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Role of Digital Technologies in Sustainable Material Selection for Interior Design

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Abstract
The interior design industry should undergo a drastic transformation because of the integration of digital technologies and the global push for sustainability. The selection of the correct material has become a complex and time-consuming procedure. The designer needs a great deal of knowledge and strong relationships with suppliers. Currently, many digital tools that help designers reshape, evaluate, and specify sustainable materials. Digital tools include **Building Information Modelling (BIM)**, **Artificial Intelligence (AI)**, **Augmented Reality (AR)**, and **Life Cycle Assessment (LCA)** (Khalil et al., 2025). This article explores how these technologies function in practice, their benefits, their limitations, and their future potential in making sustainable material selection more accessible, accurate, and efficient. Drawing from real-world examples and emerging research, the article demonstrates that these digital technologies are not merely tools but are becoming core agents of change in sustainable interior design practice.

Introduction
Material production in the construction industry, including the interior design sector, requires substantial energy. Materials such as cement, steel, flooring, tiles, paints, and stones produce significant environmental consequences (Płoszaj-Mazurek & Ryńska, 2024). All these materials are extracted from the earth, processed in factories, transported across continents, and installed in buildings. This process consumes substantial energy, generates carbon emissions, uses considerable water, and sometimes releases toxic chemicals. A deeper analysis shows that the interior design industry has emerged as a significant contributor to environmental problems. Designers have been implementing many sustainable materials, such as recycled materials, low-VOC paints, and **FSC-certified wood**, for decades, but these efforts have remained largely theoretical rather than being implemented in practice (Kang & Guerin, 2009).
All these materials are extracted from the Earth, processed in factories, transported across continents, and installed in buildings. This process consumes energy, generates carbon emissions, uses significant amounts of water, and sometimes releases toxic chemicals. If we deeply analyse, the interior design industry is a significant contributor to environmental problems (Hasırcı et al., 2025). Designers have been implementing many sustainable materials, such as recycled materials, low-VOC paints, and **FSC-certified wood**, for decades, yet the actual frequency of sustainable choices in practice remains limited (marlonbeach, 2021). But the practical question is how to solve this problem. How can designers quickly understand which material is sustainable? Is a bamboo floor more eco-friendly than reclaimed oak?

Does a recycled-content carpet tile have lower carbon emissions than virgin nylon? How do different materials perform over a building's entire lifetime? These questions are genuinely difficult to answer without detailed data, analytical tools, and time, and most designers have limited access to these.

But nowadays, digital platforms are changing this. We now have more opportunities to learn about materials. A new generation of software platforms, databases, simulation tools, and intelligent systems is making it possible for designers to access environmental data, simulate design outcomes, and make better-informed sustainability decisions in real time within their workflow. This article explores how these technologies function, why they matter, and what challenges still need to be overcome.

Understanding Sustainable Material Selection: The Core Challenge

Sustainability in material selection is not a single attribute; it is a multidimensional concept. If a material is considered sustainable, it has to satisfy many criteria, such as having a low carbon footprint during extraction, manufacturing, and transportation, not containing or releasing harmful chemicals during use, being durable enough to last for many years, and being able to be repaired, repurposed, or recycled at the end of its life.

A sustainable material is obtained in ways that do not deplete natural resources or harm ecosystems (Assali, 2020).

In practice, no material is perfect in all these dimensions. A highly durable material sometimes requires energy-intensive manufacturing. A locally sourced natural material might not meet fire safety codes.

Sometimes, a material with excellent recycled content might be difficult to recycle at the end of its life. Understanding all these factors requires substantial data.

The Limitations of the Traditional Process

The selection of materials in large quantities is always done manually. Designers receive samples from suppliers, consult product catalogues, trust certain brands, and attend exhibitions and trade shows. All these are based on their professional experience. This system works technically and functionally very well, but it is poorly equipped to handle environmental impact, energy use, material validation, sustainability, and related issues.

Suppliers are not always transparent about the environmental impact of materials. Certifications such as **LEED credits** and **Environmental Product Declarations (EPDs)** are not consistently applied. Comparing products from different suppliers using different standards is like comparing apples and oranges (Pichette et al., 2023). Most designers are unaware of material data related to environmental evaluation, such as the carbon footprint, life cycle assessment, and other sustainability indicators.

As a result, sustainability is often treated only as a checklist on paper. For example, sometimes a particular product is evaluated only because of its green label and recycled content, without a detailed assessment of its overall environmental impact.

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Designers use different software, such as Autodesk, Graphisoft, and ArchiCAD, to create models, understand the total embodied carbon of material choices, compare alternatives, and explore how different specifications affect the overall environmental performance of a project.

Some platforms help integrate real-time calculators that update automatically, allowing designers to see the sustainability implications of their choices without leaving their design environment.

EPD Integration and Material Libraries

Environmental Product Declarations (EPDs) are documents that provide the environmental data of a specific product. They help the construction industry understand the environmental profile of every material, similar to a nutritional label. Most manufacturers publish EPDs for their products, and designers and contractors get the opportunity to compare the environmental performance of materials. Several companies have developed digital platform libraries of EPD data, which can be integrated directly with the designer's workflow to improve the design process.

The **EC3 (Embodied Carbon in Construction Calculator)**, developed by **Building Transparency**, allows designers and contractors to compare the carbon footprint of different materials, enabling them to choose the material with the lowest carbon emissions. Integrating such tools with BIM models creates a seamless flow from material selection to environmental analysis.

Artificial Intelligence and Machine Learning in Material Recommendation

Artificial Intelligence (AI) plays a major role in selecting sustainable materials. It is a maturing field that provides access to a large volume of data faster than human beings, and it helps to identify patterns and make recommendations that would take designers hours or days to arrive at manually (Hu et al., 2025).

In the context of sustainable material selection, AI helps in several areas. It recommends materials by considering the project type, climatic zone, budget, sustainability targets, and aesthetic preferences, and suggests materials that fit those criteria.

It also helps designers by using simple question-and-processing tools, which enable them to search for sustainability information more intuitively. Machine learning tools are trained to predict how materials will age in a specific environment, as well as their durability and long-term sustainability (Arslan & Munawar, 2026).

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Software platforms such as LCA tools enable designers and architects to conduct simple Life Cycle Assessments of the materials they are working with alongside the design tools. **One Click LCA**, for example, can be integrated with BIM software or other design software, and the details or reports of the selected material specifications can be generated within hours. This tool is feasible not only as a one-time exercise but also as a regular part of design decision-making.

The ability to compare the lifetime environmental impact of different materials through these options is important, not just for upfront carbon but also for performance over decades. It can be a significant advance for sustainable design.

If a material appears very cheap and low impact at the point of purchase, it may carry significant long-term costs in energy, maintenance, and replacement. Life Cycle Assessment makes these hidden environmental and economic costs visible. Furthermore, emerging technologies like Large Language Models can accelerate these assessments by automating the extraction of technical specifications from disparate product documentation (Turhan, 2023).

Augmented Reality and Virtual Reality in Material Visualisation

One of the main challenges of sustainable materials is that, although they are environmentally responsible choices, they are sometimes not visually appealing to clients. Natural materials may have high recycled content and eco-friendly finishes, but they may not look glossy and perfectly finished to clients, at least not in a product brochure or in a small material sample.

Augmented Reality (AR) and Virtual Reality (VR) help to overcome this problem. They allow clients to virtually experience the surface finish and appearance of materials before samples are ordered and commitments are made. By using AR applications, clients can experience the real room and see how the flooring feels, how the walls appear, how light affects the interior, and how the materials look. This helps designers finalise the materials, and they can be ordered without any doubt.

A VR environment allows clients to experience the full interior space with specific material selections before construction begins. If clients want any changes after experiencing the fully rendered images, designers get the opportunity to change the materials before implementation, and they can achieve significant cost savings during execution. Companies such as **Twinmotion**, **Enscape**, and **Chaos Group** provide rendering and visualisation platforms that integrate with design software. At the beginning of the project, designers can generate photorealistic renderings of sustainable materials, and if any changes come from the client side, the materials can be easily modified. These platforms also provide details about the sustainability, environmental impact, and lifetime performance of those materials.

Parametric Design and Computational Optimisation

Parametric design is an approach to design in which the form, structure, or configuration of a space or object is controlled by adjustable parameters and rules rather than fixed manual decisions. In interior design, parametric design can be applied to material layout, pattern formation, acoustic design, surface configuration, and other design elements. When sustainability criteria are embedded into the parametric model, design software can explore thousands of design variations and identify the best design that meets both aesthetic and environmental objectives.

There are different platforms that offer similar capabilities, such as **Grasshopper** and **Dynamo**. There are also computational design plug-ins that support sustainability metrics.

In a practical sense, parametric optimisation helps designers determine the exact quantity of materials, optimise cutting patterns, and identify the most efficient structural configurations that require less material (Chen et al., 2023). It also helps balance cost, durability, and carbon footprint.

It is known that parametric design has historically been common in architectural and industrial design, and it is now becoming more accessible to interior designers through plug-and-play tools.

Real-World Applications and Case Studies

Healthcare Sector

In healthcare design, designers face many challenges. The products must be durable, non-toxic, antimicrobial, acoustically efficient, and visually calming while meeting strict health and safety regulations. Digital tools are very valuable in this sector.

Commercial Office Fit-Out

The commercial office sector has been an early adopter of digital sustainability tools. Corporate clients often demand green building certifications such as **LEED** and **WELL**.

Interior designers working on office projects use BIM, embodied carbon calculators, and Environmental Product Declaration (EPD) databases to meet increasingly ambitious sustainability targets that these rating systems require.

Residential High-End Design

Even in residential design, some clients prefer sustainability details in their projects, which are supported by digital technologies. For example, a studio in Singapore has developed a client-facing application that allows homeowners to see how different sustainable material options will look in their homes using their smartphones. Each sustainable product in the database is accompanied by a simple, consumer-friendly explanation of its environmental credentials.

When clients experience these visualisations, they get a better understanding of the different types of materials used in their homes. They can view natural clay plaster, terrazzo flooring, and other sustainable materials in their actual home environment rather than on a small sample card. As a result, they are more likely to choose these materials.

Benefits of Digital Technology in Sustainable Material Selection

Speed and Efficiency

The main benefit of using digital tools is reducing the time required to research and evaluate sustainable materials. Designers can spend several days conducting manual research, contacting suppliers, requesting data sheets, cross-referencing certifications, and calculating environmental impacts. This time saving makes it economically feasible to conduct sustainability analysis on projects of all scales, not just major institutional projects.

Improved Accuracy and Transparency

Digital tools reduce reliance on supplier claims and anecdotal information by replacing them with verified, standardised data. When an EPD-integrated platform is used to compare products, designers can be confident that the comparison is based on a consistent methodology rather than selectively chosen marketing statistics. This improved accuracy strengthens the credibility of sustainability claims and makes greenwashing—the practice of making false or misleading environmental claims—much harder to sustain.

Challenges and Limitations

Data Quality and Availability

The effectiveness of sustainable material and sustainability tools entirely depends on the quality and completeness of the data they contain. In the case of small manufacturers, developing countries, or traditional craft industries, there is often a lack of reliable environmental data. When data is missing, digital tools cannot provide meaningful analysis. Designers must fall back on estimates or assumptions that may not accurately reflect reality.

The quality of EPDs and environmental data also varies considerably. Different EPDs for similar products may use different system boundaries and impact assessment methods, making meaningful comparisons difficult. Even when data is available, the industry needs standardised and mandatory environmental data requirements for all building products. This remains aspirational rather than fully achieved.

Cost and Accessibility

While digital tools are democratising access to sustainability expertise, many of the most powerful platforms require significant licence costs. **One Click LCA**, BIM software subscriptions, and high-quality parametric design tools can represent a substantial expense for small design practices. Although affordable and free options are emerging, they generally offer less functionality and less comprehensive data than premium platforms.

Hardware costs also play a role. AR and VR applications require reasonably powerful smartphones, tablets, or headsets. Not only designers but also clients must have access to the necessary hardware, limiting the reach of these tools in some markets.

Skills and Training

Digital tools only deliver value if designers know how to use them effectively. Conducting sustainability analysis in BIM, interpreting LCA outputs, and setting up parametric optimisation models all require specialised skills that are not always included in interior design education programmes. Many designers were trained using traditional methods and therefore need to adapt to new digital tools.

Interior designers need to invest in continuous training if they want professional growth. They must continue practising and learning to keep up with new digital technologies. Likewise, educational institutions should update their curricula according to industry developments and include digital sustainability tools as a core component of interior design education.

The Future of Digital Technology in Sustainable Interior Design

Digital technology is changing the way buildings and interior spaces are designed. In the future, new technologies will help designers choose better materials, reduce waste, save energy, and protect the environment. These technologies will not replace designers, but they will make their work easier, faster, and more accurate.

One of the most important future technologies is **Artificial Intelligence (AI)**. AI can act as a smart assistant for designers. It can search for eco-friendly materials, compare different products, check their environmental impact, and suggest the best options based on the project. Instead of spending many hours searching for information, designers can use AI to get quick and useful suggestions while still making the final decision themselves.

Another exciting development is the **Digital Twin**. A digital twin is a virtual copy of a real building or room. It receives information from sensors installed in the building. These sensors can measure things such as temperature, energy use, air quality, and how materials wear over time. This helps designers understand how materials perform in real life and use that knowledge to improve future projects.

The future will also focus on the **Circular Economy**, which means using materials for as long as possible instead of throwing them away. Digital tools will help keep track of every material used in a building. This is done through **Material Passports**, which are digital records containing details such as where a material came from, what it is made of, when it was installed, how it should be maintained, and whether it can be reused or recycled. When a building is renovated or demolished, these records make it easier to recover valuable materials instead of sending them to landfills.

Another useful technology is **Blockchain**. Blockchain is a secure digital record that cannot be easily changed. It helps track a product from the factory to the construction site. For example, if a wooden floor is labelled as environmentally friendly, blockchain can prove where the wood came from and whether it was responsibly sourced. This increases trust and makes it easier for designers and customers to choose truly sustainable products.

Policy, Education, and Industry Support for Sustainable Interior Design

Digital technology is helping interior designers make better and more environmentally friendly choices. However, technology alone is not enough. Governments, educational institutions, industries, and professionals must work together to make sustainable interior design successful.

The **government** plays an important role by creating rules and standards that encourage the use of sustainable materials. Manufacturers should provide clear information about their products, such as where the materials come from, their environmental impact, and whether they can be recycled. Green building certification systems such as **LEED, BREEAM, WELL, and the Living Building Challenge** also encourage designers to use eco-friendly materials and digital tools to create healthier and more sustainable buildings.

Education and training are also very important. Interior design students should learn how to use modern digital tools such as **Building Information Modelling (BIM), Life Cycle Assessment (LCA) software, and digital material databases** during their studies. Professional designers should continue learning through workshops, certification programmes, and training courses. Material manufacturers and software companies can also support designers by providing simple learning resources and technical guidance.

Finally, **collaboration** among everyone involved in a construction project is essential. Sustainable material selection requires teamwork among material suppliers, manufacturers, interior designers, architects, contractors, and building owners. Digital technologies make it easier to share information, compare materials, and make better decisions. When everyone uses common standards and shares reliable data, the design process becomes more efficient, transparent, and environmentally responsible.

Conclusion

Digital technology has become an important part of sustainable interior design. Today, designers can use modern tools such as **Building Information Modelling (BIM), artificial intelligence (AI), Life Cycle Assessment (LCA) software, augmented reality (AR), and digital material databases** to select environmentally friendly materials more easily and accurately. These technologies help designers compare materials, understand their environmental impact, reduce waste, and make better decisions throughout the design process.

The use of digital tools also saves time, improves communication with clients, and makes sustainable design more affordable and accessible, even for small design firms. In addition, these technologies support the reuse and recycling of materials, helping to build a more sustainable and circular construction industry.

However, digital technology is not a complete solution. Some challenges still exist, such as limited environmental data for certain materials, the cost of advanced software, and the need for proper training. Most importantly, technology cannot replace the knowledge, creativity, and ethical responsibility of interior designers. Designers must continue to make thoughtful decisions that balance environmental protection, functionality, aesthetics, and the needs of users.

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