 lean design tools. This model divides the implementation into three phases.

At the beginning of the book, the author presents a timeline for application of the tools, in other words, the phase of a product's development in which those tools may be applied (from project selection to production launch). An organization might be able to apply them for that purpose, but what if the organization were unfamiliar with them and had no experience in applying them? In the maturity model, he describes the sequence in which those tools could be applied (divided into three phases). The tools of the first level of maturity should be applied for a showcase project. After the organization has collected the new tools, systematized the lessons learned and trained its personnel in their use, it should deploy them in all its projects. The tools of the second level of maturity should then be applied to a new showcase project, and so on. This approach is too simplistic and generic and an organization could not rely on it to support the application of lean design tools.

At the end of each section, the author presents a list of references that gives readers good recommendations for further reading.

In the conclusions, the author attempts to connect the tools and sustainable development, which he calls green. That is a good remark, but he fails to offer any new content for practical application, as a guidebook might have done.

In summary, I recommend this book because of the didactic approach it adopts to introduce practitioners to lean

design tools. The book has its merits, provided one disregards its sole focus on cost, whereas the benefits of the application of those tools transcend cost reduction. My advice to the reader is: Do not worry whether or not a tool is in accordance with the lean design. Also, forget the fashion but apply the tools integrated in the framework proposed by the author, as well as new concepts such as set-based concurrent engineering or even the maturity model. However, keep in mind that there are many other state-of-the-art approaches and complementary tools that can be used in this framework, such as quality gates, virtual engineering, digital product model, performance measurement indicators, systematic project management, collaborative engineering and IT solutions for product life cycle management, product development management and the CAx tools. The product launch considering marketing knowledge should also be seen in this context as Toyota's production preparation process. Other issues that might be addressed are sustainable product development and eco-design, whereby concepts of recycling, reuse, and remanufacturing should be integrated in the framework. Mr. Mascitelli would probably aver that these tools will be presented in his next books of the lean guidebook series, which may consider other dimensions of product development. Nevertheless, this process is holistic and the tools of any given dimension cannot be applied separately. After the publication of the next two books, the author will no doubt create a synthesis of the three. However, it might prove impracticable to present all the tools in a single book.

The above considerations, however, do not count against this book, which I recommend for study by product development practitioners and students.

Henrique Rozenfeld
Nucleus of Advanced Manufacturing
Engineering School of São Carlos
University of São Paulo
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