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Eco-efficiency Measures for Sustainability

Eco-efficiency is defined as the delivery of cost-effective products and services that meet human needs and improve quality of life, while progressively reducing ecological impacts and resource use throughout their life cycle, aligning with the earth's carrying capacity. It emphasizes efficient use of materials and energy to achieve profitability and value addition.

Introduction

First of all, eco-efficiency is about designing products that reduce environmental impact while still meeting people’s needs. In this project, the cocoon is designed to help reduce children’s anxiety in waiting rooms through calming scents, visuals, and sounds, while also being accessible (including wheelchair access) and hygienic

Because this is a healthcare-related environment, sustainability is not only about the environment but also about well-being and safety. Research **[1]** shows that the design of spaces, including sound, light, and sensory elements, can have a strong impact on stress and anxiety levels, especially in children.

Environmental

From an environmental point of view, the main focus is on the materials used and their impact. There are several aspects about it:

- Recycling
- Reducing
- Re-using

When it comes to the product, it is essential to limit its harmful impact on the environment. This can be done by cutting down, reusing, and recycling raw materials, considering energy use throughout every stage of the project, and reducing transportation as much as possible.

Regarding our project: The cocoon uses aluminium and brass, which are good choices in terms of sustainability because they are very durable and highly recyclable. Aluminium, especially, can be recycled many times without losing quality, which fits well with circular design principles.

However, materials like acoustic foam can be problematic because they are often made from petroleum-based products and can release harmful emissions like Volatile Organic Compounds (VOCs). According to studies **[2]** and **[3]**, more sustainable alternatives include recycled textile-based acoustic panels or Polyethylene Terephthalate (PET) felt, which can achieve similar acoustic performance with lower environmental impact.

The antimicrobial technical textile is important for hygiene, but it’s also important to make sure it has low chemical emissions and is safe for indoor air quality, especially since children are more sensitive to pollutants.

Another important aspect of the project’s sustainability is the decision to work with Portuguese suppliers. By sourcing materials locally, the environmental impact related to transportation can be

reduced, especially in terms of CO_2 emissions from long-distance shipping. Research in sustainable supply chains **[4]** shows that transport distance is directly linked to carbon emissions, and reducing this distance is an effective way to lower the overall environmental impact of a product.

In addition, transportation is a major contributor to global greenhouse gas emissions, with the transport sector accounting for a significant share of energy-related emissions **[5]**.

By working with local suppliers, the project can therefore reduce transport distances and associated emissions. At the same time, this approach supports the local economy, allows for shorter delivery times, and improves communication and quality control. For this project, materials such as aluminium, technical textiles, and acoustic solutions should, whenever possible, be sourced from suppliers based in Portugal.

Economical

The economic aspect of sustainability focuses on creating long-term economic growth, profitability, and stability without harming environmental or social systems. It ensures businesses remain viable while operating ethically, using resources efficiently, and fostering innovation.

This aspect can be an issue because it is often the most challenging, as it is closely tied to political perspectives, influencing views on what is considered economically viable, as well as the potential impact on businesses, employment, and job opportunities.

It is important to offer incentives that motivate companies to go beyond legal requirements and follow sustainable practices. At the same time, individuals should be encouraged to contribute in whatever ways they can, whenever possible.

Social

The social aspect is actually one of the most important parts of this project.

The cocoon is designed to create a safe and calming space for children, helping to reduce anxiety while they wait.

Accessibility is also key. By including wheelchair access, the design becomes more inclusive and usable for a wider range of children, which is an important part of sustainable design.

The use of non-toxic and antimicrobial materials also improves safety, especially for children who may be more vulnerable to infections or poor air quality.

Additionally, reducing noise and stress doesn’t just help patients—it can also improve the experience for parents and healthcare staff, making the whole environment more comfortable.

Life Cycle Analysis

Looking at the full life cycle of the cocoon helps understand its overall impact.
Here are the different phases:

- Materials: Aluminium and brass require a lot of energy to produce, but they can be recycled, which reduces long-term impact. Textiles and acoustic materials could be improved by using recycled or bio-based options.
- Production: The cocoon is designed with a structure using aluminium bows and brass panels. Prefabricated parts reduce manufacturing waste and energy use, and assembling the cocoon on-site is more efficient than building it from scratch. Choosing low-energy manufacturing processes for metal bending, panel cutting, and textile finishing can also make a difference.
- Transport: Transporting materials can contribute significantly to the product's carbon footprint, especially for heavy or bulky items like brass panels or acoustic boards. By sourcing materials from Portuguese suppliers (F. Marques da Silva S.A. **[6]**, **[7]**, Artnovion **[8]**, Monteiro Fabrics **[9]**, we can reduce transport distances, which lowers CO_2 emissions, shortens delivery times, and simplifies logistics. Using local suppliers also supports the local economy and makes communication and quality control easier.
- Use: The cocoon is designed to last a long time, thanks to durable metals and textiles. Low maintenance requirements (especially with antimicrobial textiles) reduce environmental and economic costs during use. Additionally, by providing calming sounds and visuals, the cocoon helps reduce stress in children, which is a social benefit not usually quantified in LCA but is an important part of its life-cycle value.
- End-of-life: The design allows for disassembly and recycling. Aluminium and brass can be fully recycled, while textiles and acoustic materials could be reused or repurposed if chosen carefully. Designing for end-of-life reduces waste and supports circular economy principles. Choosing more recyclable or bio-based materials further improves sustainability.

Summary

The LCA shows that the main impacts are in material production and transportation, while the use and end-of-life phases have lower environmental burdens if the materials are durable and recyclable. By choosing local suppliers, modular construction, and sustainable materials, the cocoon project maximizes eco-efficiency while still being functional, safe, and calming for children.

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