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Integration of Environmental and Social Values in Cultural Spaces: Sustainable and Inclusive Wayfinding Materials for Museums

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Abstract: In the context of use of large museum centers, numerous national and international methodological experiments show that the wayfinding project must consider the needs of both habitual users (user-centered design) and local communities (design for communities) and the importance of environmental protection (eco-design) as a priority interest of the community. This "double target", "user-centered" and "environment-centered" can be applied during the selection process of materials to be used in the project. With respect to these possibilities, this contribution intends to present the results of research focused on material characterization of the reception and distribution spaces of large museum centers. This characterization is based on use of sensory materials and aims to evaluate their impact on the usability and sustainability of wayfinding systems. The paper directed towards a proposal for organization of integrated information on new generation so-called smart materials; within the design of a wayfinding system, these can balance the aesthetic-perceptual and performance and environmental impact, in order to allow designers to make informed decisions oriented towards inclusion and sustainability. The study was addressed by conducting two phases of systematic literature and library review of materials. The investigations conducted led to achievement of a first research result which consists in the identification of a "standard sheet" for the mapping and cataloging of the materials used for wayfinding. The "standard sheet" allows organizing the information on smart, sensorial, and eco-friendly materials, balancing the aesthetic-perceptive component with the performance on the environmental impact along the entire life cycle in a circular perspective. This tool could guide designers towards an environmental communication project oriented towards sustainability and is effective for usability and wayfinding.

Key words: Wayfinding, eco-friendly materials, sensory materials, user-centered design, eco-design, innovative museum.

1. Introduction

The long participatory process that led to the new definition of a museum, and by extension, of a place of culture, approved by ICOM (International Council of Museums) on 24 August 2022 at the Extraordinary General Assembly in Prague emphasized the need to broaden the responsibilities of museums. In addition to the preservation of heritage, the importance of raising awareness of the issues of inclusion, accessibility, conservation, management, planning and transmission of cultural heritage to future generations was highlighted, placing museums in the broader category of services (Fig. 1). The key words and concepts most shared by the international community—consisting of 126 committees worldwide—were expressed in the following definition: the museum is a not-for-profit, permanent institution in the service of society, open to the public, accessible and inclusive; the museum promotes diversity and sustainability. These contents are included in the objectives expressed in the PNRR (National Recovery and Resilience Plan) Measure 1, C.3, Inv.1.2, "Removal of physical and cognitive barriers in museums, libraries and archives";

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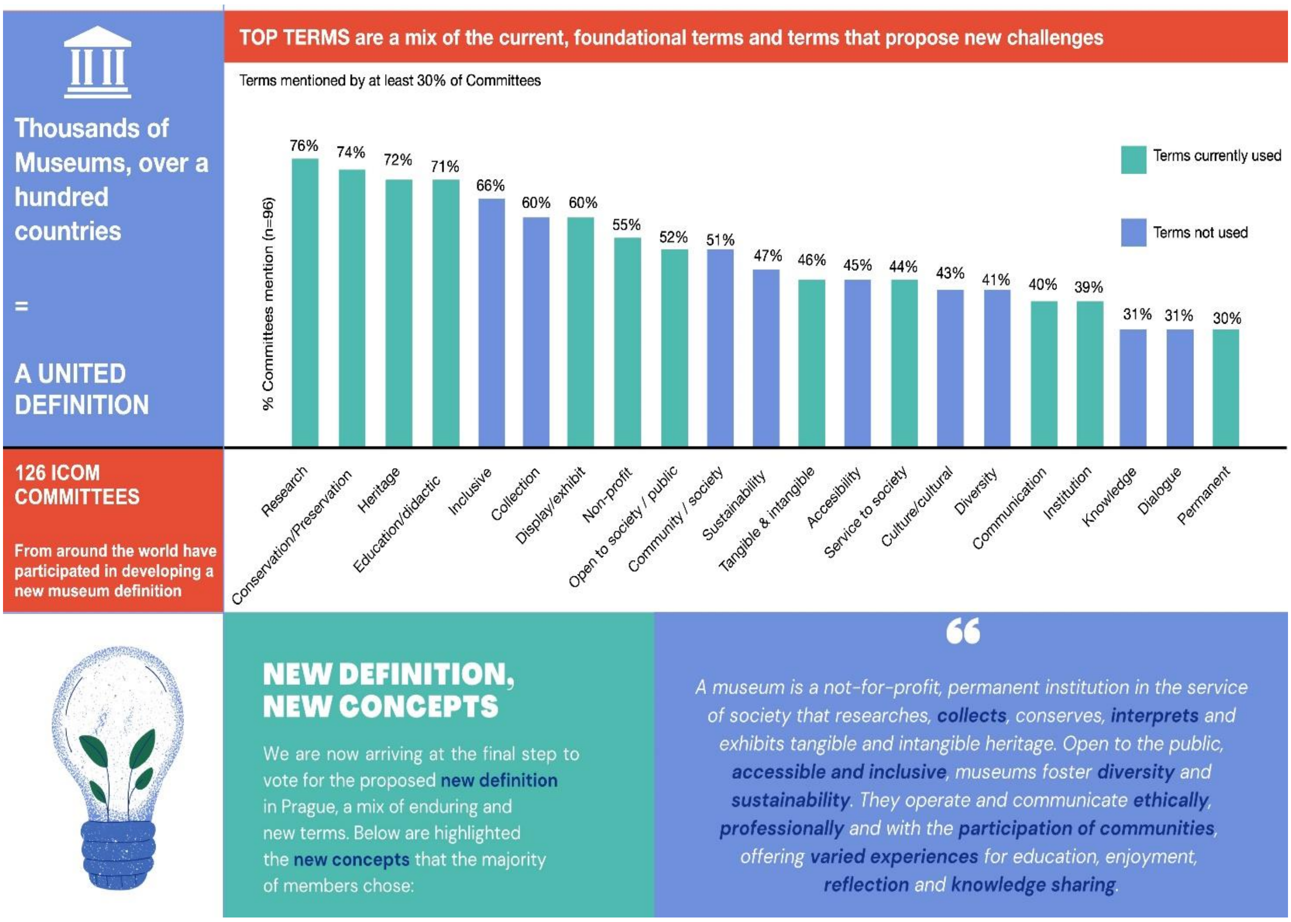

Fig. 1 Schematization of the process for the new definition of "museum". Graphic reworking by the authors.

and are shared by the progressive process of awareness of the environmental impact of public activities promoted by EU (European Union) Directives (2004/18/EC), the UN 2030 Agenda, the 8th Environmental Action Programme of the EU and the Italian PNRR. The latter introduces the reform on mandatory CAM (minimum environmental criteria), also foreseen for the cultural sector, a category not yet covered by the National Action Plan for Environmental Sustainability on GPP[1]. This is an orientation that can bring great benefits in terms of the environment and health, considering that public procurement represents about 17% of the GDP (gross domestic product) in Italy and about 14% in the countries of the EU, a non-marginal share of the market.

The museum is, therefore, identified as a service in terms of use, interaction with users and experience in which it is important to operate both according to the need for environmental protection (eco-design) and in relation to the needs of their more or less usual users (*user-centered design*) and local communities (*design for communities*, eco-museum) through processes of valorization of territorial identity, landscape and widespread cultural heritage, material and immaterial [1-3]. This "dual target", "user-centered" and "environment-centered" should be a constant in

[1] GPP (green public procurement) is an environmental policy instrument that aims to foster the development of a market for products and services with a reduced environmental impact through the lever of public demand, contributing, in a decisive way, to the achievement of the objectives of the main European strategies such as the Resource Efficiency or Circular Economy strategies. Among the various instruments, we find the definition of minimum environmental criteria (CAM), defined for the various phases of the purchasing process, aimed at identifying the best design solution, product or service from an environmental point of view along the life cycle, taking into account market availability.

cultural contexts, but in museum spaces it reveals its greatest effectiveness especially in the context of wayfinding projects [4]. The latter deals not only with communication systems (signage), but also with the organization and connotation of space such as to facilitate the development of cognitive maps, facilitate perceptive processes, improve the quality of human-environment interaction and appreciation of the venue itself and give a new visual identity to the reception and exhibition spaces. When designing an inclusive and sustainable wayfinding system that provides a coordinated image of communication spaces and artefacts, the selection of materials plays a decisive role as it can significantly influence the user experience, ensuring an accessible environment for all and reducing the environmental impact in the long term.

The paper is directed towards a proposal for organization of integrated information on new generation so-called smart materials that contribute to the characterization of the environment in an integrated and coordinated manner and no longer constitute a static and "immovable" component, but a dynamic one in the determination of spaces. Such materials—within the design of a wayfinding system—can balance the aesthetic-perceptual and performance and environmental impact, in order to allow designers to make informed decisions oriented towards inclusion and sustainability.

This is done in the belief that for the purposes of communication it is important to provide multiple areas of information on materials, integrating sensory properties (for example brightness) with the related parameters that objectively influence that property (for example the reflectance index). The information is then completed with indications on sustainability and integration of natural materials, as well as on construction practices based on standardization of components, modularity, lightness, reversibility, and adaptability to different conditions of use.

The systematization of these heterogeneous pieces of information could help designers, in the materials selection phase, to evaluate the sensorial and perceptive expectations of users and subsequently guide them in the process of identifying intentional signals and attributing the appropriate communicative meaning, after verification of the congruity of the relationships between them and the sustainability of natural resources in reference to various factors (social, economic, ecological, spatial, and cultural).

With respect to these possibilities, this contribution intends to present the results of research focused on the material characterization of the reception and distribution spaces of large museum centers through the use of sensorial and eco-friendly materials, as an impact factor on the usability and sustainability of cultural venues.

2. Sustainability and Inclusivity in the Wayfinding Project in Museums: Material Selection Criteria

In the relationship between the physical environment and people's orientation, one of the first themes to emerge, from the most recent and specific literature in the field of museums and from the latest regulatory provisions [5-7], is how the treatment of surfaces, the way in which materials are applied, influences people's perception and often takes on an active and persuasive role [8-10]. Moreover, their characteristics in terms of environmental impact convey messages of awareness of environmental issues that are essential today and provide performance and economic data comparable with the constraints dictated by the client and the reference context [11]. Therefore, the technological choices that configure the internal spaces of museums must be carried out on the basis of a (continually growing) range of performances that the "surface" system can provide: from mechanical ones, to durability, to environmental impact, etc. to sensorial ones that transform it into both a static and a dynamic means of communication. The research considers the wayfinding project as an opportunity to apply strategies to enhance public assistance and orientation services by improving accessibility—not only physical, sensorial, and cognitive, through useful information for the visitor to build his own "mental map"—but also cultural through a material characterization of all the internal surfaces that effectively convey the values of the heritage, in the broadest possible sense. The "communication" within the museum involves the signage system but also the internal finishing materials (floors, coverings, false ceilings, internal fixtures) of the set-ups and how they are assembled. As suggested by the *Guidelines for Communication in Museums: Internal Signs, Captions and Panels* of the Mibact [12] and by the *Guidelines Produced by the Tuscany Region: Eco-Design for Temporary Exhibitions* [13] the materials for the project wayfinding signals should be selected with the intention of making them eco-user-friendly signals. In particular, the guidelines focus several times on the need for long-lasting materials—capable of being effective and efficient throughout their life cycle, generating minimal impact on the environment and containing the costs of their creation and maintenance—and eco-friendly materials with low environmental impact, made from natural raw materials or their reuse, produced with social commitment, if possible, processed within a short distance and certified (Forest Stewardship Council certificate, Ecolabel, etc.).

Specifically for the research presented here, the materials for the wayfinding project were studied with respect to the following three aspects:

- the objective aspects deriving from *Performance Based Design* and therefore from the efficiency of operational behavior determined by measurable parameters such as mechanical, physical, thermal and optical properties, the environmental impact along the entire life cycle, etc., quantifiable with LCA (life cycle assessment) methodologies [14] and EPD (environmental product declarations) certifications [15];
- the subjective aspects deriving from the communicativeness of a space and the ways in which people "navigate" within it (spatial orientation), through the ability of their own sensorial characteristics to convey useful information from the context [16], in line with user-centered approaches (*Universal Design*, *Design for All*, *Participative Design*).
- the constructive aspects deriving from the way in which materials and components are assembled in response to the variability of exhibition and perceptive needs of users and the demands of sustainable development, through the application of the transfer to museum wayfinding of design for disassembling logics now widely tested in many industrial sectors and long since theorized and experimented in industrial design [17], which affect adaptability to external/internal stresses in terms of ease of maintainability, disassembly, replaceability and reparability.

According to this approach, wayfinding becomes a means to communicate the space in which people exhibit and move, conveying the values of environmental sustainability. It is a system for experimenting with new materials and technologies and a method for putting into practice all those criteria linked to a relatively new design culture that is in use both in construction and especially in eco-design. In the wayfinding project, even for temporary set-ups, it is important to consider the significant number of materials and technical solutions involved in the entire supply chain throughout the life cycle of the materials required for exhibition set-ups. Therefore, tools are needed to intercept demand, provide structured information (criteria and methods for selecting technical choices and materials, indicators), and design criteria (for assembling materials and components) to create a temporary, adaptable, and repeatable wayfinding system with dual social and environmental value.

3. Methodology

The methodology used involved the organization of two phases of the research, the first part—concerning the material selection phase—was centred on the knowledge of the characteristics of the materials used in the wayfindig project and their compliance with the requirements of inclusion and sustainability; the second part—concerning the project phase—was centred on the criteria of preparation, assembly and decommissioning.

In the first phase of the research, a mapping and filing of the materials used for wayfinding was conducted through an investigation conducted on the material heritage cataloged in seven national and international material libraries—real and virtual archives of materials [18] (Table 1). Precisely the investigation conducted on these experiential, tactile and sensorial databases, as well as multimedia and interactive information ones, made it possible to identify a repertoire of materials that can be evaluated with respect to both qualitative and quantitative impacts aimed at supporting choices appropriate to the specificities of the sites and also at expressive material characterization of the technical elements that configure internal spaces.

The investigations led to selection of materials in relation to their communicative characteristics (color, texture, visual attributes), some of their properties (acoustic, olfactory) or innovative characteristics (photochromic, thermochromic/thermo-tropic, electrochromic materials, fiber optic fabrics and electroluminescent films, photoluminescent films, dichroic films, etc.) and to comparison of them with environmental performance (environmental impact, and presence of product and process certifications).

This research highlighted some critical issues in the methods of selecting materials and in updating the databases of the material libraries consulted. Materials are often consultable by “raw material” (wood, steel, plastic, etc.) or by application (roofing, structures, closures, etc.) and not by connoting properties which would facilitate research aimed at their usability and application in specific contexts. Furthermore, information on the environmental impact and their sustainability is not explicitly declared in the product data sheets, referring the user to direct contact with the supplier company to understand the type and level of detail of the environmental certifications they have produced. The filing also includes the perceptive and sustainability characteristics, which can be traced separately, however, and in a few cases technical information is expressed which allows for real comparison in terms of performance; more frequently there is an empirical perceptive approach.

Table 1 Participant list for material libraries survey.

No. of material libraries selected	Name	Link	Professional profile	NA: Nationals IN: International
1	Material Design Point	web.uniromal.it/saperi_.co/ materialdesignpoint	Educational	NA
2	ArTec	materioteca.iuav.it/	Educational	NA
3	Mmaterial Connexion	www.materialconnexion.com/	Commercial	IN
4	MATto	http://www.matto.design/it	Commercial	NA
5	Materioteca Politecnico di Milano	opac.biblio.polimi.it/SebinaOpac/. do?locale=eng&sysb=materioteca	Educational	NA
6	Materially	www.materially.eu/	Commercial	IN
7	MATto	www.matto.design/it/home-page/	Commercial	IN

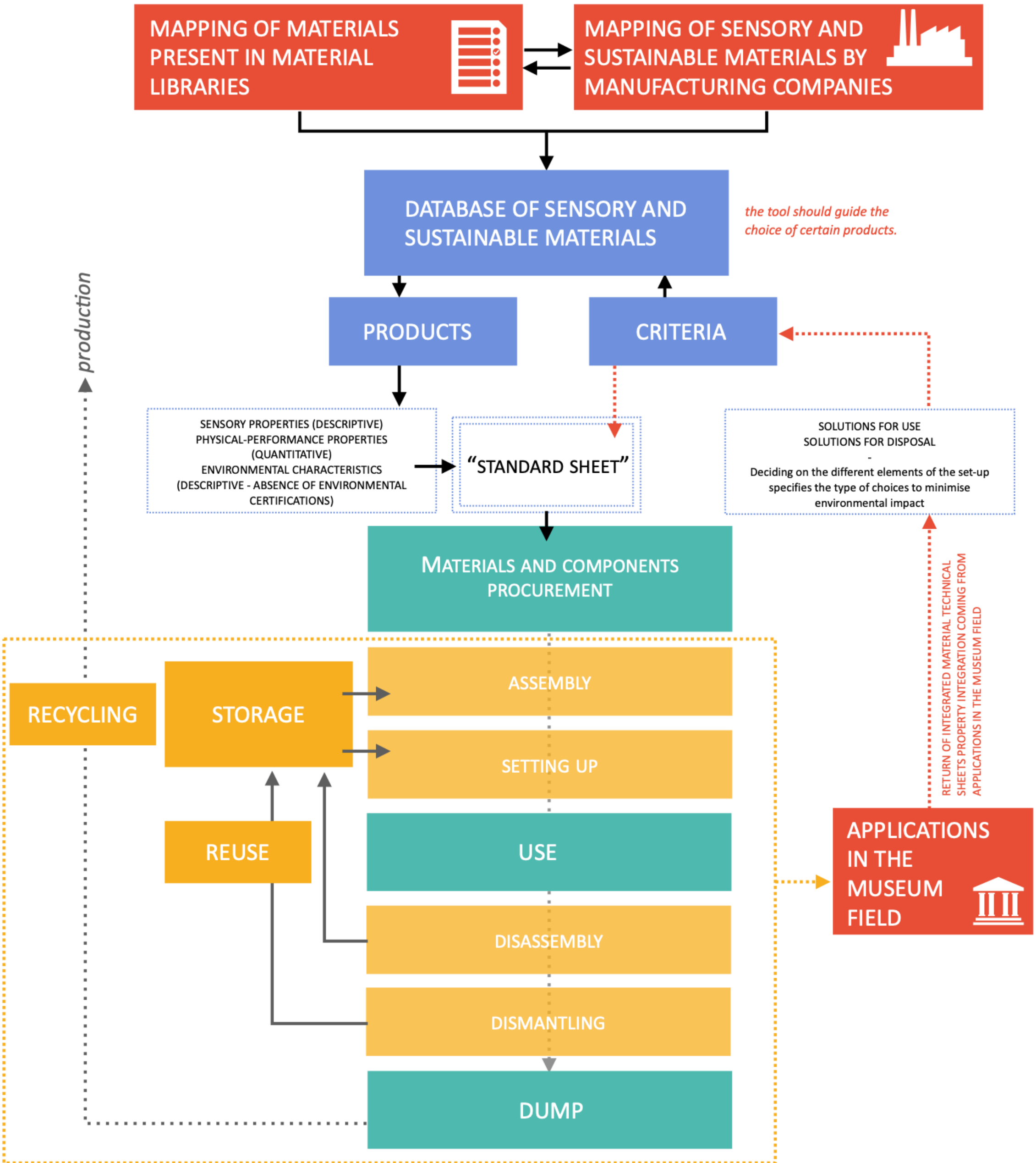

Fig. 2 Schematization of methodological process.

A first result of the research involved the selection of around 100 products and the development of a "model sheet" for their cataloguing based on technical-perceptive-environmental data, in order to facilitate consultation of the repertoire of technical and material solutions which the designer can draw on to choose the most appropriate. The "standard sheet" is an effective tool for managing a substantial amount of information on materials and for displaying quantitative and qualitative data in an integrated way. It is also a useful tool for guiding stakeholders (public patrons, museum directors, exhibition curators, designers, financiers) in the choice of certain products.

A second phase of the research involved the development of design criteria that determine those "sustainable" actions to be taken during the design phase aimed at reducing the environmental impact of the designed wayfinding system. Considering the "time" component of the wayfinding project, which requires continuous updating with respect to the variability of the requirements found in the various installations, the issue of the sustainability of the intervention does not only concern the "how to do it"—i.e. the choice of material—but also the "what will become of it after its short life"—i.e. its decommissioning. The opportunity to use criteria for organizing and managing the internal process of design, realization and decommissioning could be an opportunity for cultural sites to know and monitor what is available, for how long it will be used, and how it will be used.

The discussion with the producers of the materials selected by the material libraries and the comparison with the different actors involved in the museum field (superintendents, museum directors, designers, curators, visitors, employees, quality certification bodies) made it possible to verify and monitor the way of use (type of use, installation techniques allowing easy substitution, reversibility of the component/material, type of disposal) of the materials used in the wayfinding project and to define a list of design criteria. These criteria were subsequently implemented in the material catalogue sheets (Fig. 2).

The dual cataloging makes it possible to identify the family of materials containing the functional principles, thus providing a section on the technical and sensorial characteristics of the material (allowing addition of missing or additional information relating to the environmental impact). It also makes it possible to identify the possible application contexts, together with assembly/disassembly, maintenance and disposal options.

4. Results: Towards an Integrated Material's Information System

A first group of materials were selected from those catalogued in the material libraries concerning their distinguishing features:

- Accessibility: materials that ensure usability by people with a wide range of abilities/disabilities;
- User experience: materials capable of incorporating the user's needs, functional and dimensional characteristics.

These defining characteristics made it possible to select sensory materials for the interior finishes and wayfinding system that maximize usability and reduce "museum fatigue", that is to say, gradual loss of attention towards the exhibition due to mental and physical tiredness caused by difficulty in "reading" and understanding the environmental stimuli contained in the museum space. This facilitates an intuitive human-environment interaction (stress reduction factor) also through the spatial configuration and appropriate use of sensorial materials for the internal finishes and for the wayfinding system [19-21]. By meeting the needs of a larger number of visitors, sensory materials also reduce the time spent by staff reassuring and helping visitors in difficulty and transmitting the feeling of a well-organized and quality service in order to increase the number of visitors (economic sustainability factors). This text discusses materials that rely on more than just visual perception for communication. These materials integrate various signals, such as acoustic, tactile, vibratory, electromagnetic, or infrared, to interact with people's physical, perceptual, and cognitive parameters. This allows individuals to find autonomous and proactive ways to enjoy the available options. As a result of the survey conducted, and the importance emphasised by Passini [19], Wang et al. [22], and Arthur and Passini [23] regarding the sensorial characteristics of materials and how it is possible to measure/verify them [21] and of the results that the orientation literature has explored regarding the influence that reference points [24-26] and the material characterization of paths [27, 28] which play in the orientation process, the sensory characteristics that can best be controlled also from a quantitative and not just qualitative point of view (for example reflectance, texture relief, glossiness), as well as qualitative macro-objectives—ability of the material to produce visual stimuli, auditory stimulation, tactile stimulation, olfactory stimulation, have been included in the information sheet.

A second group of materials were selected according to the requirement of sustainability. These are materials characterized by high sustainability in terms of environmental impact, circular design, production, disassembly, and recycling processes.

In this field, emblematic is the research conducted in recent years on *bio-based* materials, inspired by biological systems (biodegradable, compostable, recyclable) with "resilient capabilities" in terms of optimization of the production process with respect to the consumption of resources and the impacts produced [29]; *react-based* materials integrated with nanotechnologies functional to the activation of self-regulation processes (*Phase Change Material*) which reduce dependence on external maintenance/energy sources [30]. On the basis of this survey, a section on the availability of environmental certificates and labels (type I, II, III) and compliance with the following macro-objectives was included in the standard form: ability of the material to minimise material resources (minimise the material content of the element in the assembly phase, minimise waste and scrap, minimise packaging) and energy (minimise energy for production, assembly and installation; minimise energy consumption for transport and storage); minimise the toxicity/noxiousness of resources (materials with minimum toxicity); use resources and processes with low environmental impact (choose renewable and bio-compatible, recycled or recyclable materials).

The materials selected from the material libraries with respect to the connotating requirements in the areas of inclusion and sustainability were further screened to discard those materials that did not present connotating characteristics in both thematic areas. This phase was supported by the reading of data sheets and direct contact with manufacturers, which made it possible to collect additional data to complete those already present in the material libraries' databases and was aimed at achieving the desired integration between sensorial/perceptual characteristics, performance characteristics and environmental impact.

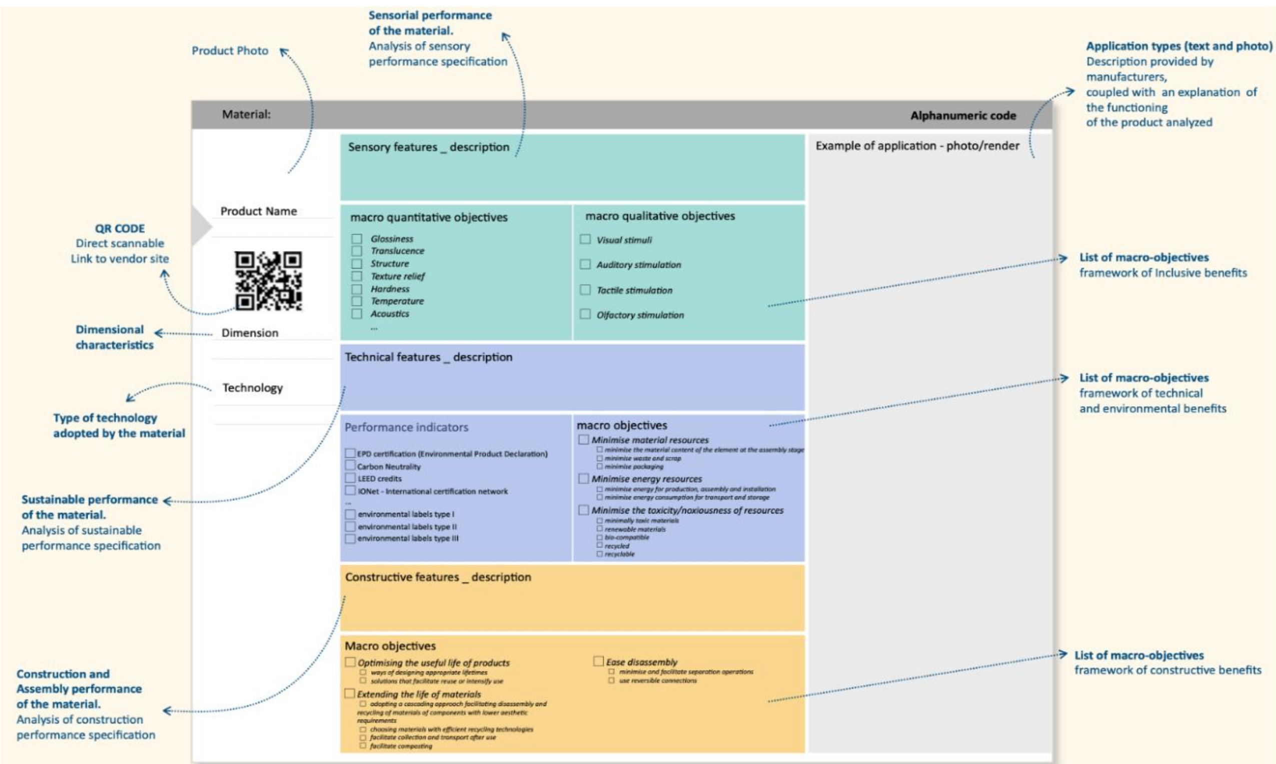

Fig. 3 Standard sheet model.

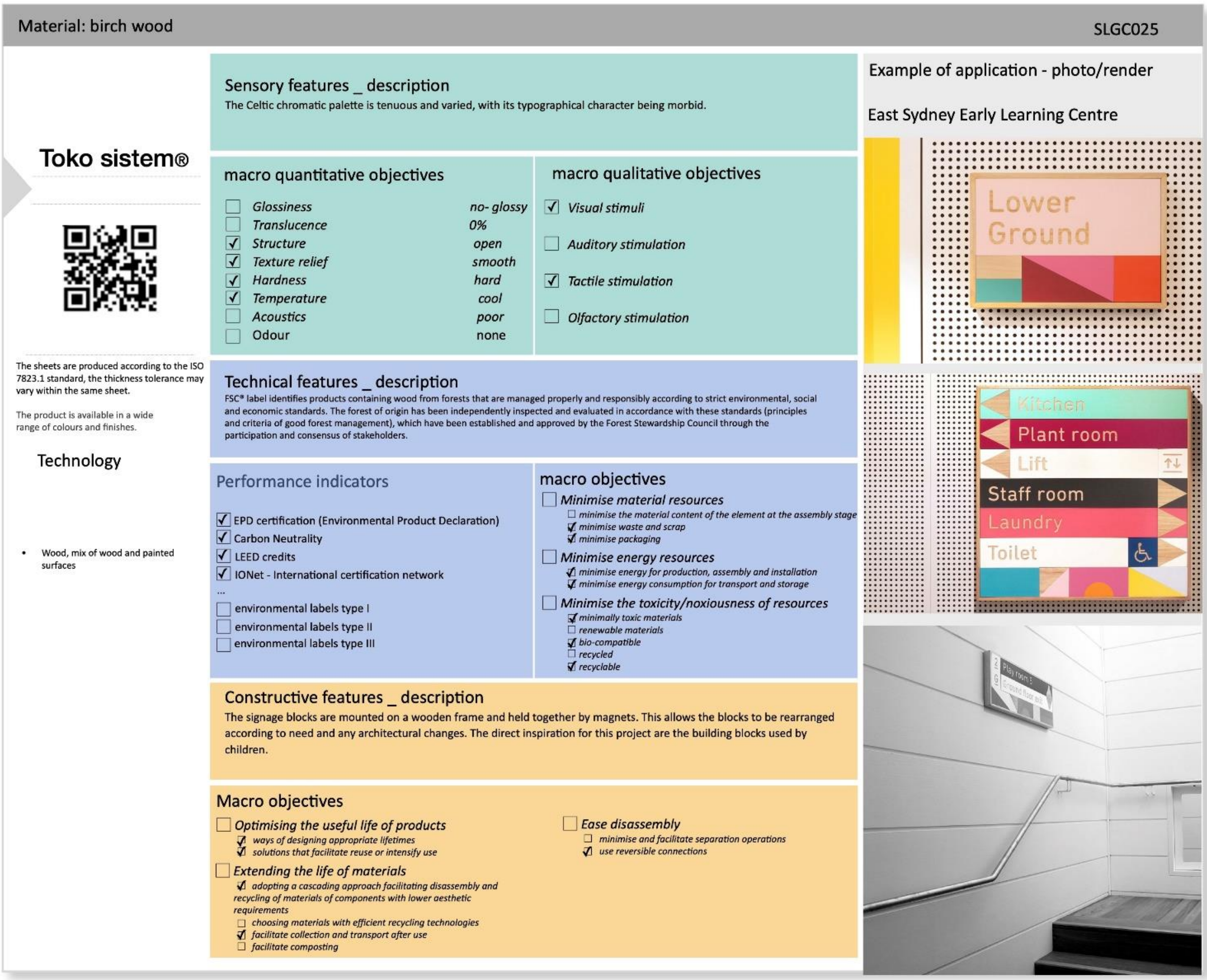

Fig. 4 Example of standard sheet.

The information contained in the "standard sheet", summarized above, while constituting a useful tool for the various stakeholders (public patrons, museum directors, exhibition curators, designers, financiers) to guide their choice within a database of available products, is not exhaustive for directing their choices towards "eco-friendly" products. This further step will require information on construction and application aspects that can only be found in the design phase (Fig. 3).

For this reason, a subsequent investigation phase was conducted into how the selected materials are applied within the cultural venues, in order to identify a check-list of design criteria relating to the optimisation of the useful life of the products (design modes of appropriate lifetimes, solutions that facilitate reuse or intensify use e.g. through shared use); to the life extension of materials (adopt a cascade approach by facilitating disassembly and recycling of component with lower aesthetic requirements, choose materials with efficient recycling technologies, facilitate collection and transport after use, facilitate composting); to the ease of disassembly (minimise and facilitate separation operations, use reversible connections).

Significant in this area are design solutions that refer to materials based on innovative business models that consider new types of relationship/exchange of materials/components between different operators, through collaboration networks (loop economy, industrial ecology, industrial symbiosis processes), sharing platforms (sharing economy, product-service systems, re-manufacturing platform) and methodologies such as Design for Manufacture and Assembly, Design for Deconstruction or Disassembly, which facilitate the recoverability, reusability, reconditionability, recyclability of end-of-life materials and production waste (Fig. 4).

5. Conclusions

Although there is no shortage of literature and concrete examples of the application of inclusive and sustainability approaches to the museum wayfinding project, there is a gap in the articulation of a unitary and complete framework to implement the different aspects in an integrated and systemic way. While LCA methodology itself and EPD certifications have progressively included social aspects in evaluation of products, they are not able to give a unified vision of the social aspects of sustainability including perceptive issues. The first proposals for inclusion of social aspects in LCA evaluation mostly focused on issues related to corporate social responsibility (behaviors and decisions linked to the observed processes, and socio-economic processes originating from decisions at the macro and micro scale) and to product responsibility, with a vision extended to the entire life cycle [31], leaving aside the aspects of environmental well-being deriving from the easy, pleasant and safe use of a place regardless of one's abilities.

This first step to bring out how social and environmental aspects are intimately linked and influence each other has led to the integration of the two types of data and will facilitate the construction of a database of wayfinding materials in museums that could potentially be able to:

- carry out a complete integration of data relating to sustainability and sensorial/perceptive aspects coming from different classification systems;
- manage the incompleteness connected to materials' technical information through the collection of data from multiple sources;
- manage both the archiving and the processing of materials' data sets to carry out (i) efficient simulations about the performance of the materials in use; (ii) selection with respect to the sustainability and sensorial objectives of the wayfinding project.

By adopting a functional way-finding project, complete and integrated with spaces and configuration of sites, visitors will be able to appreciate the richness of cultural heritage. Museums will therefore acquire more reliability, sustainability and pleasantness, with a consequent potential improvement in their financial (increased number of visitors) and educational-didactic (quicker dissemination of proposed cultural themes) success.

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