Industrial design and innovation

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Abstract: An evaluation of industrial design education in Brazil as seen by industrialists is presented. This evaluation is part of a survey conducted among industrial design teachers, industrialists, and design professionals who are independent or employed in government research organisations. The performance of newly graduated industrial designers (NGD) working for companies concerning development of projects and processes which innovate and differentiate these industries from their competitors was studied. The relationship between industrial design and innovation, characterizing the activity, the required skills and abilities of professionals, and its possible contribution to bring Brazil into an innovative economy is discussed. The objective is to gather information that might contribute to improving the quality of design education and come closer to those who order and make designs. The results suggest that design education must be reviewed and analyzed in more depth and that industrial concerns are not always aware of design.
Keywords: industrial design, innovation, design education, designer.

1. Introduction

The objective of this article is to compare industrial design education, as provided by university courses, with the needs of industrial enterprises. The aim is to find what happens when a designer is called to work in the development of a product or service, difficulties faced and the deficiencies in his education. This should lead to a broader knowledge on the subject and allow actions to be implemented. A survey was made, in which some industrial concerns representatives were consulted. The approach adopted was reading and interpreting of the reality presented.

The work of the industrial designer was considered, specifically that of the product designer who works in/for industries, in the development of products/processes that lead to innovation and differentiation from competitors. Thus, Section 2 of this paper approaches the area of design, characterizes the activity and the professional, describes the industrial designers' education and establishes the relation between design and innovation. Section 3 describes the Brazilian and international industrial contexts on what refers to innovation. Section 4 presents the survey made in firms and compares some of the information obtained with the theoretical support to the survey. Section 5, finally, presents the conclusions and considerations.

2. Design

2.1. Design and the designer

According to the ICSID - International Council of Societies of Industrial Design Definition (2004), "design is a creative activity whose aim is to establish the multi-faceted qualities of objects, processes, services and their systems in whole life-cycles". ICSID considers design as the "central factor of the innovative humanization of technologies and the crucial factor of cultural and economic exchange." Accordingly, it is the role of the designer to seek, discover and assess structural, organizational, functional, expressive and economic relationships that propitiate global, social, and cultural ethics. These involve the concern with global sustainability and environment protection; with benefits and freedom for all human beings indistinctively; with cultural diversity, despite of the globalization.

Designers find opportunities in creative industries, which include adverting, architecture, arts, crafts, design, film and video, interactive leisure, software, music, performing arts, publishing, software and computer services, TV and radio (DESIGN, 2006).

There are various possibilities for work in design consulting firms (external design) or in firms (internal

design). Designers can be hired with a contract, receive for projects, work for a monthly fee, receive royalties for the projects they develop or, even, establish mixed forms of payment for their work. They can work by themselves, be part of a design team, or associate or head of a design office.

2.2. Education

Bachelors' degree in industrial design has been available in Brazil, at the Escola Superior de Desenho Industrial - ESDI, since 1962, in Rio de Janeiro. Graduate courses, lato and stricto sensu, leading to masters and doctors degrees are also available in a few schools.

Several specializations and possibilities are offered by many schools: product industrial/design, product development, product project, visual programming, visual communication, interface design, fashion/clothes design, interior design, landscaping, design management. Some of them have emphasis on tourism and hotel management, ceramic design, textile design, digital design, new technologies in publishing design, package design, electronic media, equipment design, ergonomics, shoes and accessories design, style and design (fashion), ecodesign, surface design, furniture design ministry of education internet site (BRASIL, 2006).

Design education is regulated by the law 9394, December 1996 - LDBEN - Lei de diretrizes e bases da educação nacional (BRASIL, 1996a); and by the resolution CNE/CES (Conselho Nacional de Educação/Câmara de Educação Superior) 5/2004, march 2004, which approves the national curricular rules (BRASIL, 2004a).

2.3. Technological innovation and design

WALSH (1996) analyses the role of design from different perspectives - economic, sociological and management - and reaches the conclusion that what the firms expectations from design varies very much, in the same way that varies the place of design in the manufacturing companies' hierarchy as well as the attitudes and strategies towards design. Thus, different people within and outside the firm - the designers themselves, marketing managers, consumers - all have different views on design. It is a common fact that firms do not hire designers, even when their products by their nature require the work of a designer.

The author associates design to innovation, as it aims to relate the hardware to the dimensions, instinctive responses and emotional needs of the user, but notes that some new products are designed but involve no technological change. Strategic management may see the function of design as adding value, increasing production efficiency in use of materials and energy, and generating increased profits. Industrial design, therefore, is important both in developing the form of an innovative product, and in designing products that are new but do not involve new technology.

WALSH (1996) acknowledges in the life cycle of an industry or technology three phases that involve design, from an early period primarily of designing for experimentation and technological innovation, to one where designing for technical improvement, lower costs and ease of manufacture becomes more important, and finally a mature phase where a multiplicity of design variations, fashions, styles and re-designs within product ranges aimed at different market segments predominates.

In the second phase design goes from a basic idea to an original technological innovation. In the third phase design can, eventually, result in additional product innovation, in the emergence of a dominant design and families of design variant. Thus, design is crucial to innovation, but it is also important in competitivity (price, efficient use of materials, simplification of manufacture), in the differentiation and safety of products.

WALSH (1996) points out that, outside the firms, the designer deals with trends in consumers' behavior and patterns of demand, among other subjects while, inside the firms, he deals with technical possibilities, market demand and opportunities and accesses other areas such as R&D (research and development), marketing, production, finance and materials testing.

3. The industrial context

Product development and management association (PDMA, 2006) - acts mainly in the United States and Canada and for 30 years has been offering resources for the development, information, collaboration and professional promotion for the management of new products. The reports on their researches best practices allow an understanding of the industry situation in developed countries and how the questions relating to innovation are dealt with.

Two studies provide an economic and social profile of Brazilian production as a whole. RESENDE & TAFNER (2005) deal with development and social inclusion in Brazil, now and in the future. Chapter 2 discusses innovation and competition, and brings enough information to define the position of brazilian industry in relation to other countries. IBGE's industrial research of technological innovation - pesquisa industrial de inovação tecnológica - PINTEC (2005), published with the support of the financiadora de estudos e projetos - FINEP and of the Ministério de Ciência e Tecnologia, aims to establish national and regional indicators of technological innovation in the brazilian industrial companies employing ten or more people.

3.1. Situation in developed countries

GRIFFIN (1997) presents the results found in different surveys about the best practices in the development of new products new product development (NPD) from the first one, in 1968 until 1995, the most recent one. Following

these, it can be noticed the changes in practices along the time, the complexity of the aspects involved and the amount of knowledge needed. This author observes that the firms work in dynamic competitive environments that make the processes of management also dynamic, preserving the efficacy and the profits. NPD can be affected by some changes in businesses, noticed until the mid 90s such as growth at the level of competition (more firms competing for the same markets), quick changes in the market environment, higher rates of technical obsolescence and shorter product life cycle.

The first survey on NPD practices made by Booz, Allen and Hamilton (BAH) dates for 1968. In 1982 they made a new survey. In 1990 PDMA made, among its members, its first study of product development practices.

Other surveys about best practices were made in different firms, in the first half of the 90s. The results vary a lot, and the findings, interesting. One of the surveys notices the geographic question - japanese firms developing new products in completely different ways from the USA firms. In another survey, the subject of success was the focus - the more successful firms using NPD to obtain or maintain competitive advantages, to fill in a growing gap, to stop erosion of the profit margin, to use a new technology; and the less successful firms using NPD to keep or attract clients. Still in another survey, the practices of products development are associated to NPD performance, which is defined as a combination of self-assessments of cycle time, innovativeness, success rate and revenue contribution.

In 1995 PDMA made its second survey of best practices in product development. This research combined items of several former researches and had as objective to determine the present stage of performance and practices of product development, to understand how product development changed along the time; to determine if there were differences in practices or performance of NPD among the industrial segments and search of tools that make the difference in product development.

The research was sent to more than 14,500 potential respondents (only North-Americans) and had a total amount of answers low for this kind of research: 2.7%. It allowed the conclusion that there is not a sole and best way to organize NPD, and brought to light the following main data:

- the implementation of the processes distinguishes 'best practices' firms and 'the rest of the firms', and makes the distinction between service and production of manufactured goods;
- best practice firms correspond to only 22% of the total, and their success comes from the extended or better use of several effective and simultaneous NPD practices. These companies expect almost half of their sales to come from products commercialized in the last three years;
- more than 84% of the most innovative projects used multifunctional teams;
- in 1968 the products development mortality curve showed that, on average, 58 ideas were considered for every new product successfully commercialized; in 1995 it takes 6.6 ideas to generate one success. Firms are more efficient in weeding out less probable projects earlier in the NPD process; and
- NPD cycle times, which in 1990 was an average of 23.8 months for more innovative projects, down approximately 1/3 in 1995.

3.2. Situation in Brazil

In RESENDE & TAFNER (2005) study, the favorable situation to technological innovation is well defined. Innovative economies create new products and/or processes for the world market, while imitative economies absorb and improve innovations created in other economies. The higher the technological intensity, the larger the growth in exports while, the lower the technological intensity, the more mature is the product, more consolidated are the technologies and lower are the opportunities for new developments. Brazil needs a technological active learning strategy, which consists of absorbing and mastering advanced technologies, overcoming imitation, decreasing the technological gaps and increasing productivity. Japan is an example of this strategic implementation which led the country into a really innovative economy.

In what concerns scientific production it happens that patents and brands granted to brazilians in the United States are still few. The number of scientific papers published by Brazilians in international scientific journals, as well as the number of brazilian M.Sc. and Ph.D. and D.Sc. has been increasing; however, the majority of this highly prepared group works in universities. It is a potential not yet much exploited in the brazilian innovation process.

The innovation law - Lei de inovação - nº 10.973 (BRASIL, 2004b) intends to approximate firms, universities and research organizations in order to promote innovation and technological learning. It aims at extending research into the firms. This law foresees and favors, among other things, the establishment of alliances, strategies, cooperation projects, technological entrepreneurial actions, sharing of laboratories, equipments etc.

Innovation in products brings the firms larger gains. Innovation in processes must be meaningful to the utility and quality of the product.

Some indicators of the brazilian industry:

- the innovation rate in brazilian firms with more than ten employees is 31.5%, which is considered low. The quality of the innovation is also low. Only 4.1% innovate in products and 2.8% innovate in processes;

- from the 72 thousand brazilian firms with more than ten employees, only 1.7% innovates and differentiates products (1224 companies). The great majority do not differentiate their products and have lower productivity, and therefore do not get significant benefits from innovation; they are scattered all over the national territory and are relevant only in job offering; and
- 70.6% of the brazilian firms that innovated and differentiated their products also innovated in the production process. Of those, 35.7% innovated processes. That indicates that, in this case, the creation of new products implies in innovation in processes (RESENDE & TAFNER, 2005).

Firms that innovate and differentiate products have average higher revenues. On the average export much more than others and their insertion in the international commerce is differentiated: they are more competitive. The average wages of the people employed is higher, their average educational level is much higher, and stay longer in the firm. Summing up, the strategy based on product innovation and differentiation proves to be socially inclusive.

In geographic terms, brazilian industry as a whole, and also those that innovate and differentiate products, concentrate mainly in São Paulo, Rio de Janeiro, Porto Alegre, Belo Horizonte, Curitiba, Salvador, Vitória, Fortaleza and Recife (always at a main municipal districts and its neighborhoods). In terms of obstacles to the innovation efforts mentioned in the survey, all include "economic risk", "high costs", and "lack of adequate financial support". It is important to notice that, in Brazil, government financial support is directed more towards acquisition of equipment and to innovation of process than to product innovation.

4. Survey at the companies

The main driver of the survey was the absence (or insufficiency) of answers to many crucial questions, such as: Where/how students look for jobs after graduation? How do they present themselves to potential employers? Are they aware of their competence? Do they know how to formulate concepts? Are they able to solve problems? Are their actions effective? Do they communicate in an adequate manner? Do they know how to learn, listen, and consider? Do they have adequate technical knowledge?

The working hypothesis in this study is that the training currently offered to the future designers is not adequate: it does not provide them with appropriate conditions for professional life; the newly graduated designers (NGD) work, as a whole, is not considered very satisfactory by those who hire their services; and does not contribute to improve people's lives.

4.1. Description

The theoretical referential basis to this work has provided a map of the main aspects to be pursued in the interviews and guided the selection of the questions, particularly those related to the designers education, to the design activity and to design professionals.

Interviews were made with representatives of industrial firms in the states of Rio de Janeiro, São Paulo and Paraná, and the answers were analyzed. On the whole there were 10 interviews in transformation industries - section D of the classificação nacional de atividades econômicas (CNAE) - all medium or large firms with at least 150 employees. The universe of these firms includes from the most simple to the multinational leaders in their segments (Table 1). The number of interviews is compatible with the number used in other kinds of research, such a delphi technique, for example.

In selecting the interviewees the relation of the firm and its products with the activity of design, the adequacy of the function of the interviewees (knowledge of production and market roles, direct relation with in-house or consultant designers and economic view of the process), their personal competence, knowledge and perception for the verification of the hypothesis of this study was considered.

Table 1. General overview of the interviewed firms.

CNAE group	Local (city, state)	Main products	In charge of design
29	Rio de Janeiro, RJ	Bathroom and kitchen metals	Board + engineer + employees
29	Rio de Janeiro, RJ	bathroom and kitchen metals	Board + technician
28	Nova Friburgo, RJ	Hardware, locks	External design
28	Nova Friburgo, RJ	Hardware, locks	Board + technician
31	São José dos Pinhais, PR	House appliances	In-house design
31	São Paulo, SP	House appliances	In-house design
31	São Paulo, SP	Lighting	In-house design
35	Queimados, RJ	Boats	Board + hired firm
36	Rio de Janeiro, RJ	Furniture	In-house design
32	Rio de Janeiro, RJ	Electronic appliances	In-house design

Among the industrial interviewees only one had technical level education and the other nine, university level. From these, 1 was a manager, 1 system analyst, 3 engineers and 4 industrial designers. From those of university level, 5 were nearer to the design activity, either by education (3 designers), or by teaching experience in design courses (1 designer/ex-professor and 1 engineer/professor). Four of the interviewees had graduate courses (*lato sensu* or M. Sc.). All studied in Brazil (Figure 1).

The professional experience of the interviewees ranged from 9 to 30 years. 7 of the interviewees had experience in supervision, management or even company presidency, ranging from 2 to 9 years; one of them has owned his company for 20 years (Figure 2).

It is assumed, consequently, that the answers given by the interviewees are adequate to bring to light the discussion about industrial designers' education and their possibility of getting jobs.

4.2. Characteristics of the firms

Evaluating the production of the industries they represented the interviewees answered to a list of questions in which they were encouraged to elaborate. 70% of the interviewees recognized that they had little strategic planning; 60% thought that they recognized the necessity of design and that they knew the consumers well; 90% thought they knew very well the clients and competitors; 80% thought that they knew the suppliers (Figure 3). It seems a contradictory that companies that admit to have, in their majority, little strategic planning, on the one hand, to be capable of recognizing the needs for design, on the other hand; or even consider that they knew very well their consumers, their clients, their suppliers and their competitors.

Still evaluating the production, 90% of the interviewees declared that the processes in their companies are clearly defined, but only 60% of them stated that there is a "quality manual" - and here it seems to lay another inconsistency.

In regard to industrial property, 90% of the interviewees confirmed that they have patents and trademarks. Industrial property is one of the protection methods used by the firms to guarantee the property of innovation results. PINTEC revealed that the most used competitive tool in the dispute and protection of markets is the brand that emphasizes registration of trademarks. Secondly, comes industrial secret. Patents and industrial designs, altogether, come as the third type of mechanism of protection most used in medium and small enterprises, but firms with 100 or more workers patents and registers are the second most used practice, or the industrial secret is equally important. It can be inferred, therefore, from PINTEC data, that the interviewees refer in their answers more probably to trademarks - with the exception of the firms leaders in their segments, multinationals, which have patents.

As to R&D, 90% declare that they have in-house research and development. Internal R&D activities include creative and systematic activities, which aim at increasing knowledge and permitting their use in new applications,

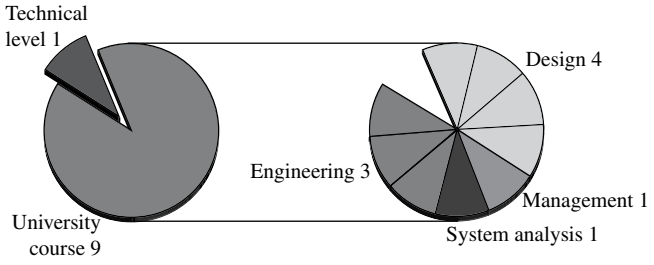

Figure 1. Level of education and area of instruction of the interviewees.

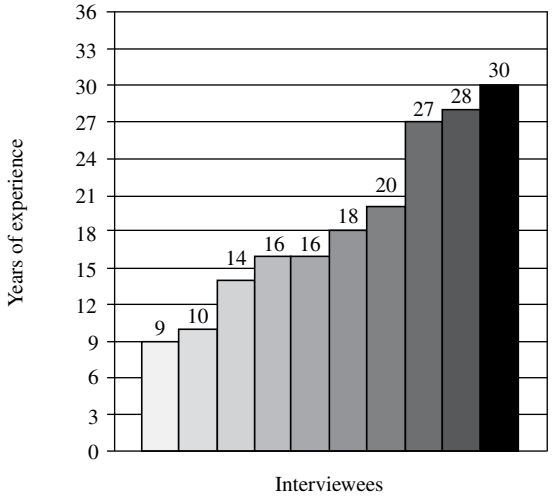

Figure 2. Professional experience of the interviewees.

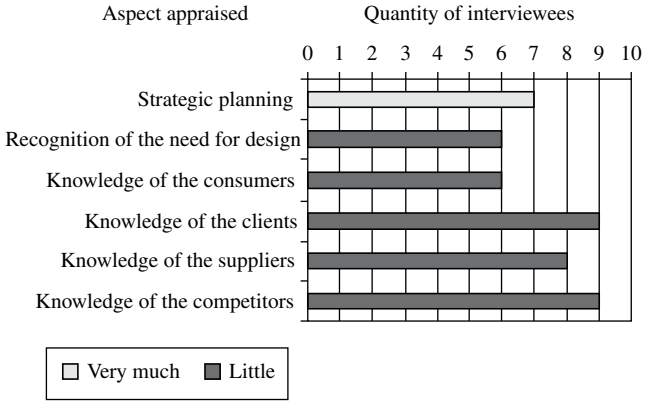

Figure 3. Opinion/perception of the interviewees about some questions related to production

such as new or technically improved products and processes; PINTEC revealed that the number of firms that have internal R&D activities is decreasing, although some firms have been spending more with internal R&D.

When discussing how they differ in relation from competitors, two interviewees mentioned design explicitly, while other three mentioned the characteristics of a good design: "finishing touch and durability", "product innovation", "the product more rational/practical/usable/ with better cost benefit (…) we offer more for what the consumer pays". Therefore, half of the interviewees consider design as a differential in relation to competitors.

Characterizing their sources of design information, 18% of the answers pointed to visits to fairs, 15%, journals, 13%, internet research, 10% research on other segments not their own, 8% study of the competitors (Figure 4). The remaining answers (others) pointed to consulting catalogues, consumers, the market (2% each), workshops, books and clients (1% each). Only one of the interviewees did not know what to answer.

According to the PINTEC report, the most mentioned and valued sources of information remain the internal area of the firms (their own experience), suppliers, fairs and exhibitions, clients or competitors, and what is learned and researched in the internet, in lectures, meetings and specialized publications.

In the ways of acquisition of design the following modalities stand out: on the one hand development by in-house designer or team, and the corporative development in the leader firms in their segments (44% of the answers); the development by a consultant designer or consultant design firms (19% of the answers), on the other hand. A third possibility is the joint development with firms of other segments - for example, of electronics (13% of the answers). The other forms of acquisition of design (others) point out contests, partnerships to enhance and stimulate creativity, the firm owner making the design himself, or the owner with the team of technicians and engineers (6% of the answers each). In one of the firms where the design is developed by the board of directors out two experiences of hiring external designers were mentioned and evaluated as good: "the directors of the firm left behind certain bad habits" according to the interviewee. One of the interviewees did not know what to answer (Figure 5).

As to how design is hired or negotiated, only 4 of the interviewees answered. Two of the firms hire by project; the other two firms, by royalties. One of them, leader in its segment, has a contest in global scale.

From all the interviewees, 90% declared that products launched or reformulated in the last two years were internally developed.

The innovative activities related to launching or reformulating products in the last two years (Figure 6) happened in 6 of the firms, according to the interviewees that pointed out design - including safety, usability, interaction with the consumer (45% of the answers). The other answers mentioned: new market segments, new system, new component, new line in the processes, in technology, in production (8% of the answers each).

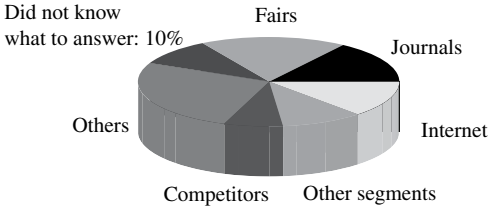

Figure 4. Sources of information.

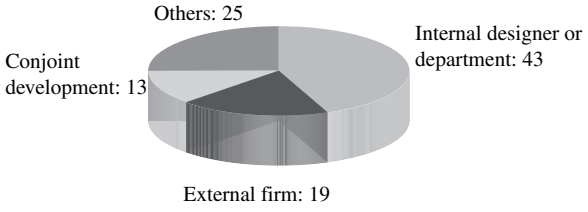

Figure 5. Acquisition of design (%).

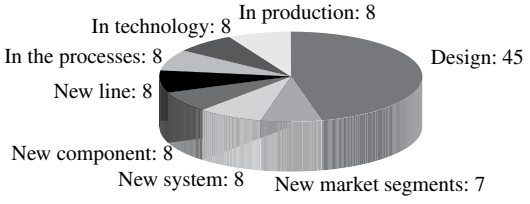

Figure 6. Innovative activities in the last 2 years (%).

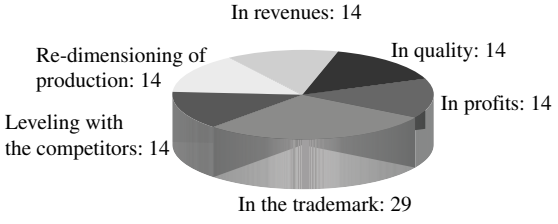

Figure 7. Impact of innovative activities (%).

The impact of the innovative activities (Figure 7) was mentioned by 6 of the interviewees on the trademark (28% of the answers in the leading companies in their segments). The other answers were leveling with the competitors, re-dimensioning of production revenues, quality, profit (14% of the answers each).

PINTEC tries to identify the impacts associated to product, market, process, aspects related to environment, health, and safety and conformity to rules and norms. According to the PINTEC report, the impacts of the innovative activities are the improvement of the quality of the products, the factors associated to the position of the company in the market, and the factors associated to the process and the flexibility of production.

4.3. Knowledge of the interviewees

The interviewees were asked their view about the meaning of design was and what a designer is - open questions, allowing the interviewee freedom to answer as he thought best. The answers can be organized into two different groups. Five of the interviewees with education in design or teaching activity in design courses, characterized by broad views, proximity or contextualization, and the group of the other 5 interviewees, characterized by partiality, lack of knowledge, or lack of realism.

In the first group the interviewees considered design as an activity related to the development of more humanized products that comply with the needs and improve people's lives; or a strategic tool for differentiation from competitors, add value to the product and win a market share. They also mention articulation of different concepts such as use, production, manufacture, safety, etc., more to the designer's point of view.

This first group stressed, among others, the following attributes in the designer qualities: technical knowledge, aesthetic sensibility; the capacity to make good products possible, launch tendencies, add value to the trademark, turn non-determined situations into determined situations; ergonomic, functional and production aspects; ability to articulate the different professionals involved. Strange as it may seem, one of the interviewees stated that the designer does not need, necessarily, to have formal education in design, but the attitude.

The second group of the interviewees expressed their views on design exclusively as an attractor for the consumers; or showed their lack of familiarity with the concept of design; they even admitted the design potential and virtues but hope that it does not give too much labor or increase costs; or hope that it increases sales and promotes business. This second group sees the designer as capable of analyzing the market and brings success to the company.

FERROLI et al. (2003) point to the lack of preparation of great part of brazilian firms to face international competition, due to the long period in which they were helped by the governmental protectionism. When investing in design these firms do not know how to act and face difficulties of several kinds; they take design for style, do not understand what contribution design can bring to products and to the firm, and leave concerns with quality, among other mistakes, to the end of the production process.

The interviewees' answers confirm that, even in the industries in which the nature of the product demands design, still a considerable part of the entrepreneurs do not understand the meaning of the activity, the real benefits it can bring and ignore the whole potential of a designer's contribution.

4.4. Newly graduated designers (NGD)

Figure 8 shows selected interviewees' perception of the quality of design education. Twenty nine types of design knowledge or abilities were presented, organized in six areas - communication and expression, management, marketing, technical, production/distribution, others - stated as excellent, good, fair, bad, extremely bad.

In Figure 8 it can be seen that to half of the industrials interviewed, the newly graduated designers (NGD) have average knowledge of tendencies. WALSH (1996)

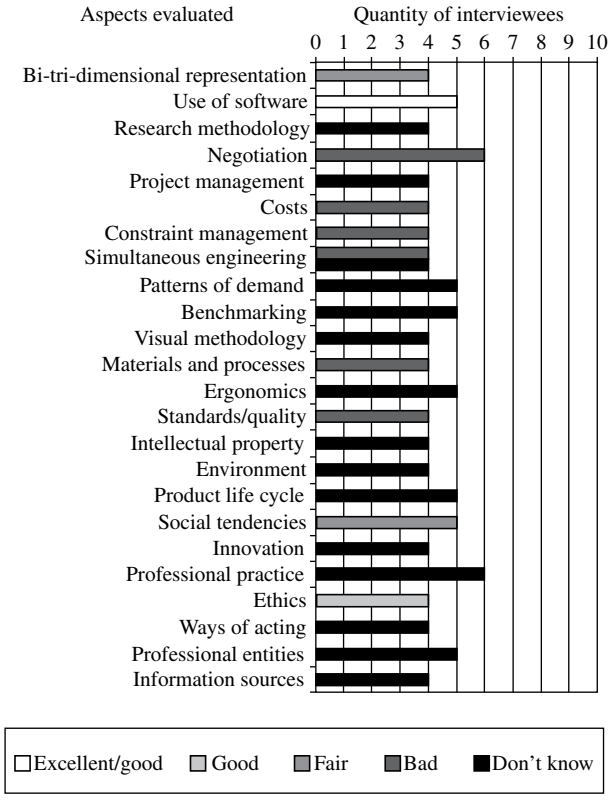

Figure 8. Opinion/perception of the interviewees about the quality of designer's education

describes the designer as an intermediary between the sets of professionals inside and outside the firm. He contributes to the innovation process outside R&D, through the marketing of new product (via packaging, brochure, manual and advertising design and corporate identity) and the design of the process, layout and sequencing of tasks for the production of the new product. To this author, therefore, to increase innovation's value implies in that the professional of design have the capacity to analyze reality and to articulate with several different instances, aiming at developing innovative projects. From this point of view the knowledge that the designer has of tendencies must be at least good, not just fair.

Still in Figure 8 it can be seen that to 60% of the interviewees, NGD do not have negotiation ability. To prepare traditional firm executives to deal with the design management seems to be a hard task, as suggests GORB (1987), especially when they are older people, who must overcome educational and cultural barriers. On the other hand, to prepare designers for management implies in giving them the instruments with the terminology, and at least some basic norms and values of the business world in which they will have to work. This is something in which they are simply not interested. Besides, design constitutes the process that relates the company to the consumer.

Forty percent of the industrials placed as fair the NGD knowledge of bi and tri-dimensional representation; and as bad their knowledge of materials and processes, costs, and management of constraints (Figure 8). The DCN - diretrizes curriculares nacionais (**national curricula directives**) of graduation in design establishes that the course must develop the capacity to express concepts and solutions with different techniques of visual expression and reproduction, to provide knowledge of the production sector of the specialization chosen by the student and to provide a deep knowledge of production management, including quality, productivity, factory physical layout, inventory, among other aspects (art. 4th., II - VI - VII).

Forty percent of these industrials stated as bad the NGD knowledge of simultaneous engineering, and other 40% did not know what to answer (Figure 8). Simultaneous engineering is made possible when the project is developed by multifunctional teams using software in integration and decision making. Therefore, it is convenient that the NGD designer be aware of simultaneous engineering and familiar with the resources needed to its implementation.

To 40% of these industrials, NGD have bad knowledge of standards/ quality (Figure 8).

NGD were seen as excellent and as good (together) by an equal or larger number of the interviewed industrials, in the use of software. And were considered as good in ethics by 40% of those industrials (Figure 8).

Half of these industrials ignore what knowledge NGD have of: patterns of demand, benchmarking, ergonomics, product life cycle, professional entities. 60% of the interviewees have no idea of how NGD are prepared to act professionally and 40% of the interviewees do not know what are the abilities of NGD of research methodology, project management, visual methodology, intellectual property, environment, innovation, possibilities/ways of acting and information sources (Figure 8).

In a research made for his PhD thesis, BARBOSA (2003) confirms the insufficiency of knowledge about environment in the designers' education, placing the lack of ecological knowledge of the product designers as one of the specific difficulties when thinking of sustainability.

The opinion/perception of the interviewees about the quality of designers' education, in synthesis, is restricted to the range of aspects they know, and at this level the opinion/perception is strongly concentrated on the range of degrees that goes from bad to fair. On the other hand, the interviewees showed not to know well these professionals, as almost half of the aspects evaluated received a 'do not know" as an answer.

Some other questions, equally related to the quality of designer's education, contribute to situate them in the political, public and economic context of their area of work. These questions are as important as those already presented in Figure 8; therefore, designers are supposed to understand them. Figure 9 presents the more significant results found when the interviewees gave their opinion/perception of the understanding that NGD have of those questions. Eleven questions were presented, and the interviewees' answers classify them between excellent, good, fair, bad and extremely bad. From these only 6 had answers with the concentration of 4 or more interviewees at the same level, and 2 had answers with concentration of 4 or more

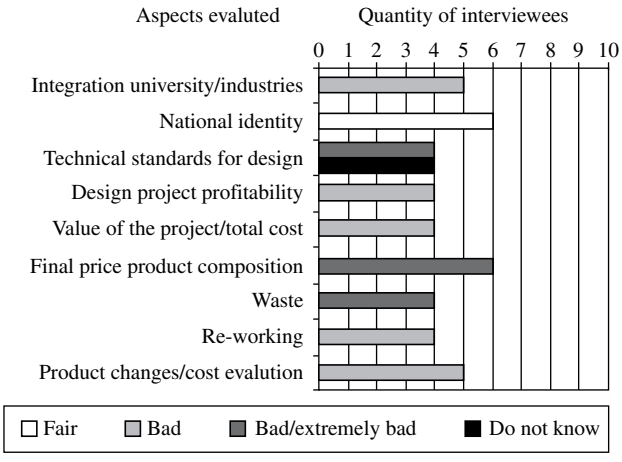

Figure 9. Policies.

interviewees in the adding up of two degrees (bad/extremely bad). About 1 of the questions the interviewees were dichotomized. And about 2 of the questions presented the interviewees were divided.

Figure 9 shows other selected interviewees' perception of the quality of design education. 11 policy, public and economic questions were presented and stated as excellent, good, fair, bad, extremely bad.

In Figure 9 it can be seen that, for 60% of the industrials interviewed, NGD are fair in their capacity to give the products they conceive a national identity. The awareness that NGD have of integration between university and industry was considered bad (50%), as well as their understanding of how product changes can increase costs (50%). According to the interviewees, NGD are also bad in estimating the design project return, in the project value (how much the project is worth) compared to the total cost and in awareness of what can lead to re-working (40%).

The Programa Brasileiro de Design (PBD) already recognized some weak points in design as practiced in Brazil. Among others it stressed the "the inexistence of the culture of design at the potential of industrial products consumer market, associated to an absence of identity of the national products" and "the low university/industry integration and consequent professional education dissociated from technological knowledge of production and economic viability" (BRASIL, 1996b).

NGD were considered as bad or extremely bad (together), in their knowledge about final product costs (60%) and about waste (40%).

In none of the studied aspects NGD were considered as excellent or good (together) by about half of the industrials interviewed.

The opinion/perception of the interviewees about the quality of the designers' education in policy, public and economic questions, therefore, concentrates in from extremely bad to bad. It is a fact that some of the aspects evaluated are not easily accessible to the knowledge of those who are outside the industry (for example, the value of the project in relation to total costs, or the final product costs composition). It is also a fact that some other aspects considered are not easily accessible to those outside the university, or outside the professional design area (for example, identity of national products, or technical standards for design). But these considerations do not invalidate the opinion/perception evaluation of the interviewees about NGD.

4.5. The activity and the professionals

The interviewees expressed their opinion about the activity and the professional performance of the designers.

Their choices resulted in the following profiles as in Figures 10-14 shown below.

Focusing the question of project and of technology, BARBOSA (2003) points out that designers have been being educated, for decades, in a frame of mind guided by objects that solve artificial or secondary problems and do not contribute to improve human life quality. The result

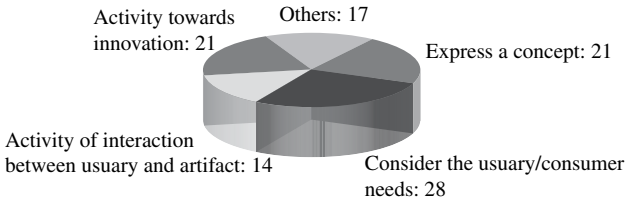

Figure 10. Meanings of the design project (%).

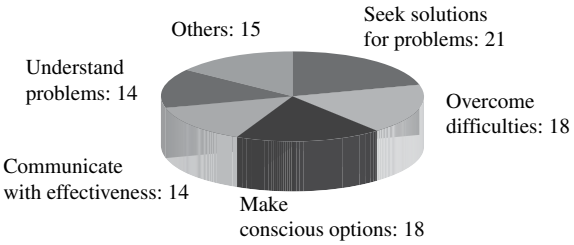

Figure 11. Designer's responsibility (%).

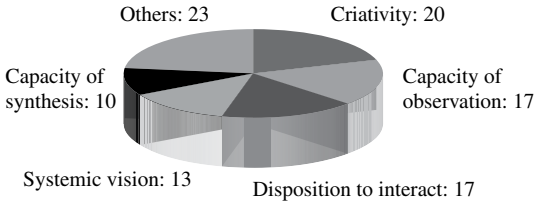

Figure 12. Designer's most important qualities (%).

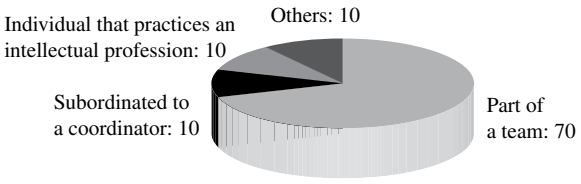

Figure 13. How the designer is seen (%).

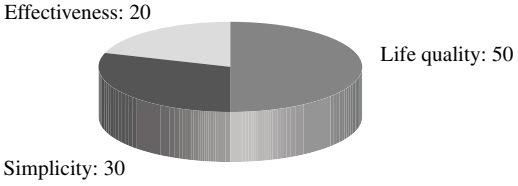

Figure 14. Designer's principal idea (%).

generates speculation and variety, but not much innovation and real aggregated value. The analysis and revision of this model would stimulate environmental responsibility of the designers and, consequently, directing their creative towards an innovative capacity of constructing the future and preserving the species.

In this respect, BRASIL & AZEVEDO (2003) consider that, in terms of design, comprehensive solutions demand more than product projects or even of services; they demand system or net projects.

SENGE (1998) enumerated mastery, mental models, shared vision and team learning as the basic disciplines to innovate learning organizations, and a fifth discipline - systems thinking - that gathers all that. However, as NEVES (2003) points out, these concepts were applied to firms and to NGOs (non governmental organizations), but few cases in the literature refer to educational institutions, especially universities. He presents as example engineering education in which students are not stimulated to develop competences in team work, systemic vision of the work environment and of personal relations involved in carrying out tasks, express personal points of view in technical debates, be creative.

5. Conclusions and final considerations

Back to the proposed object of the survey on the adequacy of industrial design education to the industries needs one can consider that:

- the universe of interviewees is expressive. They are mature, experienced professionals, working in well-known firms, responsible in part for their success and with an interest for results;
- the questions related to production bring to light some contradictions. While they admit not to have much strategic planning, the majority states to recognize the needs for design, the users/consumers, clients, suppliers and competitors. At the same time that they maintain in-house designers or hire consultant designers, in some firms there are no designers at all, or the design is the result of the initiative of the direction or of the technicians. Although the totality related the development of products in the last two years, only 60% of them described the innovative activities in connection to this development and were able to point out the impact consequent of these activities. Although almost all declared that the processes in their firms are clearly defined, only 60% of them affirmed that there was a "quality manual";
- the knowledge the interviewees have of design and of a designer's job falls into two groups. The first are those who are able to select and hire a professional, optimizing their experience in the product/service for the benefit of the firm; this group consists of people sensitive to design, either by their own education, or by their knowledge of the current designers' education. The second are those who have less knowledge in the area of design, either by their education or by their distance from the areas comprehended by design, or even by dire matters related to the immediate survival of the firm - and that ends showing up in the results or in the quality of its products/services;
- NGD are not well seen by the interviewees; they feel that NGD arrive badly-prepared in professional life. At the same time, the interviewees did not know how to answer half of the proposed items. Again, the dichotomy appears: those who know design evaluate the designers badly; those with a scarce knowledge of design do not know how to evaluate them;
- in public, economic or policy questions the interviewees did not have doubts or showed lack of knowledge, maybe because those questions link to the designer's level of maturity and their world view; here also the NGD received a low evaluation; and
- about conceptual questions of design - the meaning of the activity, the inherent responsibilities, the skills of the professional and the ethical question - the interviewees had no difficulty to state their opinions, except for the natural difficulty to choose one or some of the aspects proposed. One can conclude that design and design professionals have their value recognized.

These considerations allow two conclusions:

- first, that when called to contribute with his knowledge and experience for the development of a product or service, the NGD find difficulties. His contribution may not be well dimensioned, the design activity may not be correctly placed, the firm may not be prepared to absorb design and its consequent changes; and
- second, that the inadequacies in NGD education may limit and impair the results of his intervention, contributing to diminish the image of the activity.

The hypothesis formulated for this survey is thus confirmed: that the education currently offered to the future industrial designer is not satisfactory. It is suggested that education in design needs to be revised, broadened and deepened in the aspects considered the most critical especially at the level of management knowledge. As a result it is expected that the NGD acquire basic conditions to enter into professional life, act in a positive and efficient way to help those who hire their services and improve people's lives. As a consequence the designers themselves turn into agents of transformation, bringing more information about their activities and contributing to create in the firms favorable working environment.

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