

Sustainable sustainability in interiors through I(E-)nnovative modular systems



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Abstract

The primary strategy for manufacturing sustainable products for interiors environment is to use recycled or repurposed raw materials and to develop new materials with minimum embedded carbon. However, the use of such products is still to get desired traction in mainstream interiors industry due to lack of other distinct differentiations and cost factors.

Moreover, with this strategy many products like carpet, tiles, paints, glass are available but may be considered inadequate in case of modular systems for interiors like partitions, ceilings, panelling, workstations etc, which may have potential to incorporate many more attributes for more sustainability – future modifiability for instance.

For accelerated and urgent fulfilment of sustainability goals, more effective and alternate strategies to design and manufacture sustainable interior building materials with attributes such as innovation, creative freedom for designers, customizability and variants, cost-effectiveness, high performance is desired.

Research for solution to such demanding requirements led through many books and resources on the net. It was surmised that these strategies could be inspired from movements like “frugal innovation” and other domains like “building block toys”.

Concept of using minimum and innovatively engineered components, made with recycled materials, with possibility of numerous assembly configurations to make modular systems, can provide creative flexibility to designers. This can drive widespread appeal and use, reduce development and manufacturing costs, logistics and carbon footprint, as well as allow future modification to end-users for long life cycle.

This would however require a continuous commitment to innovation at all levels of an organization, for which the author has coined the term “Entrepreneurial innovation” or E-nnovation. Such all-encompassing strategy can help percolate use of sustainable material to mainstream interiors projects effortlessly and contribute

significantly in the drive for sustainability. More such innovative strategies need to be researched and crystallized to enhance the use of sustainable materials.

Thesis statement

There is an urgent need for strategies to make available innovative, customizable and cost-effective modular systems in Interiors, which can help drive sustainability goals, effortlessly to some extent, in mainstream interior design and projects

Introduction

Sustainability in interior design is vital due to limited resources and the urgency to achieve net-zero goals. Despite increased awareness, legislative efforts, and technological advancements, the adoption of sustainable practices in the interior industry remains slow and uneven. Efforts have primarily focused on energy-efficient lighting and air conditioning, while sustainable design in interiors is often limited to select projects, constrained by economic factors, limited awareness, and weak regulations.

The mainstream interior industry tends to prioritize aesthetics, functionality, and creativity over sustainability, treating it as an isolated consideration rather than integrating it into design principles. While recycled and repurposed materials like carpets, boards, and tiles with low VOCs and recycled content are available, their adoption is hindered by higher costs and a lack of distinctive, innovative features to appeal to the broader market. These products are typically chosen for projects driven by environmentally conscious stakeholders or those seeking sustainability certifications.

Another challenge lies in balancing the need for change in interior environments with the long-term durability required for sustainability. Modular systems, including partitions, ceilings, and workstations, hold significant potential for addressing these challenges. However, only a few modular systems are certified as sustainable, and they often face similar barriers, such as limited innovation and higher costs, due to the focus on recycled materials without fully leveraging modularity.

Modularity itself is a sustainable strategy, enabling mass production, cost-effectiveness, and efficient resource use. It offers opportunities to incorporate creative freedom, customization, and future adaptability—currently constrained in many available modular systems. To advance sustainability, the industry must explore and implement innovative strategies to design and manufacture modular systems that are cost-effective, customizable, and future-proof.

Drawing inspiration from other domains, such as modular block toys, can provide valuable insights for developing sustainable solutions. By integrating these principles, modular systems can play a pivotal role in mainstreaming sustainability in the interior design industry and addressing its pressing environmental challenges.

Methodology

A desk-based, qualitative and exploratory approach was used to refer to multiple secondary sources, including published research papers, e-books, and industry reports.

- Data Collection
 - Literature Review:
 - Academic research papers and articles on modular systems, sustainability in interior design, and innovative strategies for materials and processes
 - Databases such as, Google Scholar, ResearchGate, and institutional repositories
 - Books and white papers authored by industry leaders and experts on sustainable materials and modular design
 - Platforms such as Amazon Kindle, Springer, and Elsevier
 - Industry Reports:
 - Study reports from global organizations and institutions such as the United Nations Environment Programme (UNEP), World Green Building Council, and Indian Green Building Council (IGBC)
 - Online Case Studies:
 - Investigated online case studies of companies and projects implementing modular systems effectively
 - Included examples from iqubx.com and similar organizations for in-depth understanding
- Data Analysis
 - Thematic Analysis: Identify recurring themes, such as barriers to sustainability, innovative solutions, and the role of modular systems.
 - Comparative Analysis: Compare various strategies and approaches across case studies and literature to evaluate their feasibility and potential impact.
- Framework Development
 - Develop a conceptual framework for innovative modular systems that incorporates principles of sustainability, innovation, and cost-effectiveness.
- Limitations
 - Absence of primary research may limit the depth of insights

Discussions/Findings

In the realm of manufacturing and buildings (Architecture), organizations are adopting modular approach to drive cost-effectiveness and sustainability. Some basic principles are observed.

1. **Modular Design Principles:** Implementing modular design allows for the creation of products composed of interchangeable components. This approach enhances flexibility, reduces costs, and facilitates customization by enabling the efficient configuration of products to meet specific customer needs.

Modularization subdivides the product logically to provide both economies of scale and the ability to create different configurations for increased value for customers. The modularity of a product is a measurement of how configurable it is, meaning how many combinations you can build with a given number of building blocks.

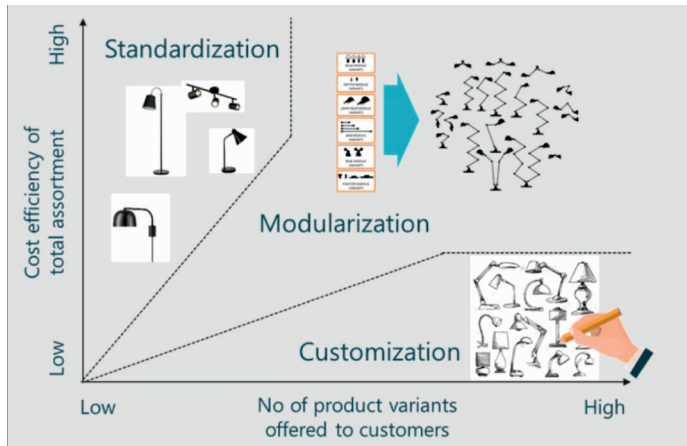


Figure 1: Benefits of Modularization

Modularization captures the benefits of standardization and customization as shown in Figure 1. Modular Systems are prevalent in product-focused industries such as home appliances, telecom, and project-oriented businesses such as software development to increase code reuse, enable parallel development, and reduce testing effort. [6]

2. **Standardization and Interoperability:** The construction industry is rapidly adopting modular construction as the go-to strategy to meet the demands for faster, more affordable, and environmentally sustainable building solutions. Standardized modular components enhance compatibility, simplify assembly,

and reduce production costs and time while supporting scalability and operational efficiency in modular construction. [7]

Design for Manufacturing and Assembly (DfMA): Integrating DfMA principles streamlines production and assembly processes, enhancing efficiency and reducing costs. In modular home construction, applying DfMA has been shown to shorten design phases and minimize production errors. By adhering to guidelines that simplify assembly and manufacturing, DfMA practices reduce complexity. Collaboration between design and production teams is essential for optimizing modular manufacturing outcomes. As shown in Figure 2, nine key concepts are essential for developing a comprehensive modular design strategy. [8]

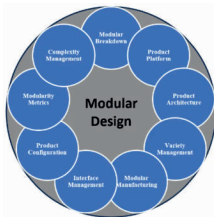


Figure : Key concepts for comprehensive modular design strategy

Flexible Manufacturing Systems: Developing modular product architectures allows for flexible manufacturing systems that can adapt to fluctuating market demands. This approach supports mass customization, enabling tailored solutions without significant cost increases, thereby enhancing both customizability and sustainability. [6]

Case Studies and References

“Jugaad” or “frugal innovation”, emphasizes creating cost-effective, efficient, and sustainable solutions by maximizing available resources. Frugal innovation focuses on resource efficiency by utilizing locally sourced and recycled materials to achieve more with less. It prioritizes simple, functional designs that streamline manufacturing and assembly, reduce production time and costs, and maintain quality.

Moladi Construction System: As shown in Figure 3, Moladi, a South African company, developed a cost-effective construction method using reusable plastic moulds to create modular structures that reduce material costs and construction time.

<https://moladi.blogspot.com/2015/06/frugal-innovation-in-africa-jugaad.html>

- Jugaad or Frugal Innovation: In their book "Frugal Innovation: How to Do More with Less", Navi Radjou and Jaideep Prabhu describe that emerging global marketplace demands speed and productivity by doing more with less, while creating sustainable value and reducing environmental impact. The authors discuss creating versatile products using minimal components. This approach aligns with the concept of modular design, where a limited set of standardized



Figure : Re-usable modular plastic framework

parts can be configured in various ways to produce multiple products.

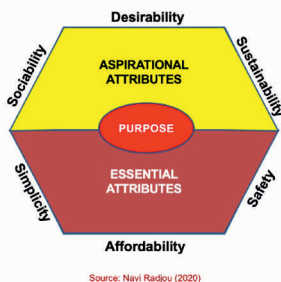
While the book provides numerous examples of frugal innovation, specific case studies illustrating the use of minimal

components to create different products are not explicitly detailed. [9]

- Frugal Innovation and Modular Design: In his study published in the Philosophical Transactions of the Royal Society A, Jaideep Prabhu explores how frugal innovation involves creating more value with fewer resources, often through modular designs that enhance sustainability and cost-effectiveness. [10]
- Modular Design in Interior Spaces: An article on Dreamden discusses how modular interior design uses pre-made, interchangeable pieces to create flexible and stylish spaces, allowing for customization and adaptability. [11]
- Frugal Innovation in Manufacturing: In his article in Forbes, Frugal innovation: Manufacturers' new imperatives, 2020, Navi Radjou highlights how manufacturers are adopting frugal innovation principles, such as modular design, to optimize resources and enhance product offerings. He espouses a framework for designing products demarcating their essential and aspirational attributes as shown on Figure 4. [12]

By integrating frugal innovation principles, designers and manufacturers of modular interior systems can develop solutions that are not only cost-effective and

THE 7 KEY PRODUCT ATTRIBUTES



Source: Navi Radjou (2020)

Figure : Framework for product development

customizable but also sustainable and responsive to the needs of diverse markets. Having achieved a broad understanding of strategies adopted in architecture and manufacturing, as well as having studied the broad principles of “Frugal innovation”, the attention was focussed on Building block toys like Lego™, which have inspired the author of this paper. No direct reference or any published article was found, but I would like to draw parallels between Lego™ toys and potential strategies for modular interior systems.

Watching my child build houses, trees, and cars with Lego™ blocks highlighted their use of minimal standardized components to create diverse outputs—a concept directly applicable to modular design strategies in industries like interior systems.

Key Principles and Parallels

Principle	Lego™	Modular Design in Interiors
Standardized Components for Versatility	A limited set of block types can be combined in countless configurations to create diverse structures like houses, cars, or trees.	A core set of modular components (e.g., panels, frames, connectors) can be assembled to create partitions, workstations, ceilings, or storage units, reducing the need for a vast inventory of unique parts.
Customization and Creativity	Users can creatively reconfigure blocks to design unique models, demonstrating high adaptability.	Modular components allow architects and designers to tailor spaces creatively, accommodating unique user requirements or aesthetic preferences.
Efficiency and Sustainability	Reusability of blocks encourages sustainability, as the same set can be used repeatedly without waste.	Using modular systems reduces waste during construction, promotes resource efficiency, and extends product lifecycle through reconfiguration.
Economy of Scale	Standardized production of blocks reduces manufacturing costs while maintaining quality.	Mass production of modular parts lowers costs and ensures consistency, making sustainable design more accessible.
Future Modifiability	Blocks can be disassembled and reused for new creations, ensuring long-term usability.	Systems designed for disassembly allow for reconfiguration or updates to meet changing needs, enhancing longevity and reducing environmental impact.

This approach aligns with the frugal innovation principle of "doing more with less" and is particularly effective in contexts demanding sustainability, cost-effectiveness,

and adaptability. By adopting a modular block strategy inspired by toys like Lego™, the interior design industry can achieve greater flexibility, creativity, and environmental sustainability in modular systems.

E-nnovation at work: Iqubx a Case study

A rigorous framework has been developed by at IQUBX modular interior systems on principles of frugal innovation – “maximum from minimum resources”.

Innovative modular systems have been designed from minimum possible number of components using recycled aluminium. As shown in Figure 6-8, these systems can be assembled in numerous configurations to give innovative, adaptable, customizable solutions depending on the diverse functional, aesthetic and performance requirements of both designers and end users.

This strategy reduces development time, costs, and carbon footprint, making systems cost-effective and sustainable. It offers creative freedom to designers with adaptable designs, increasing appeal to designers and end-users. Future modifiability ensures long lifecycles, while extrusion-based production enables scalable manufacturing with minimal steps, further enhancing efficiency and sustainability.



Figure : Different shapes of baffle ceilings created from same modular components

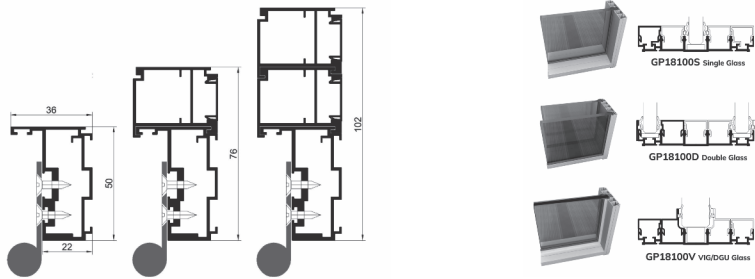


Figure: Three type of glass partitions to accommodate single glass, double glass and DGU in same system. The innovative construction also allows for very high sound insulation

Recycled aluminium has been chosen as the raw material because it:

- Has low embedded carbon
- Can be recycled endlessly without losing any material property
- Can be manufactured into highly detailed extrusions allowing complex design and flexible joinery
- Has high strength-to-weight ratio and low weight for lower logistics and handling costs

These systems are sustainable, cost-effective, and innovative, driving sustainability in mainstream interior projects through desirability rather than reliance on government incentives. Products like glass partitions, doors, baffle ceilings, and more are developed with speed and agility, offering custom solutions. Certified with Type 1 Ecolabel by the Green Products and Services Council, IQUBX holds the most Green-certified architectural products in India, along with three patents and over 100 design registrations, showcasing its commitment to innovation and sustainability.

www.iqubx.com

Conclusion

Innovative modular systems inspired by frugal innovation and building block concepts can advance sustainability in interior design. By prioritizing customizability, cost-effectiveness, and modifiability, these systems address barriers to adopting sustainable materials. The author's concept of "E-nnovation" emphasizes continuous innovation to achieve "Sustainable Sustainability." Collaboration among designers, manufacturers, and policymakers is vital to mainstream these systems in the industry.

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