The evolution of design methods

Abstract

The study of design methods in the 1950’s started from the perception of the increased complexity in industrial products. The linear paradigm of the first models evolved to more systemic representations of the design process. This paper presents the development of design models in order to contribute to a greater understanding of the methodology for design projects with caution to the fact that each one reflects the period in which it was developed. Based on the understanding of product design taxonomies, a framework for product design methodology was generated.

Keywords: Design Methodology; Design Methods; Design Models.

Introduction

The idea behind the word “design” is relatively recent. The concept was established in the modern era, before the Industrial Revolution. It became characteristic of this period, not only in the restrict sense of product design, house design or urban planning, but also in the sense that all dimensions of life could be planned. Design in Architecture, Industrial Design and Engineering presents particular characteristics not only technical, but social and political as well. In any field, design activity implies meeting simultaneously different requirements. This will affect the performance, the usability, the environment and the society. The simultaneously meeting of different aspects of the design problem is not new – it was a current topic in since the 1970s. This approach suggests a systemic view that considers how the requirements, such as the ergonomic or technologic ones, affect each other. This systemic approach distinguishes from the dominant paradigm in the design methodology in the 1970s. The ideas of René Descartes in Discourse on the Method (1637) greatly influenced the design thinking of the time: “divide each difficulty into as many parts as possible and necessary for its adequate solution.”

The perception of inherent complexity in the product developed from the second half of the twentieth century was pointed by Christopher Alexander as one of the reasons for the emergence of design methods in the 1950s and early 1960s. The Cartesian principle of breaking down the problem in minimum units, whose partial solutions will lead to the general solution, could deal with the design problems in the functionalist period, but it was disturbed by the socio-economical, and philosophical changes in the late 1960s and 1970s. Thomas Kuhn published in 1962 The Structure of Scientific Revolutions, which postulates that the
paradigm shift is preceded by the crisis of the previous paradigm, and that evolution, by paradigm shifts, is not necessarily progressive. Kuhn’s idea indeed contradicts the previous paradigm, which can be illustrated by Karl Popper’s thought. Popper argues that all knowledge is progressive and cumulative, which conveys the idea of linearity. Paul Feyerabend comments on the evolution of methods in *Against Method: outline of an anarchistic theory of knowledge*, opposing to a general model, and arguing that the variety of strategies for dealing with product development is a way of dealing with the increasing complexity that results from a humanistic view (Bürdek, 2006).

The evolution of design methods can be reviewed, since then, as a succession of periods of skepticism and optimism. The precarious nature of the activity practiced since the Industrial Revolution until the middle of the twentieth century was perceived when compared with the complexity of new products manufactured since 1950s. In the 1960s, the belief that a simple design structure, an abstraction from the singularity of the design problems, could ensure the access to a perfect solution was common. This view displeased the main authors in the 1970s, largely due to lack of practical results of the previous years (Jones, 1984; Rittel, 1972 In: Cross, 1984) In the 1980s, based on new paradigms, the design methodology adopted new approaches that no longer have as its purpose the establishment of objective functions, but to understand how people interact with products in their environments. Studies on design methods began to explore other tools, such as scenarios method, initially developed by Herman Kahn and Alvin Toffler (Bürdek, 2006). Since the 1960s the field of Design Methodology evolved through different paths, from rationalist to anarchist. In order to contribute to a better understanding of the main current tendencies, this paper presents the evolution of design methods and proposes a framework to guide their teaching. It is part of a study that investigates the design practice of product designers and start from the premise that we should expand the study of design methods to include other approaches, especially the more flexible ones, which may be more appropriate for solving complex problems and reach high degrees of innovativeness, typical of the challenges posed by sustainable development.

The evolution of product design methodology

For a long time since its rise as a profession in the late eighteenth century to the mid-twentieth century, the design method was restricted to the method of designing through scale drawings:

The method of designing by making scale drawings will be familiar to many readers of this book. The essential difference between this, the normal method of evolving the shapes of machine-made things, and the earlier method of craft evolution, is that trial-and-error is separated from production by using a scale drawing in place of the product as the medium for experiment and change. This separation of thinking from making has several important effects (Jones, 1992, p.20)

This practice was developing at least since the Renaissance, not only in sketches of works of art, but also in mechanical projects and other innovations planned in those times. Representation techniques gained in refinement and precision through the development and standardization. Nowadays, the advance of digital technologies provides the scale drawing with resources beyond those pioneers’ imagination, (e. g. simulations and virtual immersion). The emergence of disciplines like operations research, decision-making and creative techniques, and the development of computer programming, played a major influence in the origins of new design methods during the 1960s (Cross, 2007). The early years were also characterized by constant exchange of information between design methods, artificial
intelligence, cybernetics and problem-solving theories. Many of the first authors present a clear connection to traditional sciences, as is the case of Christopher Alexander. Architect and mathematician, Alexander, one of the pioneers of the design methods movement, provide a mathematical basis for his theory on his 1964 book *Notes on the Synthesis of Form*. This closeness between science and design practice has brought insecurity to the professional. And since then design has lost its character as a personal activity that relies solely on the designer. The need to support every decision with rational arguments arose. On the other hand, the same rationality would ensure compliance for design methodology by the universities (Bonsiepe, 1978; Bürdek, 2006). Moreover, there was pressure from students of design schools that wanted “to know the specific purpose of their activities without complying with vague indications” (Bonsiepe, 1978, p. 146).

From 1950s to 1960s there was a great effort in various areas to develop design methods capable of coping with the complexity and the uncertainty present in the problems that was inherent in the technological development context. The rationalization tendency of the design methods culminate in the *Conferences on Design Methods*, held in England, under the coordination of researchers from a wide range of disciplines. A reference work of this period is the book *Design Methods*, by John Christopher Jones. It presents a collection of tools to assist the design activity and a theoretical framework about the design process. The essence of design methods developed in the 1960s relies on the division of the process in well-defined steps. These steps can be broadly described as: understand and define the problem, gather information, analyse information, develop concepts for alternative solutions, evaluate alternatives and select solution(s), test and implement. Its foundations lie in the idea of the Cartesian method of understanding the problem prior to reducing its complexity, in order to be able to tackle the problem.

One of the first representations of the design process was presented by Bruce Archer in 1963, in a sequence of articles for *Design* magazine. In these articles he suggested that the designer’s work combines intuition and cognition, and that the formalization of the creative process tends to transform it in a more scientific practice. The design process model proposed by Archer predicts the need for different approaches in different moments: systematic observation and inductive reasoning in the analytical phase, and subjective and deductive reasoning in the creative phase (Figure 1).

![Archer’s model of the design process (Cross, 2008)](image)

By that time, Morris Asimow proposed a representation that considered the life cycle of the product (Figure 2). This representation starts with the analysis of requirements, followed by a feasibility study, prior to joining the preliminary design and detailed design phases. Next
there are the activities related to the production, distribution, consumption and disposal. This method is considered as a predecessor of all the product development methods organized in separated phases (Cross, 2007).

Figure 2: Asimow’s method

Phase models, such as French’s and Pahl and Beitz’s methods (Figure 3), were developed concurrently in business and academic environments to reduce the uncertainty in the development of new products before the competition.

Figure 3: French’s and Pahl and Beitz’s methods (Roozenburg & Eeckels, 1995)
In the late 1970s, due to external influences – such as Kuhn’s, Popper’s and Feyerabend’s ideas – and in a reaction to critics, a new paradigm in the design methodology emerges. Jones stood out again with his *Essays in Design*. In this book, Jones deeply criticizes the reductionists’ methods, emphasizing the role played by emergence and intuition in the creative and investigative process (Bürdek, 2006; Jones, 1985).

With the depletion of the functionalist and rationalist paradigm, the methodology tendency of proposing a general representation of the design process changed, and studies on specific tools became more common. In addition, integration with various non-design disciplines resulted in the increase of the designer repertoire. The interest changed to the proposition of new tools such as mind maps, scenario techniques, usability testing, cooperative/participatory design, among others (Bürdek, 2006). Nevertheless the interest in describing the design process through a diagram is still present among researchers and design groups. The Design Council, from UK, presented a flexible representation for the design process in four phases: discover, define, develop and distribute (Figure 6). The form originated its name: *Double Diamond*. In this diagram, the process of divergence and convergence are associated with key moments in the design process. Discover and develop phases correspond to divergent processes, while define and distribute phases are convergent. To complement and extend this representation, the elements arranged inside the diagram indicate exploratory and focus activities on the left diamond, and cycles of prototyping, testing and refinement in the right diamond.

![Figure 4: Double Diamond (Design Council, 2007)](image)

Linearity was a common characteristic of the first representations. Even though many authors included the possibility of returns and feedbacks, this was seen as a problem or an opportunity to correct errors. Another way of understanding the process embraces the nature of uncertainty as part of the design activity. The path was no longer linear, simply because successive iterations are needed to frame the problem and the solution. To this idea of parallel evolution between problem and solution is given the name co-evolution. This concept is discussed by Maher, et al. (1996) and analyzed by Dorst and Cross (2001). L.J. March broke with the linear representation of design process, based on the assumption that the problem is dependent on the solution and that the inductive-deductive thinking is inadequate for the production of synthesis in the design process. March sought the work of the philosopher
Charles S. Pierce for the idea of abductive thinking, which is linked to the production (synthesis), while induction and deduction are related to research (analysis). In other words “deduction proves that something must be; induction shows that something actually is operative; abduction suggests that something may be” (Pierce, cited by Cross, 2008). March’s representation for design process (Figure 5) is a cyclic model that starts with production (preliminary requirements and assumptions about solution types to describe a design concept), followed by deduction (to predict solutions performance) and goes through a moment of induction (indicating changes and refinements in the concept) (Cross, 2008).

Nonlinearity can be found in IDEO’s design process, described by Brown (2008, p. 88) as “a system of spaces rather than a predefined series of orderly steps”. Figure 6 demonstrate a modus operandi that is beyond the classic models. The process, or the design space, involves three areas: inspiration, ideation and implementation. Inspiration corresponds to the circumstances that motivate the search for a solution (a problem, an observation or both). Ideation involves the generation, development and testing of ideas that could lead to a solution. Implementation deals with the product launch. Throughout a project, the three spaces can be explored, in particular the first two, in order to refine ideas and take new paths. It is important to notice that the design in IDEO is done in close collaboration with its client’s teams and that IDEO has a qualified group of multidisciplinary professionals with diverse backgrounds. This ensures that many activities can be done simultaneously, saving time in comparison with linear processes.
Faced with the need to live with antagonistic conceptions for the design methodology, Nigel Cross developed a flexible approach to the selection of product development methods. He considered variables such as level of problem definition, strategy to be adopted and, very important and largely unexplored, cognitive style of the designer. The starting point is the definition of the strategy, which describes the overall plan of action for the design and the sequence of activities. Depending on the type of problem, the strategy may be a “random search”, if there is a high degree of innovation, or a “prefab strategy”, when it comes to well-know situations. Thus, in some cases, the decision may be for the exploration of the problem with divergent thinking. In other situations, it would be the creative process, and its specific techniques. Other cases would ask for a more structured method, organized in phases. But the choice of method would depend also on the cognitive style of the designer (Cross, 2008).

**Basis for a new approach to analyse design methods**

Since the 1960s, the role of designers in new products development process has changed to encompass other activities, not only restricted to the project itself. An example of possibilities for design scope can be found in Roozenburg and Eeckels (1995), who defines design as a process of goal-directed reasoning that flows from the product function to its form (see Figure 7). Traditionally the core of design activities is related with the left side of the figure, the product designing process, not with the right side, the product planning process. But, as the authors says, “The more to right we start (…), the more open-ended the product development process will be” (Roozenburg and Eeckels, 1995, p.54). It means that innovation effectively lies on product planning, when the constraints are assumed and the goals are defined.
Simultaneously, the ideas of sustainable development have evolved greatly in recent decades. Sustainability entered the Design agenda since the criticism against the traditional production and consumption made by Victor Papanek in the 1970s. Today we can perceive different levels of interference in the sustainable product design process. Basically there are two approaches and four levels: a restorative, which corresponds to ecological redesign and development of new products, aiming at the improvement of existing solutions; and a strategic approach, encompassing the concepts of product-service system and the proposition of new scenarios, intended to modify the consumption and the production (Manzini and Vezoli, 2005). These levels of interference will certainly require different methodological approaches. Returning to the idea of complexity in design problems, it is important to consider that the degree of innovativeness will also affect the way the problem will be addressed. Naveiro (2001) defines the complexity by the project size and the frequency and quantity of problems; the innovativeness is defined by the degree of problem structuring, ranked in four categories:

- **Incremental project** – consists in the modification of product parts, keeping the original concept. It is a structured activity as the main variables of the problem and solution are already identified;
- **Complex project** – large projects involving many people and an extremely complicated information system... The frequency of problems is high, requiring great coordination efforts;
- **Creative project** – consists of projects with low degree of structure in technologically simple problems;
- **Intensive project** – projects that involve new and complex situations. As an example we can mention the Boeing 777, a huge team working with non-trivial problems (Naveiro, 2001, pp. 42-43)

Based on this classification, van der Linden and Lacerda (2009) proposed a model for organization and selection of methods for teaching purposes (Figure 8). The context in which these projects occur will be added to this first model: those of high complexity require multidisciplinary teams that meet the wide variety of problems to be resolved; the low complexity can be solved by small teams and often the designer addresses himself the major design problems. This argument led to the conclusion that projects of high complexity can be seen under the logic of rational product development process or other systemic approach, while projects of low complexity allow classical approaches to industrial design and even the use of creative process. The use of creative process was suggested by Cross (2008) as a strategy to approach the problem in situations of high uncertainty. This model adopts the division into four quadrants bounded by the axes of innovativeness (vertical) and complexity (horizontal).
A Framework for Product Design Methodology

Crossing the levels of design intervention with the vision of the process of Roozenburg and Eeckels, (1995), we find four suggestions for future strategies in product development. The impact is minor on redesign, with a simple change of form and properties, and in the design of new products, with changes in function. In a more advanced level of intervention, the design of product-service system serves the needs of various stakeholders. Finally the new scenarios proposal, involves changing values in consumption. From this association between levels of design intervention and the design process, was made a review of the model developed by van der Linden and Lacerda (2009). Initially it can link innovation with four levels of intervention, finding two groups: redesign (low innovativeness), new products, product-service system and new scenarios (high innovativeness). Therefore, the categories of incremental and complex project, which correspond to low innovativeness, are restricted to operations in form and properties. On the other hand, creative and intensive project categories allow a review of the function, needs and values. This is relevant to the issue of sustainability and also for innovation. In addition, the quadrants should better serve the characteristics assigned to each project category. As it seems reasonable to suppose that the incremental project does not has border with the intensive, neither the creative with the complex, we attempted a way to represent the relations between these classifications. For this, a sigmoid curve appeared to be adequate, because it enables to indicate in a subtle way the delimitation between the categories in the model (Figure 8). The boundaries between categories are diffused, since there are borderline cases difficult to define, in addition, the space occupied by each category is not able to be scaled, in the authors' opinions. Thus, the model serves as a framework to guide didactically the analysis of the design methods and development of new products.
As an application example, we use the models presented in the second section of this paper. Asimow, French, Pahl and Beitz correspond to product-oriented models: new products or redesign. Double Diamond, March and IDEO allow higher flexibility in use, causing them to also reach the highest levels of intervention (SPS and New Scenarios). These examples are still superficial, just as an indication of the use of the framework.

**Conclusion**

Observing the models as a manifestation of the design discourse, it was noted that during the half century occurred a significant evolution between the linear model of Bruce Archer and the cyclic model of IDEO. We should be careful when comparing models from different eras, especially considering the evolution of technology during this period, which certainly have an important role in their differences. From the era of mass production, we move to the era of mass customization (even it the first survives today; the second has become the reference). The problems which were complex in time of the pioneers Conferences on Design Methods, today carry themes such as sustainability, gender, globalization, dematerialization, and many others that have emerged as new ways and challenges. Any study of methods for product design, should assume there is a gap between the complexity of practice and the simplicity of a theoretical model. However, the models can not be neglected due to its main function as an element able to structure a complex activity to allow the detachment of the professional, which enables him to examine critically the process. Moreover, they allow the teaching of design activity, in that structured the process of beginners. Another important function of models is to standardize the language used by a team of product development, allowing communication between teams. Regarding the classification of projects into one of the categories proposed in the framework, in many cases will depend on the perception of what constitutes the problem when the project was done. The historical context of who analyses the design problem by this model will influence the analysis.
References


