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Sustainable Buildings and Interior Design

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Abstract. *This paper's main goal is to identify ways to evaluate the environmental impact of buildings and the interaction with Interior Design practices. Thus, it highlights the importance of considering the life cycle of the products inserted in the internal environment, in order to promote well-being and quality of life for user and preserve the environment. A survey of the literature in the area was carried out and, enabling detecting ways of applying sustainable concepts and practices focused on Interior Design, so that the proposed objective could be successfully achieved. The literature review detected a scarcity of Brazilian empirical studies of the applicability of Sustainable Interior Design. In the international literature, studies were identified such as Kang and Guerin (2009), which point out the need to develop teaching methods to improve Sustainable Interior Design practices in the North American environment, highlighting the importance of evaluating the life cycle of the materials used in projects. Thus, the role of interior designers goes beyond the conventional: in addition to developing projects, they should also act as educators. It is up to contemporary interior designers to introduce new ideas and values in the field of sustainable products and spaces, not limited only to their customers, but also covering society in general.*

Keywords. *Sustainable Buildings; Interior Design; Sustainable Interior Design.*

1 Introduction

Since the emergence of the concept of sustainability in the 1970s, the idea of sustainable development has been used as a new standard for society, considering the balance between economic growth and concern for social and environmental issues (PEREIRA; VIEIRA, 2009). According to the Brundtland Report (1987), the concept of sustainable development encompasses the social, environmental and economic spheres, and sustainable actions must embrace these three dimensions in order to succeed. Such development must meet the needs of present generations without compromising the ability of future generations to meet their own needs (BRUNDTLAND, 1987).

The current demand for resources is increasing all over the world, with no predictions of slowing down. The search for economic growth and increasing urban occupation entail impacts of high complexity and difficult repair to the environment (SORRENTO, 2012). In this context, a need for reflection on environmental issues in all areas of knowledge has been identified, including in the scope of construction field, where sustainability precepts must be considered from the beginning phase until its implementation (PEREIRA et al., 2008).

Among the specialties of Design is Interior Design, which is related to the development of internal environments. For Kang (2004), the construction, maintenance, and use of internal spaces demand the use

of diverse materials and equipment derived or dependent on natural resources. Such demand potentially causes environmental damage, and interior designers must strive to minimize these impacts by developing projects that are environmentally, socially, and economically sustainable. In this context, the concept of Sustainable Interior Design has arisen. It consists of a set of materials and systems that are geared toward limiting the potential negative effects on the ecosystem and its inhabitants and maximizing positive effects within the environmental, social, and economic spheres for the duration of the building's life cycle (KANG and GUERIN, 2009).

Life Cycle Assessment (LCA) can be considered one of the most effective methods to identify the real impact that an industrial process has on the environment (PEREIRA, 2003; SANTOS and PEREIRA, 2008). It is also known that Interior Design has great potential as an ally in search of sustainable development, when associated to methods that help minimizing the impact that its components generate to the ecosystem. Despite this finding, Brazilian literature is still scarce in terms of the potential of this alliance, thus raising the following research problem:

What is the potential of Interior Design with regard to the conception of sustainable buildings?

Based on the question raised above, it's defined as general objective of the study to identify the influence exerted by Interior Design on the construction of sustainable buildings, the importance of thinking about

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Sustainable Design and considering the life cycle of the products included in the projected internal environment, with the intention of promoting greater well-being and quality of life for users of the space and to preserve the environment. The specific objectives of the article can be defined as:

- To select effective methods in the existing literature to minimize the environmental impact of buildings.
- To identify examples of practices through which Interior Design can assist in promoting sustainability.

2 Sustainable Buildings

Sustainable projects consist of the practice of creating healthier building models that use renewable sources in their construction, renovation, operation, maintenance and demolition. These buildings must be efficient (sustainable), adequate to users and comfortable, quantitatively and qualitatively (PEREIRA, 2008). Pereira (2008) mentions studies of energy consumption in the life cycle of buildings, aiming to reduce their environmental impact. These studies, however, are scarce when considering Brazilian reality. This finding reinforces the need to develop research that strengthens the discourse of Sustainable Interior Design, since the intersection between Engineering, Architecture and Design occurs at several levels, and these areas are complementary and interdependent.

Sustainable construction is described as a constructive system that alters the environment in a conscious way, in order to meet the needs of housing, edification and use by the individual in the modern world, while also contributing to the preservation of the environment and its natural resources, guaranteeing quality of life for the present and future generations. Energy efficiency is one of the essential aspects of sustainable buildings. Studies show that artificial lighting accounts for 24% of the energy consumed in commercial buildings, air conditioning 48%, office equipment 15% and lifts and pumps 13% (LAMBERTS et al., 2011). This information shows the importance of the development of architectural and Interior Design projects that prioritize the use of natural lighting and ventilation, responsible for 72% of the energy consumed in commercial buildings. In addition to the prioritization of natural light and ventilation, sensitive thermal and lighting systems also help to save energy and provide greater comfort to users.

Werner Sobek (a German architect), in an interview published in *Téchné* magazine, highlighted the concept of "triple zero". This concept refers to a building that requires zero energy for its operation, using renewable sources in the building itself, having zero CO₂ emissions throughout its entire process and producing zero waste throughout its useful life. "Triple zero" is a daring concept, but in the long term there is a high economic return, mainly through energy savings, and the environmental impact caused by buildings is considerably minimized (TAMAKI, 2011).

Another important factor to consider in a sustainable building is the specification of materials. These materials and products must meet certain specific criteria so they can be classified as sustainable and raise the standard of construction, the quality of life of individuals and the surroundings. Some of these criteria are: origin and extraction of the raw material, processing, energy consumption for its transformation, emission of pollutants, durability and quality, among others. It is of crucial importance to avoid use of materials whose properties are associated with environmental problems or health hazards of individuals in contact with them (ARAÚJO, 2008).

According to Pereira et al. (2008), the diffusion and use of wood of different types, not only those widely known and used in the market, can also be used as an alternative to promote a more sustainable project. This practice helps to avoid abusive and selective deforestation, covering a wider range of species options, managed in different ways. The lack of knowledge faced by consumers, and even professionals in the area, entails standardization of the species used, so the diffusion of information on the specificities of other species available in the market is necessary (PEREIRA et al., 2008).

Sustainable construction should aim at self-sufficiency and, ideally, self-sustainability, which is the ability to self-sustain and meet one's own needs by generating and recycling one's own resources in the building itself. There are nine steps that summarize the general guidelines for sustainable buildings:

Table 1. General guidelines for sustainable buildings.

Step	Description
Energy Efficiency	Minimize or solve the energy demands generated by the building, prioritizing the use of renewable energies and systems that help reduce energy consumption.
Rational Use of Materials	Use materials that do not negatively affect the environment, the health of individuals and that contribute to promote environmental awareness.
Air Quality	Develop an integrated internal and external environment, along with the local landscape, and promote higher air quality by prioritizing natural ventilation.
Waste Management	Promote efficiency in the management of waste generated by the occupants of the building, by locally minimizing its generation.
Water Management	Save water, treat it (locally) and recycle it. It is also important to harness alternative sources, like rainwater.

Sustainable Construction Planning	The building must have a long life cycle, be economical and contain only materials that can be reused or recycled at the end of its use. The ideal goal should be zero waste.
Thermo-Acoustic Comfort	Provide comfortable thermo-acoustic conditions, with the purpose of improving the physical and psychic quality of life of occupants.
Use of Environmentally Friendly Products and Technologies	Prioritize companies that are concerned with environmental, social and cultural aspects and have the necessary certifications.
Use of Natural Resources	Use the wind, sun, humidity and vegetation, with the purpose of promoting well-being for the individuals and integrate the building with its environment, in addition to saving finite resources, such as water and energy.

Source: Araújo (2008)

Even though it is important to focus in responsible material's specification and passive energy during use, sustainable construction also encompass choosing suppliers and contractors wich have positive environmental credentials, aiming for zero waste-to-landfill during construction or demolition.

3 Sustainable Interior Design Practices

Sustainable Interior Design consists of a quest to maximize the positive impacts and minimize the negative impacts on the ecosystem, the economy and society, and extend the life cycle of the elements contained within a building. Such actions promote a harmonious alliance between environmental, economic and social development, but are still not widely practiced by Interior Design professionals (KANG and GUERIN, 2009)

The ReGreen guidelines (2008) list sustainable practices in Interior Design, focusing on residential projects. Likewise, LEED™ for commercial interiors (2016) also provides practical guidelines for Sustainable Interior Design in enterprises. Among these practices, lighting optimization is highlighted as essential for reducing the amount of energy consumed in buildings, by optimizing the use of natural light over artificial lighting.

The paper focuses its discussion on just ReGreen by ASID and LEED by USGBC. Although there are others organisms, we did not include others certifications, like BREEAM (Building Research Establishment Environmental Assessment Method), published by the UK's Building Research Establishment (BRE); Green Star, by New Zealand's, Australia's and South Africa's Green Building Council; and WELL Building Standard, by the International WELL Building

Institute (IWBI) (BREEAM, 2017; GREEN BUILDING COUNCIL AUSTRALIA, 2017; IWBI, 2017).

Table 2. Practical guidelines for applying Sustainable Interior Design - Lighting.

ReGreen	LEED
Develop lighting projects that are more flexible and less dependent on the current layout of the space.	Adopt automatic curtain and lighting control systems: Intelligent systems optimize the use of artificial light and help save energy.
Always choose natural lighting over artificial lighting.	Always prioritize natural light and allow as many individuals as possible to have access to outdoor views.

Source: Adapted from ReGreen (2008) and LEED (2016)

In addition, among the guidelines, the use of resources and materials that do not negatively affect the environment is also highlighted (Table 3).

Table 3. Practical guidelines for applying Sustainable Interior Design - Resources and materials.

ReGreen	LEED
Use materials that do not contain toxic substances or that come from rapidly renewable sources in order to help reduce the area used to grow building materials.	Minimize or solve the energy demands generated by building, prioritizing the use of renewable energies and systems that help reduce energy consumption.
Consider the durability and the recycling capacity of materials and products to avoid their disposal in landfills.	
Specify standard sized products to avoid material waste.	

Source: Adapted from ReGreen (2008) and LEED (2016)

The guidelines also highlight the need to prioritize products from companies that are concerned with environmental and social aspects, and have the appropriate certifications for each sector.

Table 4. Practical guidelines for applying Sustainable Interior Design - Choice of suppliers and use of environmentally friendly equipment/technologies.

ReGreen	LEED
Hire contractors that use the LEED™ rating system.	Specify materials produced regionally or within an 800 km radius, avoiding the use of petroleum based fuels.
Specify appliances with the EnergyStar™ standard for energy efficiency.	
Choose suppliers that have the necessary certification, ensuring that inputs come	

from an ecologically and socially correct production process.	
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Source: Adapted from ReGreen (2008) and LEED (2016)

In the development phase of the project, the need to develop flexible designs is emphasized so that they can be adapted to different layouts without the need for significant changes, and consequently, without the unnecessary disposal of materials (Table 5).

Table 5. Practical guidelines for applying Sustainable Interior Design - Layout.

ReGreen	LEED
Prioritize durable designs, anticipating possible future changes.	Develop a timeless design, avoiding future remodelling and unnecessary disposal of materials.

Source: Adapted from ReGreen (2008) and LEED (2016)

Lastly, LEED, considering commercial buildings, highlights the need for specific infrastructure to provide adequate management of the waste produced by buildings (Table 6).

Table 6. Practical guidelines for applying Sustainable Interior Design - Waste management.

ReGreen	LEED
	Install waste baskets with divisions for plastic, paper, metal, glass and organic products, available in places with easy access.

Source: Adapted from ReGreen (2008) and LEED (2016)

Further research sought to evaluate the actual application of Sustainable Design practices by professionals in the area. Among the works, Kang and Guerin's (2009) research is highlighted. That survey evaluated the current stage of evolution of Sustainable Interior Design. The results obtained by the authors indicated that students and professionals in the area do not have enough information about the specific characteristics of Sustainable Interior Design to put it into practice, although they understand the importance of the concept.

Wingate (2014) examined the relationship between popular perception and Sustainable Interior Design practices in the residential setting. Wingate (2014) concluded that the factor that influences the integration of the characteristics of Sustainable Interior Design in the residential context is the environmental attitude. However, the literature on Brazilian reality is lacking studies in this area. Zmyslowski (2009), for example, discussed the link between sustainability and Interior Design, but did not present an empirical approach.

4 Life Cycle Assessment (LCA)

According to Ézio Manzini, as cited in Pereira and Vieira (2009), designers should promote social innovations and guide society on the right path. They should actively work to develop Design for sustainability. However, environmental issues are still not widely considered in the previous phases of design, unlike factors such as aesthetics and functionality (PEREIRA, 2003).

Life cycle assessment is an evaluation method that considers consumption of energy, water and raw materials, the waste produced and the quantity of gaseous and aqueous pollutants emitted during industrial processes. This method was introduced by the Midwest Research Institute of the United States in 1974 (QUARANTE, 1994 apud PEREIRA, 2003).

The concept of LCA can be defined as a quantitative balance of matter and energy flows exchanged with the environment (input and output) and potential impacts caused by a production system throughout its life cycle when it comes to health and the well-being of humans, animals and plants, or regarding the availability of natural resources in the future (PEREIRA et al., 2006; SANTOS and PEREIRA, 2008). Through application of the LCA methods, it is possible to improve the ecological aspects of products, helping to choose indicators and also decisions regarding the design phase. The method consists of analysing the raw materials, including the services and products associated with them, as well as the secondary raw materials, and the energy spent in the life cycle of industrial products in various areas. Life cycle assessment is complex and requires multidisciplinary cooperation, so it is important for professionals specialized in diverse areas to work together. In this concept, the flow (input and output) in each process is considered from the extraction of the raw material to the final disposal of the residue in the environment (SANTOS and PEREIRA, 2008). This method, however, does not effectively consider economic and social aspects associated with the product in question (PEREIRA, 2003).

Qualitative alternatives for LCA have also been developed from the Sustainable Design approach, based on simplified life cycle information, as well as other information and indicators outside the scope of LCA. These indicators identify, for example, the recycling capacity of the product, the specification of materials that are harmful to health, the number of components that can be reused, the cost of the materials and their difficulty of segregation in dismantling (ADDA and JEAN, 1999, apud PEREIRA, 2003). The methods are easier to put into practice when dealing with these approaches, and do not require much specific knowledge by practitioners who apply them. This factor also provides an evaluation with less time spent, allowing its application in small and medium enterprises (LINDAHL, 1999, apud PEREIRA, 2003).

Sustainable Design entails consideration of what will be consumed, produced, processed and discarded. It must have the ability to predict and plan its impacts

before, during and at the end of a building's useful life. The most effective and complete tool to quantify these impacts is LCA, which is accepted by the entire international community as the only legitimate basis for comparing technologies, materials, components and services provided and used (ARAÚJO, 2008).

Schneiderman and Freihoefer (2012) point out that discussing materials in Design universities can serve as a starting point for perceiving the importance of designing with ecological and sustainable awareness. Interior designers should specify materials that can be recycled, derived from renewable resources that do not emit pollutants that can be harmful to the environment. However, to go beyond basic environmental knowledge and understand sustainability in an integrated way, students should also consider a set of criteria that reflect the potential impacts of the materials used, including the impact of the full production process and also the end of product's life, possible reuse, recycling or disposal.

Therefore, the importance of understanding life cycle assessment (LCA) is highlighted in this field, as this method can be applied to Interior Design to assist the decision-making of professionals in the area. Associated with the Sustainable Interior Design guidelines, LCA can help extend the life cycle of the internal environment and the components present in it, as well as minimizing the impacts generated by them.

5 Final Considerations and Suggestions for Future Research

The present study sought to detect methods by which Interior Design can assist in the development of more sustainable buildings, as well as to identify examples of sustainable practices applied to Interior Design projects. Based on an essentially bibliographical research, it identified that sustainable practices are applicable to most Interior Design projects, both commercial and residential.

The quality of the internal environment and its elements are factors directly related to the interior designer. Thus, concern with lighting (prioritizing natural instead of artificial lighting) and thermal comfort; the origin of materials (from faster renewable sources and environmentally/socially correct processes) and the reuse and rationalization of water, are examples of issues that should be considered in the development of sustainable interior designs (ZMYSLOWSKI, 2009).

Observing the guidelines for sustainable buildings proposed by ReGreen and LEED many practices in common are revealed, most of them directly related to Interior Design. The three guidelines focus on the optimization of energy, prioritizing natural lighting and ventilation as an alternative to reduce their consumption, as well as the specification of highly recyclable materials from renewable sources that do not harm the well-being of the environment and the health of occupants (ARAÚJO, 2008; REGREEN, 2008; LEED, 2016). Therefore, combining sustainable practices with architecture and Interior Design can increase the energy efficiency of a building, reduce the amount of residues it

produces, extend its life cycle by specifying durable materials and products originating from "clean" processes, through more flexible designs, suited to different uses.

There is also a need to broaden students' and professionals' understanding of concepts related to sustainability, since they have low knowledge or understanding of sustainable design. In particular, life cycle assessment is considered an effective tool to measure the impact of the entire production process (e.g., manufacturing, transportation, impact of the human workforce), as well as after the end of use, possible reuse, recycling or disposal (SCHNEIDERMAN and FREIHOEFER, 2012).

The main study's limitation is the fact that it is a literature survey, without carrying out any applied empirical research. As a suggestion for future studies, we highlight the need for future tests, based in the existing literature from other countries, to detect if it could be applied to the Brazilian's reality and identify Brazil's specificities. Thus, it's suggested for future research the conduction of empirical studies to identify Sustainable Interior Design practices in Brazil's reality context, so that these actions can be more easily applied by Brazilian professionals in the field.

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