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Nine Factors Guiding the Theory in Design Education and the Practice of Teaching in Industrial Design

Abstract

This paper presents a review of different authors' approaches about a framework to guide design education and practice. Such framework was named as "factors", "points", "conditions", "requirements", words that have been used as a significant part of the discourse of modern design thinkers and educators. Basically those factors are identified with the notions of form, function, and information, man, utility, economy, aesthetic, ergonomics, industry, and others. Our particular approach to that issue is that clear design factors are important to the definition of industrial design disciplines. However, although the design factors have been listed and explained in many occasions, imprecision and overlapping of concepts led to misinterpretation in situations where design foundations were not strong enough, or not sufficiently developed. Different interpretations can be inferred by the study of the denotation of each term used by the authors in their countries and period of time in their Design definitions. The main contribution of this paper to the field of design education is a review of concepts and a proposal of nine design factors that have been helpful in guiding industrial design teaching practice and design education. Some teaching techniques for product development in Industrial Design courses are presented. One can consider the need to constant improvement of concepts in order to support the disciplines of industrial design programs due to global social and cultural changes provoked by the industrial societies over the past five decades.

Key words*: methods of teaching in industrial design; development design education.*

Introduction

In the first years of the 1990s, a visitor to the Escola Superior de Desenho Industrial, ESDI, in Rio de Janeiro, would find on the walls a poster with the message "Design*: forma, função, informação*". That picture is only one of many signals of the lasting influence from the German HfG-Ulm, industrial design educational institution, to the educational philosophy of the *carioca* school. In Brazil, design education for adults started in 1955, however, only in the beginning of the following decade the teaching of Industrial Design was established at university level, thanks to the effort of museumlogists, independent graphic artists, politicians and historians.

The strong presence of the German HfG-Ulm on the educational philosophy of the Brazilian ESDI is well documented not only on speeches of directors but also on the approach of academic works. Many student's project of the *form* of a new product, demonstrated that their creative ideas were based considering *functional* and *informational* aspects of the industrial design process. Those projectual principles were consistently taught at the main Brazilian industrial design courses until the end of the 1980s, but, by the 90's, were questioned, fragmented and lost. In the central region of Rio Grande do Sul, however, a group of teachers and researchers shaped under the Ulmian formula – *form, function, and information* – were concerned about the lack of a sound direction of design education and teaching of industrial design in Brazil.

Some questions were formulated: What is the present theoretical foundation used in the teaching of product design? What impact the artistic design movements like "radical", "memphis" and "post-modernist" have caused to the educational theory and teaching practice of industrial design? If the impact was positive, should Brazilian industrial design courses twist to "art design" or "craft revival design"? How to preserve and conserve core values regarding projectual education?

Most answers for those questions were found in books related to the theory and practice of Industrial Design, e.g., Dreyfuss (1955); Archer (1966); Bonsiepe, (1978, 1984); Löback, (1992); Redig, (1977, 2005). These works, beyond providing information to develop new theories about the role that industrial designers in nations like Brazil (c.f., Papanek, 1977, Bonsiepe, 1977, 1991; Margolin, 2007), also offer very useful source of information for the creation of teaching tecniques product design projectual factors.

Theoretical structures which help design education principles

The American industrial designer Henry Dreyfuss (1904-1972) wrote in the book *Designing for People* (1955), that "…the industrial designer has a *modus operandi*. No matter how elusive his assignment may be he approaches it with confidence. We have a yardstick in our office for good industrial design. It represents twenty-five years of experience, and we apply it to every design problem. It has five points: (1) *Utility* and *Safety*, (2) *Maintenance*, (3) *Cost*, (4) *Sales Appeal*, (5) *Appearance*" (Dreyfuss, 2003:178-179).

Almost ten years later, not only Dreyfuss considered that these points were an essential part of the whole projectual profession. Teachers from the other side of the Atlantic understood that the responsibility of the industrial designer has well defined guidelines to drive creativity, albeit the words chosen to describe them were not the same.

In 1964, David Pye (1914-1993), teacher of furniture design at the Royal College of Art, London, wrote one important book related to the nature of design in the project of industrial products. He specified "six conditions which should be satisfied in any design: (1) It must correctly embody the essential principle of *arrangement*; (2) The components of the device must be *geometrically* related – in extend and position – to each other and to the objectives, in whatever particular ways suit these particular objects and this particular result; (3) the *components must be strong* enough to transmit and resist forces or the intended resulted required; (4) *Access* must be provided (this is a special case the two above)". Pye unites these four together to refer as the requirements of use, and adds: "(5) the cost of the result must be acceptable. This is the requirement of *easy* and *economy*. (6) The *appearance* of the device must be acceptable". The six Pye *conditions* could be summarised into three requirements: use, economy and appearance.

Comparing Dreyfuss' *points* (1955) with Pye's *conditions* (1964) one can observe similarities not only in the terms employed but also in the correspondence among their ideas about issues to be considered in the professional practice of Industrial Design.

For instance, the term "use" utilised by Pye embodies the ideas of "arrangement and order", which is a Vitruvian principle and corresponds to what Gui Bonsiepe (1936-) would call "synthesis and formal coherence". That means that an industrial designer must give to the "components of a device a geometric relationship". When Pye suggests that components must be strong enough to transmit and resist forces, the association with materials, technology and scientific knowledge is inevitable. The expression "provide access" is related to craftsmanship and also to the possibility of mass production manufacturing. Cost is a concern for Dreyfuss and Pye in the sense of the efficient management of the resources of a community, the sparing and concise use of energy and materials.

Basic sources for definition of projectual design factors

The first explicit ideas about projectual factors were developed between 1964 and 1966, by Bruce Archer (1922-2005). Archer said that *"the art of designing is the art of reconciliation. There is a whole complex of factors arising from the three main aspects of the industrial design – function, marketing and manufacturing. These factors are always competing and sometimes they are in direct conflict, but they must be reconciled in the end product. ... The word "compromise" is avoided because it implies some half-way house which might very well leave each of the competing requirements equally unsatisfying. Reconciliation implies that the conflict is resolved. ... Design begins with the need".* And this is one of the differences between the industrial designer and the artistic designer.

It is expected that only after the discovery of a need in the material culture or in her/his environment the industrial designer could find desire in doing design and making designs. The industrial designer should get motivation to design an industrial product mainly from the way s(he) needs to remove or avoid a misfit situation found in the material culture, or in the environment surrounding her/him. The artistic designer, on the other hand, works ideas mainly based on her/his own desires, i.e., feelings of ambition, appetite, anxiety, impulse to do new things which might, first of all, to give pleasure, satisfaction and joy to oneself. That is not what characterises the industrial designer.

It would be important to quote largely Bruce Archer not only because this paper is addressed for most of industrial design teacher who did not had access to his discourse, in the 60's, but also because he defended systematic methods for the industrial design practice. Bruce Archer said that industrial design is more close to knowledge-based reasoning, rather than inspiration or intuition, less still, free creativity. Archer defended that industrial design, as a projectual activity, shows some sequence of actions that starts from the "environment acting on man", following "man performing work", and "work acting and... having side effects on the environment".

Archer also said that the industrial designer, in order to perform that activity, should be aware of the nine classes of industrial design factors – aesthetics, motivation, function, ergonomics, mechanism, structure, production, economics, presentation – and their relevance, in the product design process of creation, for use, sale and manufacture.

Yet, according to Archer, *for convenience, the consideration involved can be reduced to three human factors (motivation, ergonomics, and aesthetics) and three technical factors (function, mechanism, structure). Examination of similar generalised conditions at the point of manufacture and point of presentation or sale suggests three further factors (production, economics, presentation), indicating nine design factors all together.*

More than thirty years latter, Archer's ideas would fit like a glove to some contexts and academic levels of the industrial design teaching in the South of the Brazilian country.

About industrial design in Brazil

By 1975, those Anglo-American ideas about projectual factors have reached Brazil already, and those were revised and presented in the book *Sobre Desenho Industrial* (1977), by Joaquim Redig (1942-). Actually, Redig's ideas about projectual design factors were presented as a constructivist poem. Its contents influenced and shaped the concept of Industrial Design in Brazil, at least for those teachers concerned to the project of industrial goods. Redig points out that "in the sixties, when the thinking about Design in Brazil was being organised, particularly at ESDI, the shape of a triangle was used to represent the principles in which Design is based (Figure 1).

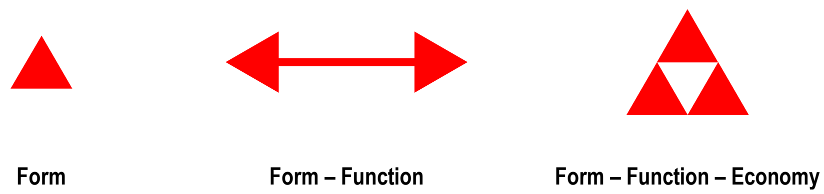


Figure 1. Design concepts and evolution of its main objectives

That idea comes from the Louis H. Sullivan functionalist concept "form follows function" and, later, to reach "a more tangible data", as Redig would say, the term "economy" was included.

In *Sobre Desenho Industrial* (About Industrial Design) Redig expanded that triangular concept with the concepts of "utility", "cost" and "man", perhaps in reference to Dreyfuss, Pye and Bonsiepe himself, one of the persons that Redig acknowledges in his book. Brazilian industrial designers learned from Redig, then, that the three Pye requirements (use, economy and appearance) could be increased to six, forming, now, a hexagon. Redig pointed out that those words overlap or restrain the creation of ideas in some projects. So, to gain full understanding of those concepts, Redig unfolded each word into other analogical, parallel or consequent words. Then, for the word "man", for instance, Redig associated *consumer*, *necessity*, *society*. To "form" he connected visual *perception*, *aesthetics*, and *information*. To "utility" he attached *functionalism*, *use*, *communication*. To "industry", he added *manufacture, machinery*, *technology*. "Cost" was unfolded into the notions of *rationalisation*, *productivity*, *economy*. "Environment" was explained as *ecosystem*, *harmony* and *natural* resources.

The concepts of Dreyfuss, Pye and Redig can be summarised in key-words, Figure 2.

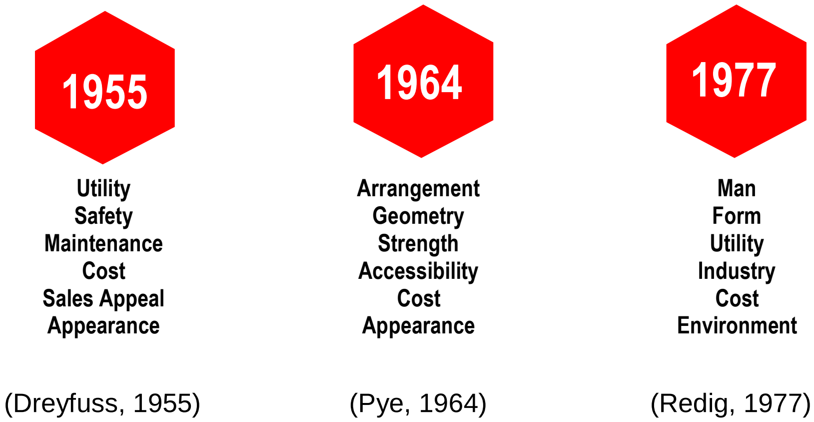


Figure 2. Key-words to the projectual design factors

In 1977, Redig defined Industrial Design as "*the simultaneous equation of ergonomic, perceptive, anthropological, technological, economic, and ecological factors in the project of the physical elements and structures necessary to human life, welfare and culture*". In his second book, *Sentido do Design* (1983), Redig maintained the previous definition of Industrial Design and its projectual factors but slightly altered the hierarchy of the six features of Industrial Design from 1977 definition. Within that new definition, he established, then, six factors, i.e. things that contribute to a result in Industrial Design: *ergonomics, perception, anthropology, technology, economy and ecology*. In 2005, *Sobre Desenho Industrial* was reedited unaltered, and the repercussion was impressive, because of the things that, at that time, were being developed in course disciplines related to product designing.

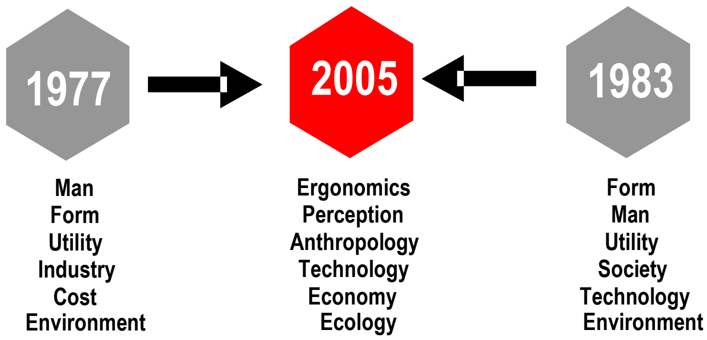


Figure 3. Redig's concepts towards the six projectual factors

Teaching techniques for product development in industrial design courses

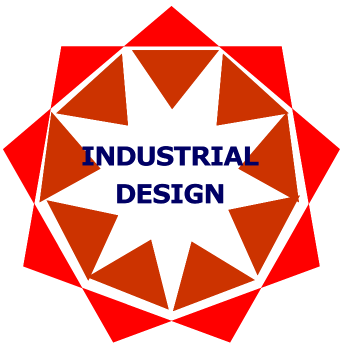
Language and words can shape our thinking and support our judgment. And that is well perceived in the meaning given by Redig to the terms in his definition of Industrial Design. For instance, when he replaced the word *industry* by *technology* he freed the notion from the adjective *industrial* – related to the sense of manufacturing, mass production goods –, and created new possibilities to bridge the Latin word *industria* – meaning care, attitude, application, diligence, work, effort – with words seldom used in the teaching of industrial design: *industriousity* (which can mean the capability of human beings acting creatively but intellectually); and *industriality* (which means the ability of human beings to make, craft and manufacture new things, objects or products).

The question that must be addressed is: how can an industrial design teacher maximize the relationship between teaching and learning? How to deal with that when students are confused with so many design concepts? Why "soft" artistic designing seems to be more desirable among those students who have just started an under graduation course? Is it easier to teach "soft" than "hard" design? Why there is no terminological agreement among teachers and industrial design thinkers to treat matters related to design theory and its practice?

Those questions were addressed in Rio Grande do Sul, for more than a decade, some studies have been made to link subjects and to connect fragments from that huge design theory puzzle. Some of the results have helped to develop new design ideas and theories that improved the quality of the product design teaching. Projectual design factors helped to systematise material culture lessons towards a vocational practice in industrial design. But, how to apply those notions presented in the projectual factors to teaching? How to make students understand the need to apply projectual factors in the analytical techniques used in the product designing process?

Reorganising word categories to express projectual factors in designing

In helping industrial design students to express themselves before their class mates and tutors it is necessary to teach them how to reduce into a few words the numerous ideas behind Redig's projectual factors. For example, when concerned with the anthropology factor we recommend that students investigate and study the cultural *ideas* and *behaviours* from the human group or society belonging to a specific marketing place to which the product is addressed. The key-words are resumed as *idea* and *behaviour*. The data collected are valuable to avoid misunderstanding about product features like colours and shapes with implication to religion, social and political associations. If the matter is related to the *ecology* factor, students are taught to bear in mind that their project should indicate how to *preserve* (keep save from harm or danger), and to *conserve* (keep from change, loss or destruction) our environment. If the *economy* factor is being studied, students should show awareness about the manufacturing *cost* (the prices to be paid for producing a good) and material culture *value* (quality of being useful or desirable in an industrial product). The same procedure should be adopted to the other three Redig projectual factors, say: *ergonomics*, *technology* and *perception*.



1. Anthropology (human cultural **ideas** / **behaviours**)
2. Ecology (environmental **preservation** / **conservation**)
3, Economy (manufacture **cost** / material culture **value**)
4. Ergonomics (human **adaptability** / **comfort**)
5. Geometry (geometric **synthesis** / **coherence**)
6. Marketing (product **price** / **promotion**)
7. Philosophy (**aesthetics** and **ethics**)
8. Psychology (human **perception** / **creativity**)
9. Technology (production **materials** / **processes**).

Figure 4. The nine projectual design factors

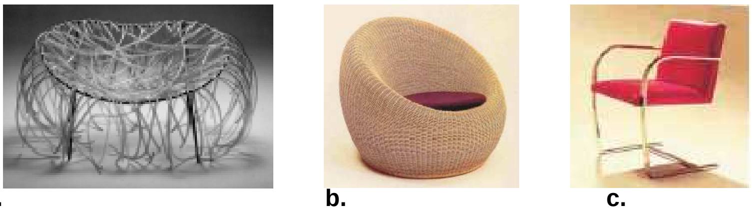
We found it necessary, however, to adapt some of the projectual factors proposed by Dreyfuss, Pye and Redig. For example, "appearance" initially associated to *aesthetics*, was put together with *ethics* to ensue a new projectual factor called *Philosophy*. Redig's projectual factor "*perception*" together with "creativity" was placed into a wider category named *Psychology*. *Marketing* was added as a factor with the intention to let it clearer that, although market issues are often influential to industrial design process, Marketing is not Industrial Design. It is recommended that students investigate why competing products' have different *prices* (sum of money for which something is to be sold or bought), why the investment and the quality of *promotional* advertising campaign vary from one place to other and from one country to another. Research should be carried out based on the 4P from the Marketing Mix (Price, Promotion, Product, and Place).

The inclusion of the *Geometry* factor was also considered pertinent. We wonder if the classical authors did not let it explicit because in earlier times knowledge about geometry was inherent to the background of genuine industrial designers. Today, the computer generated images and products give the students the illusion of an absence of geometry. However, an even more complex geometry is behind curves and curls. The higher the technology the more geometry lay behind industrial aesthetics (Elam, 2001, 2004; Moles, 2001). It will be always important to know, therefore, how to confer formal *order* and coherent functional an informational *arrange* to the design synthesis (Mayall, 1979). So, Redig's six and Archer's nine projectual factors were adapted and added to eighteen sub factors:

Teaching Technique – Exercise 1: levels of order towards the arrangement of factors

After the presentation of the nine projectual factors it is necessary that students understand questions related to industrial product taxonomy. That would permit them: (**1**) to define the product design formal approach (if design is based on handicraft, artistic or industrial aesthetics); (**2**) to acquire a wider product *functional* lexical (necessary to develop the vocabulary of the design language and understand the links between industrial products in their universe of creative possibilities); (**3**) to evaluate the hierarchy of the projectual factors in a specific industrial product design. For the first situation – classification of form by its aesthetical approach –, it is suggested that students start a survey at the Internet or in books (cf. Tambini, 1990) to understand and group handicraft, artistic and industrial products, using as analogy the same criteria defined by Ravi Poovaiah (1986:14-20), who considers that if a graphic form shows excess of details we have a "low graphic order". In opposition, if a graphic form is depicted basically in its configuration lines and planes, what we have is an element of "high geometric order" (Figure 5).

Artefact design



a. b. c.

Graphic design

a. b. c.

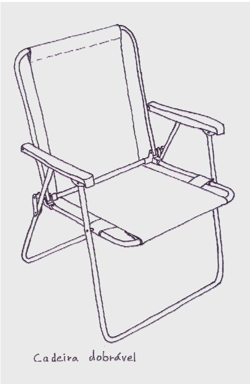
Fashion design

a. b. c.

Figure 5. Low, medium and high geometrical order in artistic, craft and industrial aesthetics.

Teaching Technique – Exercise 2: product design taxonomy for understanding factors

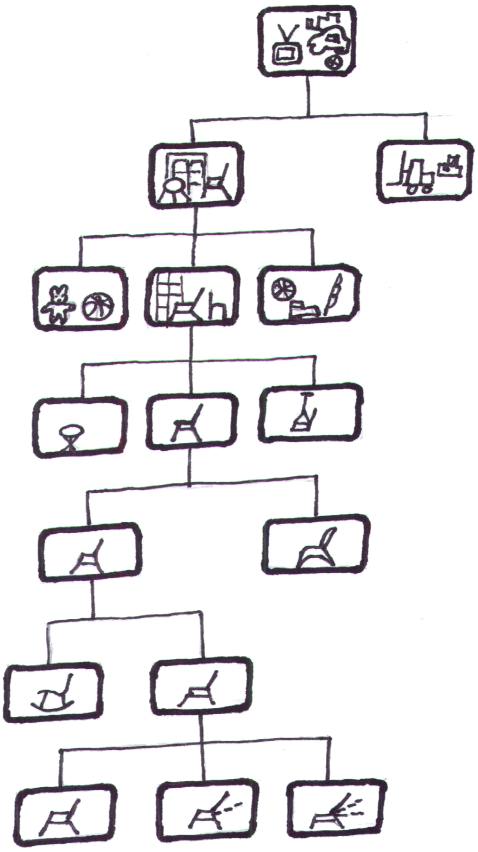
After having understood and defined part of the philosophical and geometrical factors of an industrial product category, the student is taught to make a taxonomy of products related to that one which is being designed. If Ravi Poovaiah and Abraham Moles were bibliographical sources for the first exercise, Lineu's animal kingdom taxonomy, is the inspiration for the second exercise. Figure 6 is an illustration from a work developed at the post-graduation course. Taking the case of the folding chair, the exercise consisted of taking a picture of an analogous product, drawing out its lines, and making two different tables to classify the product *verbally* and *visually* (Figure 6).



1. Category:	Service, Capital, **Consumer Goods**
2. Finality:	**Leisure chair /** Labour chair
3. Group:	Ludic / **Resting and Socialization** / Sports
4. Type:	Seats without backs / **Seats with backs** / Suspended seats
5.Structure:	**Metal** / Wood
6.Particularity:	Rocking chair / **Folding chair**
7.Features:	**One position** / Two positions / Multi positions

6a. Basic lines of the chair

6 b. Table with the main verbal characteristics



6c. Diagrama with a schematic range of products features

The objective here is to increase the visual vocabulary of the students helping them to memorize the features of some similar products and identifying their weak and the strong design aspects (Fig. 6a). The second step is trace a line connecting the words describing the main product characteristics in order to express verbally the initial and final projectual situations (Fig. 6b). Third step is to relate other products aiming at discovering formal, functional and informational connections (Fig.6c).

It is worth to remember that preparatory exercises allow students to place themselves more comfortably before the projectual experience. Letting students find by themselves in their way of developing an industrial product can be frustrating and unproductive in terms of vocational education. Actually, paternalisms aside, if design students are let alone, acting like “artists”, mainly in the design of a product based in the industrial aesthetics, failure is inevitable: in the process towards the creation of a product with *industriosity* and *industriality,* industrial design background references are needed.

The vocational aspects of the industrial design education should be constantly pointed out. If not, there will be more than desirable chances to get students mood indifferent in the creative process. Industrial designers behaving, *a priori*, like artists, is something quite difficult to understand but, at least in Brazil, very common.

Teaching Technique – Exercise 3: Product industrial design factors hierarchy and attributes

The third and most productive exercise towards the understanding of the nine projectual factors is presented in Figure 7. It enables industrial design student to visualise the factors phonographically (words) and iconographically (figures), considering the hierarchy among each of its attributes and of the general features of the product. The visualisation of the projectual factors hierarchy and the product design attributes were previously represented by a pie graph, as suggested by Bomfim et al. (1977, p.40), or in bars graphs as suggested by Gallina (2004). In both cases, however, the graphs represented abstract data but did not stimulate the production of iconographic representation. This third exercise includes, then, the diagram of the hierarchy of the projectual factors as well as the schema of the attributes that need attention. That facilitates the choice of more appropriate methodology to help and guide the creative and design processes.

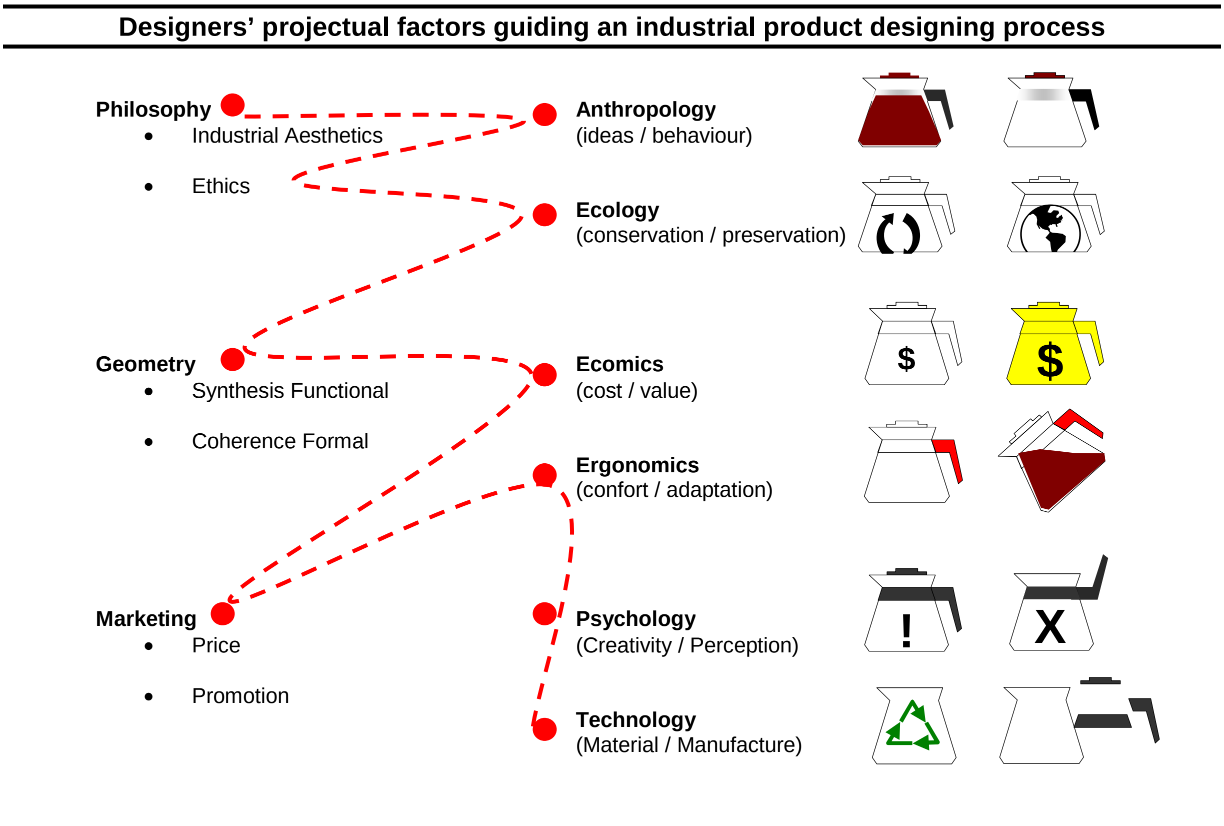


Figure 7. Diagram and schema showing hierarchy and relationship among factors, and product attributes.

The example illustrated in Figure 7 shows the case of the project of a coffeepot. In Brazil, most of the urban population filters coffee drink in thermal flasks or in glass pots. The same coffeepot should never be filled with other drinks because coffee leaves a dark stain in the glass, and a peculiar smell. A design requirement to increase sales led students to the idea of using the same mould to get the ***form*** in glass, but diversifying its ***function***. The ***information*** about the new functions would be suggested by colour of the plastic handle and top. Other drinks, like orange juice, milk, tea and water, could, finally, share the same table with coffee, in similar glass pots, each one poured into the respective container identified by a coloured handle. The glass pot was designed according to the projectual factors, as described below:

1. **Philosophy factor**: the glass pot should follow the principles of *industrial aesthetics*, i.e. without handicraft work for finishing or decoration; and *marketing centred ethics*, due to the intention of the manufacture company to raise sales by given different uses for the same product.

2. **Geometry factor**: Once defined that the glass pot must be designed according to the principles of the *industrial aesthetics*, its geometry must be harmonic, showing visual *order* and defined with the simplest lines and forms and indicating *coherence* between its parts, components and elements.

3. **Marketing factor**: The glass pot must have its *price* at the same level of its competitors. Its *promotional* and advertising campaign should focus on diversity of colour and multiple functionalities. The simplicity of the design should be pointed out.

4. **Anthropology factor**. The design of the product and of its interchangeable parts, components and elements should reinforce the *idea* about the taste quality of some drinks and, therefore, *behaviour*: prevention of using the same glass pot for different sort of drinks.

5. **Ecology factor**. All the materials applied in the manufacture process of the product should be environmentally friend and recyclable. It is possible to use compound materials, always identified in their life cycle and impact on the *preservation* of the Nature.

6. **Economic factor**. The product design itself should guarantee its increasing value throughout the times (in some cases of industrial design the simplification of form increases the value, e.g. IPod). The cost of production should not be altered with training of staff or acquisition of new tools.

7. **Ergonomics factor**. The design of the product should indicate the quality of the product in use (how it is adequate) and adaptability to the variety of sizes of human hand, protecting it from being burnt. It could also indicate visually and by touch the volumes (1litre, ½ litre, ¼ litre).

8. **Psychology factor**. Perceptively the product design should never confuse the user: every person should understand where to pour liquid into the glass pot, how to handle it, how to use the top and so on. No tricks! Creatively, the isometric and homeometric symmetry principles were suggested.

9. **Technology factor**. The main material is glass – a hard, brittle, noncrystalline, more or less transparent substance produced by fusion of dissolved silica and silicates that also contain soda and lime, etc.; and the process is the glass blowing, i.e., process of forming or shaping a mass of molten or heat-softened into ware by blowing air into it through a tube.

It is recommended that students, after those three exercices to select and identify projectual factors, follow the Gui Bonsiepe's industrial design methodology (1978/1984), and Mike Baxter (1984) and Christopher Jones books which show useful different procedures and techniques of product design. These works can help the creative and design processes in their initial and final situations, orienting the use of analytical design and linguistics techniques: morphological, structural and functional; denotative / connotative; diachronic / synchronic; paradigmatic / sintagmatic.

After the application of those technical analyses it is possible to re-define or refine the objectives of the project and, then, applying the basic creative techniques accordingly to the complexity of product projectual situation. If, for instance, an industrial product design has its initial and final situations well-defined it is suggested to use alone or combined the following creative techniques: *Attribute listing* (Crawford, 1954); *Brainstorming* (Osborn, 1957); *Synectics* (Gordon, 1961); *Morphological Box* (Zwicky, 1947).

Final remarks

We end this paper emphasising the necessity of industrial design teachers, in Brazil and in countries with peripheral economies, to start a review of design education principles related to industrial design teaching. It is not productive to let industrial design students by themselves, alone, like artist-designers, searching by trial and error their creative paths towards a new product. Industrial designers, nowadays, have a profession that needs adult pedagogical foundation, industrial technical basis and, more than ever, a creative expertise to cope with a situation in which, around the world, the designer can have so heterogeneous backgrounds. With no planned creativity and projectual knowledge, the industrial product designer is likely to fail. The use of the notion of projectual factors has helped us to return to a profession by which it is possible to preview, foresee, project by means of design, and cope more actively with successful creative art.

This article is about the use of nine projectual factors as a method of teaching industrial design. In order to support this point, a review of the theory background towards taxonomy of projectual factors was made. We started with the theoretical structures which help the foundation of some design education principles and presented some teaching techniques for product development in Industrial Design courses. Classic books related to industrial product design were mentioned as sources for a reorganization of definitions. That has helped our students to reach a better identification of projectual priorities and hierarchies of elements that interfere in the creative directions when learning how to design a new industrial product.

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CURRICULUM VITAE

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