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Design for Sustainability in education

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Abstract

While the potential for designers to affect positive change is significant and widely acknowledged, this has remained largely untapped both within industry and education. Although some new educational curricula with environmental emphasis have begun to be developed and implemented. But this is barely a beginning and the new generation of designers still needs to be more educated in sustainability. Current design education have been rarely recognized as a relevant factor in the sustainability discourse. Furthermore, the educational practices are mostly related to eco-design strategies (e.g. energy efficiency, dematerialization, longevity, use of recycled materials, recycling). But Design for Sustainability (DfS) goes beyond the eco-design. DfS integrates social, economic, environmental and institutional aspects. Hence, it is necessary to expand the scope of design education and practice beyond style, fashion or limited trends of environmental concerns to include behavioral, social, institutional issues.

Accordingly, an educational experiment is undertaken by the industrial design students of the Art University of Isfahan, Iran which provides a more coherent framework for sustainable design education. Students have the responsibility to not only include eco-design strategies but also establish Design for Sustainability which promote socially responsible behavior among people. The paper contributes to the knowledge and experience on how integration of sustainability issues in regular product design courses can be accomplished the design activity in order to positively and effectively contribute to the radical change required by the transition towards a sustainable society.

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1. Introduction

Since the 19th century, mass production of objects transformed design from an art into a stakeholder co-shaping the future of societies. This mass production has generated negative social, environmental or institutional aspects, such as, global warming, resource depletion, solid waste, water pollution, air pollution, land degradation. Joachim, in his research entitled DEEDS named 'mess production' by mass production [1]. As Hawken argued, the industrial system is destroying the planet and only industry leaders are powerful enough to stop it [2]. Hence, the entire production and consumption system in the coming decades will require a radical reorientation as we move towards a sustainable society [3].

The traditional approach to environmental management has evolved from pollution control, the end-of-pipe approach, to preventive or cleaner production strategies. Recently, it has become clear that such interventions must be more radical and go beyond the redesigning of existing products in order to catalyze a transition towards a sustainable society. The need for sustainable behavior introduces a relatively new issue into the global debate on sustainable development. Sustainable behavior questions, not only products and services but also the way that needs and wants are

defined and fulfilled [3]. This means that designers need to be made aware of their new responsibilities and to become competent to make specific contributions in the transition towards a sustainable society.

Unfortunately, so far sustainability plays a minor role in design education and practice. Design education and profession have been rarely recognized as a relevant factor in the sustainability discourse [1]. Although in the last two decades, this situation has changed. Environmental issues have now penetrated society, education and systems of production. In particular new educational curricula (with an overt environmental emphasis) for designers have begun to be developed and implemented. But this is barely a beginning. A whole new generation of designers still needs to be educated and employed [3]. Furthermore, the educational practices are mostly related to eco-design strategies (e.g. energy efficiency, dematerialization, longevity, use of recycled materials, recycling and etc.). But Design for Sustainability (DfS) goes beyond Design for the Environment or eco-design. DfS integrates social, economic, environmental and institutional aspects and offers opportunities to get involved one's own identity beyond consuming standardized mass products [1]. Hence, it is necessary to expand the scope of design education and practice beyond style, fashion, economic issues and limited trends of environmental concerns to include behavioral, social, institutional issues.

Accordingly, this paper aims to provide one step forward in Design for Environment and uses the power of design as a deliberate means to change behavior of people. To this aim, an educational experiment is undertaken by the industrial design students of the Art University of Isfahan which provides a more coherent framework for sustainable design education. The experiment consists of practices for designing city installations which facilitates and promotes sustainability within the city. Students have the responsibility to not only include eco-design strategies but also establish a design for socially responsible behavior.

Consequently, the paper is outlined as follows: after defining the scopes of Design for Sustainability in current societies in which environmental issues were not pre-eminent, responsibilities of designer as catalysts of society in raising public awareness are largely discussed. Following, the need for focusing on socially and environmentally responsible design in education and the case study experiment at Art University of Isfahan are outlined. Finally, we evaluate the consequences of involving DfS educational program in design courses by categorizing and comparing the developed concepts of students with the outlined aims of deep DfS.

2. Design for Sustainability beyond Design for Environment

Design is an environmental focal point since design decisions have huge impacts on the environment. Considering environmental issues, designer's responsibilities become more difficult and more important than before. Designers have crucial responsibilities to create environmental friendly products and solutions for the earth. In 1971, Victor Papanek in his book *Design for Real World* define Design for Environment (DfE) as a design practice which dedicate itself to nature's principle of least effort[4]. That means consuming less, using things longer, recycling materials, and not wasting. DfE is a method to minimize or eliminate environmental impacts of a product over its life cycle. Effective DfE practice maintains or improves product quality and cost while reducing environmental impacts. Reviewing the literature shows fundamentals of design for environment can be categorized in the eco-design strategies reported in Table 1.

Increasingly more companies try to apply the above mentioned strategies in order to undergo the Cardle to Cardle (C2C) criteria's in green design. The Interface Corporation (carpeting company) is one the first and most popular companies that progressed on industrial ecology by applying multiple eco-design strategies like design for modularity (producing modular commercial floorcovering), design for serviceability (moving from selling carpets to providing a carpeting service), energy efficiency, use of recycled materials and etc. Herman Miller is a furniture company that launches their new chairs with environmentally friendly and non-toxic materials, recycled materials, easy to disassemble, high levels of recyclability after usage (both up-cycle and down-cycle), 100% green power during production line (no air or water emissions released in production), returnable and recyclable packaging. The emphasis of new Herman Miller chairs is on eliminating as many materials as possible from the construction. This "eco-dematerialization" strategy results the fewer parts and less material, the lower cost, the lighter carbon footprint and less shipping costs. Steelcase is another furniture company which applied multiple eco-design strategies, mainly, easy disassembly, using fewer parts, eliminating adhesive, eliminate the used staples and recycling. Not only Dematerialization but also Rematerialization is another eco-design strategy which is followed by many companies. Freitag bags uses truck tarps, inner tubes and seat belts to make new bags. Patagonia Clothing uses post-consumer

recycled materials in their products. Dunlop Wellington boots takes back used Wellingtons from customers. Old boots are re-ground and re-manufactured into new boots. Adidas uses ocean plastic and illegal deep-sea gillnets to make new shoes. Pentatonic created a range of furniture and products from food, electrical, plastic and textile waste, smartphones, cans and cigarette butts. Design for longevity is another eco-design strategy which is followed by companies like Stokke which applies flexibility and multi-functionality as the main idea of their product and produces furniture like Tripp Trapp Chair and Daybed that grow with the child.

Table 1. eco-design strategies

DfM Design for Manufacturability, Enabling pollution prevention during manufacturing Design for less material Design for fewer different materials Design for safer materials and processes	DfL Design for Longevity, Provide life time period of usage Flexibility Design for modularity Design for serviceability Design parts/products so that components contain materials with reuse potential in other industries.
DfEE Design for Energy Efficiency, Reduced energy demand during use Use renewable energy Zero Emission Carbon Neutrality	DfMo Design for Modularity, To ease upgrading, To delay replacement, To ease serviceability To ease later disassembly For Longer life,
DfD Design for Dematerialization, Use less virgin material Design products with less mass Reduce packaging Modify manufacturing processes to reduce by-products Maximize use of recycled materials	DfDi Design for Disassembly, To promote re-use of components, For quicker and cheaper disassembly, For more complete disassembly For dismantling by simple tools
DfP Design for Packaging, Minimize packaging, Rethink selling method or rethink ways to reach the customer	DfL Design for Logistics, Use of local materials, Less transportation or arrange outsourcing to minimize transportation
DfS Design for Serviceability, For ease of repairs, Longer life, For recapture of used/broken parts.	DfMu Design for Multifunctionality Use one product for different purposes Design for flexibility to enable changes for different functions, users, times and etc.
DfRM Design for use of recycled materials. DfR Design for Recycling, Labeling of parts, especially plastics for easier materials identification Efficient choice of materials (thermoplastics easier to recycle than thermosets) Modify manufacturing processes so that by-products can be recycled Design with less variety of materials Use of materials that can be locally recycled Design for greater materials recovery Design for safer disposal of non-recyclables Design for Economic Recycling, arrange for material reclamation, marketing incentives to promote recycling	DfHM Design for healthy materials

Accordingly, different levels of design for environment can be recognized by reviewing the existing efforts in applying the eco-design strategies. While some of the modifications are superficial, others try to modify the product (e.g. type, weight, material, packaging, service) or the procedure of making the product. A deeper levels of eco-design can be achieved by making changes to the entire product and trying to meet the function (service) in a different way. The changes from regular “snail” mail to email, film camera to digital camera, audiotape player to CD player and to iPod are examples of this deeper level of eco-design. However, as Arne Naess expressed [5], a “deep ecology” is not asking “How can we improve this product or activity?” but instead it should be “Why do we need this? Can we rather do without?”

Products (including services) are in between production and consumption (the ways they are used) [1]. Hence, a typical win-win situation is not only the eco-efficiency of production, but also the eco-efficiency of consumption and sustainable consumption. A product is efficient if the abovementioned eco-design strategies are applied in its design process, but the use efficiency of this product can also be extremely low if most of the time the product is not used. For example, there is simply little to be optimized in a kettle’s heating system, but if the amount of unnecessary water we repeatedly boil could be reduced, a substantial reduction in energy loss could be achieved. According to Lofthouse[6], study on users’ behavior during the use of a kettle, users tend to fill the kettle fuller than required, turn the kettle on, walk off to do something, then come back 5 minutes later and reboil the kettle before using the hot water.

Hence, detecting possibilities for improvement of socio-cultural rather than technical, like improving the use intensity can lead to better results in eco-design and is a step forward to design for sustainability. Choosing bicycle instead of car in the Netherlands is one of the best successful examples of questioning the need for a product and sustainable consumption instead of focusing on making that product eco efficient.

Design for Sustainability particularly aims to address the use efficiency, adding the qualitative component with social and institutional criteria[1]. Hence, DfS is understood to address not only product aspects but all dimensions of sustainability, looking at bigger systems and asking more fundamental questions about consumption and production. Unfortunately, so far, sustainability policies are based on precious little insight to what it takes to change consumer behavior towards sustainable consumption.

3. Changing behavior by design

As discussed, re-thinking lifestyles and behavioral changes will lead to greater increases in sustainability compared with redesigning products. But how design can change behavior?

Lifestyles are shaped by context and habit, and changes require at least three conditions to be given:

1. The personal motivation and information,
2. The ability to change given the restrictions of the social context (acceptance, image, peer group identity etc.)
3. The opportunity, i.e. the availability of alternatives at competitive logics.

Design plays a significant role in regulating the three above mentioned conditions through ‘form-giving’, raising awareness, changing perceptions of value and integrating these elements [7]. A product is not a neutral intermediary, but a mediator that actively mediates the relation between a user and his or her environment. Tromp et al. [8] used the example of the microwave to show that design would influence behavior patterns even implicitly and unintentionally. Utilizing microwave make families join together for fewer dinners than they did before because the microwave oven has made it so easy to quickly heat up an individual meal. This example shows that products can mediate certain behavior even without determining it.

Products that are deliberately designed to change behavior are often based on the occurrence of undesired behavior. People eat unhealthily, people drive unsafely, people irritatingly hang around at specific places, people do not pay for their train tickets, and people do not care much about the environmental issues. Designers can intervene either by discouraging the problematic behavior or by encouraging other desired or accepted behavior that is incompatible with that undesired behavior and can thereby trigger different psychological processes. Tromp et al. introduces four different types of influence on user experiences, namely, coercive, decisive, persuasive, and seductive[8].

Coercive refers to a definite prevention of an undesired behavior. Speed bump, speed limit camera are considered as a coercive intervention to stop risky driving behavior by making a punishment for the undesired behavior. Making a perceivable barrier for undesired behavior (pain) or making unacceptable user behavior overt (shame) are also considered as the examples of coercive strategy for changing behavior. Decisive strategy is making the desired behavior a necessary activity to perform to make use of the product function. Customize receptacles with different openings for trash, recyclable objects (e.g. bottles and papers) is an example of decisive intervention.

While coercive and decisive are strong types of intervention and lead to a definite change of behavior, their effects seem to be temporary and not deep on people. Meaning that people would follow their own behavioral patterns in case of removing the barriers and interventions. Fogg introduced the term persuasive design that aims to alter attitudes or behaviors of the users through persuasion and social influence, but not through coercion [9]. Poor little fish basin designed by designer Yan Lu is an example of persuasive design, which is an emotional feedback device for saving water. Social Stairs, the Piano Staircase is another persuasive design which encouraged people to take the stairs at work in favor of the elevator by triggering new motivations. Their study on the resulted behavioral changes revealed a high level of long-term social engagement. Seductive is another design intervention which can lead to a changed behavior unconsciously by triggering human tendencies for automatic behavioral responses. Woonerfs the “living streets” are the best examples of this design intervention. The concept of the woonerf was developed in the late 1960s in the city of Delft, Netherlands. Residents of a neighbourhood were upset with cut-through traffic speeding through their neighbourhood, making it unsafe. They believe eye contact and human interaction are more effective means to achieve and maintain attractive and safe areas than signs and rules. Hence, they initiated woonerf, in which the street is shared among pedestrians, bicyclists, and motor vehicles. But pedestrians have priority over cars. The street is designed without a clear division between pedestrian and auto space (i.e., no continuous curb), so motorists automatically slow down and travel with caution[10].

4. Socially and Environmentally Responsible Design in education

Although design has proven to be an influential factor in behavior, only for a few years have design researchers tried to gain adequate knowledge that would allow designers to deliberately and effectively affect behavior. The ability to conceive and practice a type of design that acts as a catalyst for something beyond the immediate product and holds the responsibility in positively influencing entails a shift in the definition of professional profiles and education. As Paolo Tombesi declared this is the difference between training and education: the former teaches the “what” and “how” of things, while the latter focuses on the “what” and “why” of actions [11]. The common design educational culture generally tends to encourage the expression of the ego and the aesthetic as well as functionality through formal design under the primacy of economic restrictions, whereas more emphasis should be placed for socially and environmentally responsible design. As a result of the common design educational culture, most of the design professionals educated without reference to the environmental impact of their design decisions and activities. In this case, many designers assume that their area of responsibility is limited to function and appearance and do not spread through the effects of their designs on people and environment no matter what their scale is [12]. Accordingly, the design education need to go beyond styling trends, consider environmental threats, recognize social and behavioral gaps and design to fill the gaps.

Some professional bodies like ARB/RIBA in UK and the Association of Danish Designers in Denmark recently acknowledged sustainability in their validation criteria but it is compartmentalized and relegated to technology subjects, rather than integrated into behavioral, social or cultural context. In this regard, some efforts are started by design communities in developed countries to translate rising public concern into action by changing their behavior to accommodate recycling or energy efficiency and by using environmental awareness as the main criteria of their design decisions. As an example, the Danish Designers' Association includes responsibility for environmental and social issues in their membership criteria, and BEDA the Bureau of European Design Associations participated in the DEEDS project, which had the mission to embed sustainability in design and design in sustainability[1]. The “Applied Ecology” program at KTH, Royal Institute of Technology in Stockholm, Sweden[13], the “Sustainable Higher Education” at university of Ghent, Belgium[14], “Social Responsibility and Sustainability Strategy 2010-2020” at the University of Edinburgh[15], and the integration of DfS with industrial design courses at Delft University of Technology [16] are other examples. However, the efforts for DfS in developing countries is still insignificant comparing to developed countries. According to Deniz [12], environmental effects have been commonly ignored through design and planning stages in developing countries. In this case, developing countries need to consider new solutions for challenging traditional procedures through new way of design thinking and applications. Designers in these countries have responsibilities to not only consider environmental issues but also create environmental awareness throughout their societies. This role has been recognized and emphasized by the United Nations, when it proclaimed the Decade of Education for Sustainable Development (DESD).

5. A Case study of design for sustainability in education

This paper presents a case study in design education which explores how designers and design educators, especially in developing countries, can set their own holistic approach to sustainability in new product development, place social awareness, responsibility and behavior in perspective and provide an inspirational practices for student designers. The experience focuses on one particular course at Art university of Isfahan (AUI), Iran (Industrial Design Group, Bachelor curriculum). The course named ‘Design 5’ is exemplary for a regular street furniture and city installation design course, which was offered for many years in a broad spectrum of disciplines as aesthetics, ergonomics, manufacturability, market considerations, but not sustainability. The Design 5 course was singled out by the curriculum developers to be developed into a design course with an increased emphasis on environmental issues and sustainability. The new defined Design 5 course at AUI is to a large extent based upon the sustainability context. In this course, students gain a holistic perspective on their environmental responsibilities, and integrating sustainability issues into product design. Through this course, students are educated to become designers that affect and guide the society toward sustainability. The subject of the course is to design a city installation or street furniture which not only gives services to the public but acts as a facilitator to sustainability. The main objective of this course is to design street furniture which are not neutral but improve the sustainability within their context. In addition to applying eco-design criteria (e.g. Minimizing the environmental impact, using recycled and recyclable materials, extending product lifecycle), the students need to take into account the following strategies through their design:

- Raise public awareness of sustainability
- Educate and sensate public on sustainability
- Promote sustainable behavior with any of the design strategies for changing behavior, namely, coercive, decisive, persuasive, and seductive.

Figure 1 presents the spectrum from a not sustainable design to eco-design and socially responsible design. The students` design are guided to move toward the end of this spectrum for establishing a deeper level of sustainability in the society.

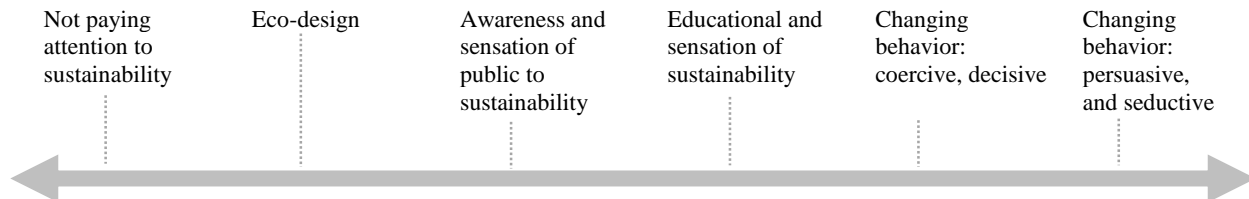


Fig1. Different levels of Design for Sustainability

6. Conclusion

As societal expectations have changed from narrowly focused environmental issues to broader sustainable development concerns, it is vital that future designers graduate with an understanding of how social impacts may affect or may be affected by their designs and decisions. It should be acknowledged that sustainable education need to have some type of a higher calling, which may be social responsibility and public design. Designers need to have heightened awareness of their contributions to environmental degradation. Accordingly, the conducted educational experiment at Art university of Isfahan (AUI) demonstrates the potential and usefulness of integrating sustainability into mainstream design practice and design education, and thereby providing the missing link between sustainable production and consumption. DfS will be offered to mainstream design education institutions to equip the next generation of designers with the necessary tools and skills in designing more sustainably.

The effectiveness of this practice, is expected to clear that sustainability was supposed to be more than just purely environmental issues, and should in general refer to 'beneficial to society'. This is explicitly to address social issues as well in particular including environmental issues. Accordingly, the course leads to expand design context in thinking and practice something beneficial for the society and set new aspirations, change perceptions of students by making use of the diversity of "value-added" criteria's to design process.

In addition, the experience gained by the course demonstrates that substituting traditional design briefs for sustainability-oriented instructions broadened the horizon of students and led to an outburst of creativity and originality. DfS requires "thinking out of the box", overcoming traditional habits, and this is a significant creativity stimulus. Putting theory into practice, making something out of nothing which, and the opportunity to choose a social-environmental problem as the main starting point of the project are among the main reasons for creativity.

In general, the Design 5 course received a positive evaluation. This is best illustrated by the outputs of the evaluation which reports that over 94% students judge either positive or very positive which led to pay much more attention to the deep sustainability. The percentage of students that stated that they had truly learned to integrate sustainability into product development was 86%. The results show that incorporating sustainability concepts in teaching Industrial design courses is not difficult and the students are more willing to understand the new concepts regarding sustainability.

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