Sustainable Furniture Design: Considerations for Building Sustainable Furniture Design

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Abstract: *The concept of sustainability has become increasingly important and needs to be thought as part of our lifestyle. It plays a key role in addressing environmental and social concerns which are critical today. Sustainability is not only being environmentally conscious; it also aims for social equity and economic development. Various assessment tools are available to assist designers, developers and regulatory bodies to reduce the negative impacts of the building construction industry. These tools raised awareness on environmental issues the world is facing also, helped achieve sustainability and improve building performance. Following the construction industry is the furniture industry. The development of technology for industrial production has changed the furniture industry bringing in a lot of environmental problems. This concern of environmental issues has led large companies to create furniture that does not create a threat to the planet. Designers need to consider different aspects when designing and creating furniture. This paper presents the thought process required for designing sustainable furniture. It enlists the criteria related to sustainable design to meet the necessities of individuals and the development of the society, wise consumption of natural resources while supporting sustainable economic growth. The study puts forth the idea of having a digital tool for assessing sustainability for a furniture designed for use and indicates its level accomplished.*

Keywords: sustainable design, eco-design, furniture design, sustainable furniture design criteria, digitalization.

1. Introduction

The term sustainability was first introduced to the public in the 1970s, and ever since then the term has become very popular, with nearly every conference mentioning the word "sustainable". According to Lele, "Sustainable development has become the watchword for international aid agencies, the jargon of development planners, the theme of conferences and learned papers, and the slogan of developmental and environmental activists." (Lele, 1991). This however doesn`t compensate for the fact the world is suffering because of human behaviors and the bad impacts it is causing right now.

First attempts for sustainable design occurred in the end of 1980s and caught attention in different sectors, furniture being one amongst them. Many art movements supported sustainable design such as the one that began with the "ready-made" movement. Today the design discipline and processes are greatly affected by the technological advances, which makes it even more critical to integrate sustainable furniture designs and digital tools.

This paper discusses sustainable furniture and attempts to come up with clear points on measuring sustainability for a furniture piece. We will start by defining sustainability and its pillars with an emphasis on economic and environmental pillars. We will also touch upon introduction of sustainable thinking and its application in design methodology by investigating strategies and criteria to make furniture sustainable. Lastly, we will view the impacts of digital tools on the practice of sustainable furniture design and highlight the importance of such tool.

Understanding Sustainability

There is much discussion about how one "defines" sustainability. The term, though very popular, is very vouge. Critics argue that the concept is useless because it cannot be "adequately defined." However, that doesn't mean no definitions were ever made. Below mentioned are few popular definitions of sustainability.

"The idea that goods and services should be produced in ways that do not use resources that cannot be replaced and that do not damage the environment." — Cambridge Dictionary

"Meeting the needs of the present without compromising the ability of future generations to meet their own needs." — The World Commission on Environment and Development

"Sustainability is the [emerging] doctrine that economic growth and development must take place, and be maintained over time, within the limits set by ecology in the broadest sense -- by the interrelations of human beings and their works, and the biosphere...It follows that environmental protection and economic development are complementary rather than antagonistic processes."— William D. Ruckelshaus. Scientific American. September 1989

Sustainable design is also known as ecological, eco-design, green design or eco-friendly design' and will refer to the process of making a sustainable product.

For the purposes of this paper sustainability is defined as a set of actions taken to reduce negative effects on the environment, society and mankind, and to reduce cost, labor of a product while providing a suitable work environment, all to improve the quality of life without draining out natural

resources. Sustainable product wherever mentioned in this paper will refer to a product that satisfies the previously mentioned terms.

Sustainability pillars

While a lot of vagueness surrounds sustainability and its many definitions. Universally, these are the three key pillars: economy, society and environment.

1) Economy: Economic activity must account for the environmental costs of production. (Ruckelshaus,1989). Orr mentioned an un-sustained world with a large number of poor people – this also affects the social equity pillar- as poor people will disrupt the lives of the comfortable, other than "it's not worth sustaining" (Orr, 2003)

2) Environment: The human species is part of nature. It`s existence depends on its ability to draw sustenance from a finite natural world; it`s continuance depends on its ability to abstain from destroying the natural system that regenerates this world. (Ruckelshaus,1989). A greed world that will eventually overwhelm the capacity and fecundity of natural systems and cycles can`t be sustained (Orr, 2003)

3) Social equity: The maintenance of a livable global environment depends on the sustainable development of the entire human family. If 80 percent of the members of our species are poor, we cannot hope to live in a world at peace. (Ruckelshaus,1989)
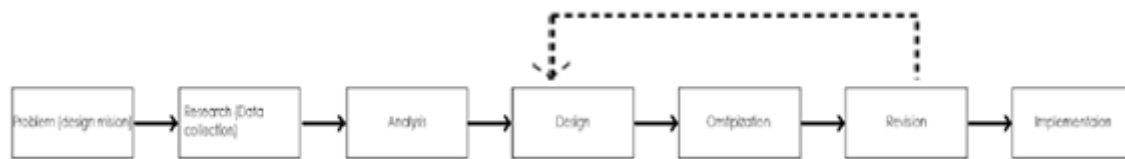
2. Design Methodologies

Mahmoodi (2001) highlights the difference between the terms 'design method' and 'design methodology'. The first refers to techniques and procedures of designing. While the latter refers to a broad strategy, plan of action, and a process of choosing and applying particular design methods and techniques.

Many design methodologies were proposed through the last century, and it's an ongoing dialogue in the architectural practice. For Vitruvius, architectural design is the process of selecting parts to achieve a whole. (cited by Lang, 1987, p. 37), Alberti (1485) shared the same thoughts with Vitruvius. Whereas, Laugier (1753) described the process of design as one of decomposing a problem, solving the components, and then synthesizing the partial solutions into whole ones. And Le Corbusier described it in his book vers une architecture as a decomposition/composition process involving several steps; the formulation of the problem in terms of the functions to be housed; the formulation of design standards; and the composition of these into built form.

Lang was the first one who suggested that introducing behavioral scientists to the practice will lead to improving the architects understanding of environment and man thus, will improve the future design process and the final product.

Figure 1: design process model

Although many design methodologies and models were proposed throughout time, they tend to share common ground. Hence, for this paper this schematic model that combines Asimow`s and Gugelot`s models (figure 1) will be considered.

Sustainable design method would start researching local community`s wealth, strengths and weaknesses in the research phase, then analyzing the data to better understand how it can be applied in the product. After obtaining the necessary knowledge the designer must synthesize that knowledge with the other design considerations producing a schematic model of their product. After finalizing the model, it would be optimized and reviewed.

Sustainable furniture design criteria

"Sustainability will come not from superficial changes but from a deeper process akin to humankind growing to a fuller stature."- David Orr.2003

- Materials: When designing a sustainable furniture, the following aspects are considered with regards to the materials used:
- Origin i.e. geographical source: Local or imported, local materials are preferred not only because they`re most likely cheaper but their transportation fees and environmental emissions are minimal.

- Natural/ synthetic source: Using renewable natural resources means drastically reducing the factory emissions poisoning the air to produce and process synthetic materials, all while sustaining the resources for future generations therefore, achieving sustainability.
- Material production and processing: How did the product come to life? How much negative gas emissions were released to the air, and what impact did that leave on the environment? These are some questions one needs to answer with regards to understanding the production.
- Transportation: Reducing the transportation distance and fees for both raw materials and final product will have better environmental and economic impact.
- Product life expectancy: One of the largest problems for sustainable design remains the fear that the initial cost of application will be too high (Nieminen, 2006; Whitemyer, 2007). This fear lacks validity once the lifecycle cost (the total cost of ownership of the building over its useful life) is taken into account. Lifecycle cost includes the cost of acquisition, operation, service, and disposal (http://dept.lamar.edu, 2007).

Flynn (2007) stated that initial building costs represent about 6% to 8% of the total cost over a 35-year period with the remaining 92% to 94% allocated for the operations and maintenance of the building. "People are learning that new sustainable materials, lighting techniques and energy

delivering systems can significantly reduce the lifecycle cost of buildings" (Whitemyer, 2007, p.12).

1) Product after life: After the product fulfills its life expectancy the following points are considered:
   - Is it easy to disassemble? Taking a product apart and reusing most of it is essential to sustainability.
   - Is it a waste or reusable: Can this product be reused again or recycled?
2) Respects other habitats: Does the making of your product rely on terminating other habitats' lives? Many furniture relies on slaughtering animals and making it using their body parts. Some furniture`s process involves negative environmental emissions harming the natural world surrounding it; humans, animals and trees.
3) Respects local climate: Does your product fit with the local climatic needs? Using the right materials is essential; materials which withstand the climatic conditions increases the furniture life expectancy.
4) Toxic parts: Does the product contain toxic parts that lead to negative impact on the health of the users or the environment? Can the parts being used trigger accidents leading to hazards?

Economy
- Local materials: Among the many benefits of using local materials is supporting local economy through providing jobs for local labor and local businesses and reducing the products initial and final cost.
- Need in the local culture: What is needed in the community will be valid, purchased and used. While it's important to look at different innovations around the world, the designer must keep in mind the community they are designing for. A designer must satisfy the community needs only then, their products will be appreciated and purchased.
- Mass production: Mass producing a product reduces the time, effort and capital need to produce per piece. Mass production option should be considered and thought of.

Social equity - Social equity is another critical component that contributes sustainable furniture. Below are a few important considerations to build sustainable furniture. The design should ensure that it:

Table 1: Sustainable Furniture Criteria

Respects culture	Offers respectful work environment
Keeps labor rights	Respects religion
Healthy / not harmful	Achieves Maslow
Promotes freedom	Promotes self-realization
Is not biased to a particular group or ethnicity (not offensive)	Supports innovation

Design stage	Criteria
Pre-Production	Using local materials
	Environment-friendly design
	Multiple functions
	The use of recycled materials
	Reducing materials input
	The use of sustainable sources
	Reducing the number of parts used
Production	Minimizing the processing of materials and negative emissions
	Minimizing energy
	Labeling the product and providing clear instructions for the users
	Package optimization
	Mass production
Product life	High performance
	Functional
	Friendly surface design
	Easily maintained
Product after-life	Ease of disassembling the product.
	Increasing the number of recyclable parts

Design for environment

According to Bogue (1997, page 288), Design for Environment (DfE) strategies are aimed at:

1) Reducing the material content and energy required in the manufacturing process
2) Increasing the use of recycled parts
3) Increasing the number of reused parts

DfE studies are mainly associated with End-of-Life Stages because of waste handling problems. Some of Design for Environment strategies based on minimizing End of Life impacts are about remanufacturing and reusing (Hauschild et al., 2004). Products should be also designed considering the cost-effective remanufacturing and landfill waste reduction. Also, a set of Design for Environment rules are suggested below which summarize the guidelines in various Design for Environment methods and tools in literature (Lagerstedt, 2003)

- Do not use toxic substances
- Minimize energy use and material consumption in manufacturing and transportation
- Minimize energy and resource consumption in product use
- Promote maintenance
- Provide long life
- Use structural features and high quality materials to minimize weight
- Use better materials, surface treatments or structural arrangements to protect products from dirt, corrosion and wear
- Arrange in advance for upgrading, repair and recycling, through good access, labeling, modules and breakpoints, and provide good manuals
- Promote upgrading, repair and recycle by using few, simple, recycled, unblended materials, and do not use alloys
- Use minimum joining elements possible, using screw, adhesives, welding, snap fits, geometric locking etc. according to Life Cycle Analysis

All of which contribute to a frequently forgotten phase, the product`s after life.

End-of-life options

End-of-Life (EoL) options must consider reducing environmental impacts at disposal as reducing the amount of waste in landfills.

EoL options include:
1) Repair: Replacing parts and repairing joints.
2) Recycle: Processing parts and incorporating them in another products
3) Reuse: Also referred to as second-hand furniture
4) Upcycle: A form of recycling involves turning waste material into a better quality. (Walimbe, Chitgopkar, 2009)

Digitalization

The design process has drastically shifted in the last couple of decades from the traditional paper-based to the digital. The evolution of digital design as a unique field of design knowledge, supported by new technologies, and producing unique understanding of designs is a phenomenon that is rapidly crystallizing in this decade. (Oxman. 2012).

Even though many computational systems were implemented in the early 60s including CRAFT, Sketchpad computer program, CAD and building information modeling (BIM). These became commercially available in the early 1980s, with the emergence of building performance simulation tools thereby empowering designers to analyze their designs in terms of different performance criteria.

Hence, many tools were created by architects, programmers and coders to ease the interaction between the architect and the software, optimizing the product, reducing time and increasing efficiency and level of detail (LoD). While these tools were originally made to help the design process, they later affected the design process itself.

The importance of a digital tool that supports environmental furniture design

The traditional role of the visual image in design once occupied by the visual strokes of the designer's pencil is today transposed and explicated by the computer's algorithmic processes. The designer's former direct relationship with visual representations through hand drawing or sketching are being replaced in digital design by visual images generated by computational processes. While processes of visual reasoning still maintain their roles in design, they have been transformed from the conventional interpretation models in which the direct experience of the visual content is replaced by coding and scripting languages in digital design. Today, the designer interacts with visual programs in modifying and advancing the processes of design by mediating computational design components or by modifying the variables of scripts and codes. (Oxman, 2017).

With this great shift in the design method, processes and tools, it is crucial that a digital tool that supports sustainable design in the field of furniture is created and improved.

3. Conclusion

This paper sets the criteria for furniture design by investigating sustainability; offers definitions, pillars and philosophy, and gives design methodologies. All of which leading to set a framework for a digital tool that will increase sustainability and help generate sustainable furniture design.

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