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User research and eco-ergonomics: encouraging environmentally effective behaviours in product users through the industrial design process

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Introduction

Sustainable development seeks to achieve economic growth, preservation of the environment and improvement of social conditions. The dominant economic model at present degrades the environment, gives little importance to cultural diversity and encourages an unsustainable way of life in the process of globalisation (Galano, 2002).

Many disciplines are taking action working towards a sustainable development. Worldwide efforts, such as the First Day of the Earth (1970), the Rio Summit (1972, 1992, 2002), or the Kyoto Protocol have produced guidelines to make specific modifications in our societies. The solutions may be political or changes in engineering, but creativity can be a powerful weapon to allow companies to offer more, satisfaction of needs, with less resources, energy, etc. (Kazazian, 2003). Design needs to work with all other disciplines involved in product development, particularly engineering, to achieve integral solutions. The design community has published a manifesto in which it is encouraged to seek sustainable development (ICSID, 2001).

Design firms such as Philips or IDEO show a particular concern for the environment when developing their own design principles (Philips, 2002). Efforts have been made to develop a documented compendium, such as the *Eco-design Handbook* (Fuad-Luke, 2002). On the other hand, there are many strategies that have yet to be assessed to prove their practical efficiency: to intensify the use of products, dematerialise the consumption by passing from products to services, etc. (Kazazian, 2003).

One strategy to address sustainable issues is to analyse products' usability, given that some commodities have a larger environmental impact during their use than during their production. Some products, such as packaging, need a thorough study of how people interact with them and what people do with them after their very short usable life span.

Products can be developed to encourage environmentally friendly and/or socially conscious behaviours in users. This can be achieved through usability principles and the concept of eco-ergonomics (Rodriguez, 2002).

Product usability is defined by product attributes that address the physical, cognitive and emotional needs of intended users (Babbar et al., 2002). We live in an artificial world that keeps growing in complexity. The environment in which we live has been developed following design decisions that affect our everyday lives and sometimes saturate the space in which we live. Research suggests that there are around 30,000 products in today's world (Norman, 1990). Many of them are confusing and difficult to use and lead to user frustration

(Nussbaum and Neff, 1991). Product usability is now an important matter to consider in the design process and recognised as a critical dimension of product quality (Babbar et al., 2002).

The concept of eco-ergonomics suggests that ergonomic methodology can be used to reduce pollution, fuel consumption, crime, the size of big cities and so on. This approach would study 'systems at the level of individuals to understand how their behaviour can be structured towards desired goals' (Salvendy, 1997).

This paper will briefly analyse the roles industrial designers can take to seek a sustainable society, with the purpose of discussing the main question:

> Can usability principles be defined and used to encourage environmentally friendly or socially conscious behaviours in users, through the design process, hence reducing the environmental impact of product use?

1. Industrial Design and Sustainable Development

One of the most influential design schools in contemporary history has been the Bauhaus. It was one of the first schools to consider design as a key element in the manufacturing process. It considered design as the unifier of aesthetic and functional factors, as opposed to the 'applied arts' or 'industrial arts'. The Bauhaus school was one of the first international design schools. The Bauhaus approach has spread across the globe as graduates took it to their home countries and beyond.

The Bauhaus manifesto now needs a revision. It states that 'Architects, sculptors, painters, we must all turn to the crafts… Let us create a new guild of craftsmen' (Gropius, 1919:1). Today's designers exhibit more than the important skills of a craftsman person; the profession has grown in complexity. Some other definitions also need a review, such as Harold Van Doren's (quoted in Papanek, 1974:35):

> Industrial Design is the practice of analysing, creating and developing products for mass-manufacture. Its goal is to achieve forms which are assured of acceptance before extensive capital investment has been made, and which can be manufactured at a price permitting wide distribution and reasonable profits.

This definition focuses on economic issues and profitability for the industry. Economic growth is an important factor for sustainable development, but it is not the only one.

Sustainable development has been defined as '...development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (UN, 1987:43). This principle suggests that future generations' needs should be considered at the same time as trying to solve today's requirements. Current production and economic systems do compromise future generations' abilities to meet their needs, by using more resources than the planet is able to regenerate. The industrial design and engineering professions have done very little to consider sustainability issues in the past.

In his book *Design for the Real World*, Victor Papanek (1974) heavily criticises the industrial design profession for leaving its responsibilities to others. Papanek suggests that the design profession operates 'as a pimp for the sales department' (p. 51). The ultimate aim of the Bauhaus was the '*Einheitskunstwerk* (Uniform Work of Art) – the great construction that recognises no boundaries between monumental and decorative art' (Gropius, 1919:2). This proposes the idea that designers of great works would consider

functional and aesthetic factors as a whole. The concept of great construction and unification is closer to the multi and inter-disciplinary approach followed by contemporary designers. Nowadays, industrial designers interact with different professions together with a number of disciplines to achieve sound solutions.

1.1. Industrial Design: a contemporary definition

It is necessary to find a definition of industrial design that reflects the current state of affairs of the profession. This definition should take heed of the ethical principles that the design community is currently developing. This will help to develop an understanding of what industrial design can achieve by working in partnership with other disciplines, such as engineering, to achieve sustainable development.

The word *design* in English dates back to the 1500's (Friedman, 2001). Merriam-Webster (2004) defines *design* as 'create, fashion, execute, or construct according to plan'. The etymological origins relate to the Medieval Latin *designare*, to outline, indicate or mark. In the same century, the word was already used as a noun, which was defined as 'a particular purpose held in view by an individual or group; deliberate, purposive planning; a mental project or scheme in which the means to an end are laid down.'

Friedman (2001) defines design as a dynamic process 'across the full range of domains required for any given outcome'. This definition offers the flexibility necessary to understand design as a changing process. However, it is necessary to relate it to the definition of industrial, to achieve a thorough understanding of the meaning of the discipline.

The Merriam-Webster dictionary (2004) defines *industrial* as '1: of or relating to industry, 2: derived from human industry' The same dictionary refers to the term *industry* as a derivation of *industrius* diligent, from Old Latin *indostruus.* The definition of *industry* is

> '2 a: systematic labour especially for some useful purpose or the creation of something of value b: a department or branch of a craft, art, business, or manufacture; *especially*: one that employs a large personnel and capital especially in manufacturing'

Harold Van Doren's definition cited earlier can easily be derived from the meaning 2b above. However, it is clear that *industry* is not only about manufacturing and large capital investment. The etymology of *industry* includes the term *industrious*, which means 'skilful, ingenious 2: persistently active: zealous 3: diligent'. Taking the etymological analysis further, *diligent* derives from the Latin *diligens*, from present participle of *diligere*: to esteem, to love (Merriam-Webster, 2004). In a romanticised interpretation, Industrial Design could be described as the *love of design*.

However, this was not the intention the first time the discipline was named Industrial Design. The Encyclopaedia Britannica (2004) offers a more generally accepted definition**: '**design of products made by large-scale industry for mass distribution. Designing such products means, first, planning their structure, operation, and appearance and then planning these to fit efficient production, distribution, and selling procedures'

(Britannica, 2004a). Again, the definition focuses on mass production, distribution and selling products.

The International Council of Societies of Industrial Design (ICSID) defines the profession as 'a creative activity whose aims are to establish the multi-faceted qualities of objects, processes, services and their systems in whole life-cycles. Therefore, design is the central factor of the innovative humanization of technologies and the crucial factor of cultural and economic exchange' (ICSID, 2001a:2). The Council establishes that design seeks to

> 'discover and assess structural, organizational, functional, expressive and economic relationships, with the task of:
>
> - enhancing global sustainability and environmental protection (global ethics);
> - giving benefits and freedom to the entire human community, individual and collective final users, producers and market protagonists (social ethics);
> - supporting cultural diversity despite the globalization of the world (cultural ethics);
> - giving products, services and systems, those forms that are expressive of (semiology) and coherent with (aesthetics) their proper complexity'

Under this point of view, design 'concerns products, services and systems conceived with tools, organizations and logic introduced by industrialization' (ICSID, 2001a:2), which means industrial design is not only about designing and producing with serial processes.

2. Industrial Design and Sustainability: different approaches

The concern about developing new ways to approach the design of products is relatively recent. The Industrial Revolution resulted in a bigger production of goods, which implied a major use of resources. Today's society is producing the largest impact on the environment in History. Design for sustainability is a reaction to the problems generated by practices that have ignored the environmental and social consequences of their actions.

One of the predecessors of sustainable concerns in design was Buckminster Fuller, who strongly believed that inventions could fix everything wrong on the planet. He put his beliefs into practice, developing for instance the famous constructive system of circular dome-shaped structures. These were extremely efficient in both practical performance and the economy of materials utilised. Other examples of his socially concerned designs were the Dymaxion House and the Dymaxion car.

A good friend and colleague of Buckminster Fuller was Victor Papanek. He had already located three different kinds of obsolescence on industrially manufactured products:

- Technological: a better way of doing things is discovered
- Material: the product breaks down, or is not usable anymore
- Artificial: 'the death-rating of a product; either the materials are substandard and will wear out in a predictable time span, or else significant parts are not replaceable or repairable' (Papanek, 1974:37).

Papanek's work and philosophy formed basis of a number of later theories regarding design and sustainability. Papanek (1995) identified some issues relating production and pollution that designers should consider, such as the choice of materials, the manufacturing process, design for disassembly and ethics in design. Papanek's philosophy has been criticised for not making the company's interests its primary concern. However, one of his most important contributions has been an awareness of the design influence on our everyday lives and environment.

Boeglin and Kazazian (1999) propose to act on each phase of the product's life, creating a closed loop that analyses choice of raw materials, production, distribution, use, recovery and disposal, and back to raw materials. Some of Boeglin and Kazazian's main contributions have been the ideas of drawing inspiration from ecosystems and the concept of dematerialisation. Although use is contemplated in their research, they only mention ways in which the product makes a more efficient use of resources and energy, with little consideration to the way people use them.

Kazazian (2003) shows a number of possible solutions to sustainability issues in his book *Il y aura l'_ge des choses légères* (*There would be the Age of Light Things*, 2003) He focuses on his previous work with Boeglin and Puyou in which dematerialisation of products is a main proposition. Converting products into services is recommended to be a basic strategy to achieve sustainable development and a thorough analysis of the ecological footprint is encouraged. Nevertheless, the impact on the environment derived from people's use of objects is feebly highlighted.

Fuad-Luke (2002) lists a series of ecological design strategies organised in phases including pre-production, materials selection, recycling, reuse, distribution, transportation, functionality, use, disposal, end of life and others. Fuad-Luke distinguishes the importance of considering the significance of products' use and their repercussions on the environment. He addresses issues that are starting points to consider how users' actions can influence the environment. He proposes that designers should develop 'products that reduce water (and power) usage... products that encourage the use of natural lighting… products that encourage repeated battery use' (Fuad-Luke, 2002:234-235). However, he fails to emphasise the importance of human behaviour and the way people actually use products.

One of the first and most common solutions to the problem of waste and overuse of resources is to use recycled or recyclable materials, but the problem is much more complex. Products have an impact on the environment and society, on different levels, at different points of their life. From natural resource extraction to disposal, products represent a burden to the environment that can be systematically assessed. Several universities and governments have worked together to develop ways to evaluate such impact before it takes place. Life Cycle Assessment (LCA) software is now available for free from different sources, such as the Delft University of Technology in the Netherlands. It is difficult to predict what will happen to the product or for how long it will be used for. This makes it difficult to predict the environmental impact during the product's use. However, the LCA represents a first step to consider a most valuable aspect of the design process, that being prevention.

Research regarding sustainability can focus on preventative environmental protection. Designers can play a principal role in the preventing stage, with the long-term goal of reducing the necessity of repairing environmental damages caused by their decisions.

3. A different strategy: analyse product's usability/user research

When analysing the products' life cycle, designers and engineers often focus on the use of resources and energy, as well as disposal effects on the environment. Research shows that the actual use of some products has a major impact on the environment (Hora et al., 2000), sometimes even larger than their actual production. This is difficult to assess due to the complexity of predicting how people will make use of the objects.

Some disciplines are studying the way people relate to objects, that is to say how people use things. These studies have created a discipline that addresses usability of products. Initially strongly based on ergonomics, usability analyses now involve social and anthropological aspects. Specific areas of the social sciences, such as ethnography, are now used to investigate human behaviour and find opportunities for new products.

Ulrich & Eppinger (2004) define the difference between technology-driven and user-driven products. These categories imply that engineering solutions seeking a sustainable development would be technologically focused. Design solutions, on the other hand, are inclined to the user-driven spectrum of products. Designers need to understand how people use products and what needs arise from such use. This is the area of usability studies.

In reality, there are very few products that exist on any of the technology-driven and user-driven extremes. Most objects will fall in between. It is of vital importance that industrial designers work closely with engineers and other disciplines engaged in production to achieve solutions that involve the society and the environment.

Usability studies normally relate to interface between humans and products. One of its main areas of development during recent years has been the design of software and web site interfaces. Usability studies of three-dimensional products have had a great impact on the design of aviation controls, with a methodological ergonomic approach.

During the 1990s, the term usability took on great importance in the development of new products. Wilcox (1994) stresses 'the importance of involving the client/customer in the design process'. Sterkenburg (1993) and Vries (1993) documented the design principles followed at Philips regarding usability issues, stressing the vital importance for designers to go out and observe people's behaviour, in order to develop products more closely related with the actual needs of users. Philips Corporate Design Usability Laboratory in Eindhoven offers the facilities to observe and monitor people's reactions when using new artefacts. One advantage this laboratory offers the company is the relatively low cost of assessing inadequacies before large investment takes place.

Dylla (quoted in von der Weth, 2003) suggests that designers do not consider user's needs especially during the early stages of projects. Usability factors such as task analysis are neglected. Usability engineering is a relatively new discipline that addresses issues of how people interact with designed systems (Nielsen, 1993).

The term *user-centred design* has been criticised when addressing usability issues, mainly because of the idea that it lacks research (Hanington, 2000, 2003; Jordan, P, 2000; Helander et al. 2001). User-centred design is a process in which human factors are understood and utilised to develop designed solutions. Since design is an activity inherent to human needs and concerns, this kind of research could be named *human-centred*

design (Hanington, 2003).

Jordan discusses the constraints of using the term *user testing* (Jordan, 2000) First of all because it can give the misleading idea of *testing the user*. Researchers need to dissuade participants from interpreting the term in such a way. A more precise definition would be *product testing* (Hanington, 2003). A new model brings into play the term *user research* and proposes a wider range of involvement in the activity, including pre-development and evaluation of new product phases. It is important to indicate the growing interest of including more than purely mechanical tasks in user research, for instance 'product desirability, pleasurable interactions, and emotional resonance' (Hanington, 2003:10).

Von der Weth draws interesting conclusions encouraging designers to learn a lot more about 'models of human behaviour, esp. the role of existing knowledge and action patterns for the use of new... products' (von der Weth, 2003:290). It is important to try and predict the effects of 'innovation on knowledge and action patterns of the users' (von der Weth, 2003:290). He states that these models and modifications of human behaviour and action patterns should consider consequences on market, politics and culture, but fails to include environmental concerns in his research. During the 'Discovering Design' Conference held in Chicago in 1990, one of the points to debate was the effect of designed products on material, social and cultural conditions (Buchanan et al., 1995).

By studying user responses and behaviours throughout the designing process, user research helps to understand ways to improve human use of new products. This encourages people to make use of products in particular ways. A basic example is the difficulty of using doors, many people do not know if they should push or pull (Norman, 1990). Appropriate designs should clearly indicate whether it is necessary to push or pull to open the door. The most basic solution is to have a flat area that only allows pushing, therefore avoiding the possibility of pulling. This is nothing but the encouragement of a particular action (behaviour) in people, achieved by the design of the product. This suggests design can modify people's behaviours.

A further example can be found in the automobile industry. Some features of new cars encourage particular behaviours. Lack of vibrations and noise produce a smooth drive that supports over speeding, because of the lack of feedback. Designers have the possibility, and responsibility, of analysing usability issues to assess the consequences of their designs on people's behaviours. Such consequences, as Buchanan mentions, will have effects on social and cultural conditions, as well as environmental ones.

Rodríguez (2001) suggests the use of ergonomic methodology to encourage environmentally friendly behaviour. Rodriguez shows an initial solution in the design of a showerhead that encourages users to save water by providing feedback on water use and time spent in the shower. The idea behind such a solution is that once people know the amount of time and water consumed in the shower, they can then make an environmentally conscious decision to take shorter showers. The showerhead is designed using recycled and recyclable materials. It can be easily disassembled for recycling. This proved to be a potentially efficient solution being awarded the first prize in the *Oullim designit* international competition by the ICSID.

Manzini (2003) constructs different sustainable scenarios, including some in which people's behaviours are structured to share products instead of buying individual ones.

He exposes that power tools, such as drills, are only used for 30 hours during their lifetime. This implies a waste of resources that could be diminished if users had an adequate system to share some objects, without compromising the ease of access.

Kazazian (2003) addresses similar problems. He shows products and services that encourage use of fewer amounts of objects in any given society. A repeated possibility, yet to be proved efficient, is a shared public transport system where cars are made available for everybody to pick up from different points around the city.

These solutions face some problems, such as the need to change consumer attitudes towards sharing products. Car pools, for instance, have not proven to be popular in many countries. Nevertheless, they are starting points to modify ways in which people consume and use products. Further research is necessary to test such outcomes and incorporate them into the everyday life.

The need to study usability issues during the development of new products is widely accepted. User research, or human research, can be a powerful tool to improve products. Similar approaches can study the consequences of the use of products on the environment, particularly focusing on people's actions and behaviours. Products developed with such an approach would also represent educational instruments for people using them. The showerhead mentioned above signifies a constant, but at the same time subtle, reminder of the value of water for everybody.

4. Conclusion

The development of new products requires the collaboration of a number of professions. Engineering approaches require industrial design to achieve sound solutions. These professions, along with marketing and other fields of knowledge, have the potential to develop products with a strong positive impact not only in the market, but also on the environment. Industrial designers have produced a manifesto in which they seek to enhance global sustainability, give benefits to the human community and support cultural diversity.

One area in which industrial design can benefit such development is in usability studies, now recognised as user or human research. Normally utilised to discover problems within current products to develop improved ones, human research offers the possibility of encouraging particular behaviours in users.

Some designers have proposed projects to address these issues, including systems that monitor water use and offer easy to read feedback, so users can make environmentally conscious decisions and save resources. More studies addressing user research and products consequences on human behaviour are necessary.

It is difficult to predict people's behaviours in complex everyday situations However, user research used in the industrial design process could help modify undesirable conduct. Designers can use such understanding to develop products that encourage socially and environmentally conscious behaviours in users.

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