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Sustainable Environmental Communication Project: Eco-Friendly and Sensory Materials for Museums

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Abstract: In the context of large museum centers, numerous national and international methodological experiments show the need to consider, in wayfinding design, both the intangible issues of experience arising from perception and involvement (user-centered design), and social and environmental issues (environment-centered design). The aim of this research is to propose a tool for organizing integrated information on so-called smart materials that takes both perspectives into account. This study was performed by conducting a two-phase systematic literature and library review of materials. Specifically, 63 scientific articles—selected by keywords, publication date and content—and 7 national and international material libraries were investigated. The investigation highlighted how the sensory characteristics of wayfinding materials in museums are treated separately from the environmental characteristics and how the quality of the technical information of the materials filed in the material libraries could be improved. The result of the research concerns the structuring of a 'standard sheet' for the cataloguing of materials that integrates technical (sensory and environmental) information while also offering a contextualization of the material within wayfinding application cases in known museums. The proposed tool facilitates designers in the selection of materials to be adopted in the wayfinding project, offering information both on their ability to offer alternative communication channels in response to different users' sense–perceptual functioning and on their quantitative environmental impact properties. This study conducted through the integration of different multidisciplinary fields (technological approach to design, inclusive design, environmental psychology, material science, visual communication, environmental protection related to people's well-being) offers a significant contribution in the context of museum wayfinding design, providing stakeholders with practical tools to select materials that promote inclusion and sustainability.

Keywords: wayfinding; eco-friendly materials; sensory materials; user-centered design; eco-design; innovative museum

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1. Introduction

The numerous national and international methodological experiments in the museum field show how museums today are trying to conquer an important space in societies, one that is of great responsibility and not easy to achieve. Museums are increasingly becoming active entities in the territory. Their value is not exclusively determined by the heritage protected and preserved within, but above all by their social role in disseminating knowledge, in sensitizing civil society to participation, in issues relating to safeguarding and management, and in the planning and transmission of cultural heritage to future generations, placing themselves in the broadest category of services [1–3].

The museum—in debate and action—deals with intangible issues of experience and aims to provide benefits to those who use it, deriving from perception (user-friendly service) and involvement (digitalization and forms of interaction) [4,5]; it also deals with tangible issues deriving from being an active service that contributes to preventing and mitigating

the difficulties and critical issues (environmental, social, accessibility and usability) of our time through strategies and initiatives [6,7]. 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 the needs of their users (user-centered design) and local communities (design for communities, eco-museum) through the processes of valorizing territorial identity, landscape and widespread cultural heritage, material and immaterial [8–10].

This "double-target", "user-centered" and "environment-centered" approach can find application, within the museum, in the wayfinding project [11]. The latter deals not only with communication systems (signage), but also with the organization and connotation of space so as to facilitate the development of cognitive maps, facilitate perceptive processes, and improve the quality of human–environment interaction and the appreciation of the venue itself.

1.1. Wayfinding: Objective and Subjective Aspects

The materials that come into play in a wayfinding project represent the interface between the user and space [12] and, as bearers of meanings, play a central role with regard to the following:

- the qualitative/quantitative objective aspects deriving from Performance-Based Design and therefore from the efficiency of operational behavior, which is determined by measurable parameters such as mechanical, physical, thermal and optical properties, the environmental impact along the entire life cycle, etc., and quantifiable with LCA methodologies [13] and EPD (Environmental Product Declaration) certifications [14];
- the perceptive/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 [15], in line with user-centered approaches (Universal Design, Design for All, Participative Design).

Objective attributes refer to physical characteristics (color, texture, hardness, etc.) that are easily verifiable and comparable by the designer, while so-called sensorial materials—and their heterogeneous and not always entirely objective technical information—require regulatory criteria and specific assessments, also in relation to the context of intervention.

From Lynch onwards, there have been many studies that have investigated the relationships between the elements that characterize the physical environment and people's spatial orientation [16–18], and the consequent domain of the mental representation of a place [19]. 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 [20–22] is how the treatment of surfaces, i.e., the way in which materials are applied, influences people's perception and often takes on an active and persuasive role [23–25]. Moreover, their characteristics in terms of environmental impact convey messages of awareness of environmental issues, which are essential today and provide performance and economic data comparable with the constraints dictated by the client and the reference context [26].

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 dynamic means of communication.

1.2. Problems in Choosing Materials

This research aims to bring to attention how today, in most of the reorganization and re-functionalization interventions applied to museum spaces, the aspects relating to wayfinding rely exclusively on the signage system. These information and orientation panels are most often made with polymeric materials that are poorly controlled from the point of view of recyclability and environmental impact, furthermore interfering (visually, chromatically and materially) with the information and cultural systems that communicate the content of the works exposed. Instead, wayfinding projects should adopt strategies to enhance public assistance and orientation services by improving accessibility—not only physical, sensorial and cognitive, through useful information that enables 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), for which the control of the environmental impact is more feasible as they are subject to mandatory certification regulations (CE marking, EPD, etc.).

As suggested by the "Guidelines for Communication in Museums: internal signs, captions and panels" of the Mibact (2015) and by the "Guidelines produced by the Tuscany Region: Eco-design for temporary exhibitions" [27,28], the materials for the wayfinding project 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. The community directives [29] which push towards "green public procurement", i.e., to 'green' public purchases, focus on the need to evaluate the environmental sustainability of signs and their too-often underestimated material characterization, with attention paid to eco-compatible materials with a low environmental impact and obtained from natural raw materials or their reuse, products with social commitment, and possibly those processed within a short distance and certified (FSC, Ecolabel, etc.). However, this approach, which favors the social and environmental values of the process, needs to be calibrated with tools capable of interpreting the demand and drawing up the structured information (criteria and methods for selecting technical choices and materials, and indicators) necessary to define and communicate needs, opportunities and priorities.

1.3. Study

This paper is directed towards a proposal for the organization of integrated information on new-generation so-called smart materials; within the design of a wayfinding system, these are capable of balancing the aesthetic–perceptual 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 particular 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 for sustainability and the integration of natural materials, as well as for construction practices based on the 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 material 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 the 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, in particular, 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 the expositive spaces.

2. Materials and Methods

For the collection and analysis of data, the research conducted adopted a qualitative methodology that began with a first phase characterized by an in-depth review of the related literature and the relative systematization of the results. This review was aimed at verifying whether the selection of materials for wayfinding in museums was performed by individually privileging the specific areas relating to the properties and characteristics of sensoriality and environmental sustainability, or whether these characteristics had been studied in an integrated way. Therefore, several strategies were used to identify potential studies/articles.

2.1. Systematic Literature Review

As a first step, a keyword search was conducted (Eco-Friendly Materials, Environment-Friendly Materials, Ecological Materials, Sensory Materials, Inclusive Materials) in relevant databases, such as Web of Science and Scopus, and further information was collected from secondary sources such as the archives of research centers (The Center for Health Design, Wayfinding Research Centre) (Table 1).

Table 1. Keyword identification and eligibility criteria used.

	User-Centered Design	**Environmental Design**
Keywords search string	Eco-Friendly Materials, Environment-Friendly Materials, Ecological Materials	Sensory Materials, Inclusive Materials
Eligibility criteria (Nature of the topic)	museum wayfinding, environmental accessibility, sustainability	

In order to obtain most of the information about the topic, a systematic and explicit design for identifying, evaluating and interpreting the existing body of recorded documents was considered [30,31]. With the objective of highlighting blank or weakly covered areas for grounding incremental studies in the field, a step-by-step methodological model was followed for the literature search; this is summarized in the diagram in Figure 1 [32].

Screening and Eligibility

The initial search, after the removal of duplicates and the application of the aforementioned eligibility criteria, resulted in 120 papers. Furthermore, titles, abstracts and keywords were then screened one by one and reviewed, in order to discard out-of-scope documents that were not excluded by the filter application in the selected databases.

- Publication date: Contributions since 2004 were included to gain insight into the latest trends over the past twenty years.
- Content: as a second step, the potential studies were compared with respect to eligibility criteria referring to three macro areas—museum wayfinding, environmental accessibility, and sustainability—in order to separate the results falling within the scope of application from those outside this scope and avoid distortions generated by keyword selection.

At the end of the screening process, 50 records were excluded.

A first theoretical result was obtained from the bibliographic research (120 selected articles), which highlighted a "sectoral" trend in the design of museum wayfinding. The articles taken into consideration address the theme of sustainable and inclusive museums, referring either to the first or second meaning, without investigating a possible synergy/interaction between the two characteristics. It follows that the need to consider a systemic approach incorporating qualitative and quantitative objectives constitutes the first innovative result in the panorama of museum wayfinding design (Figure 2).

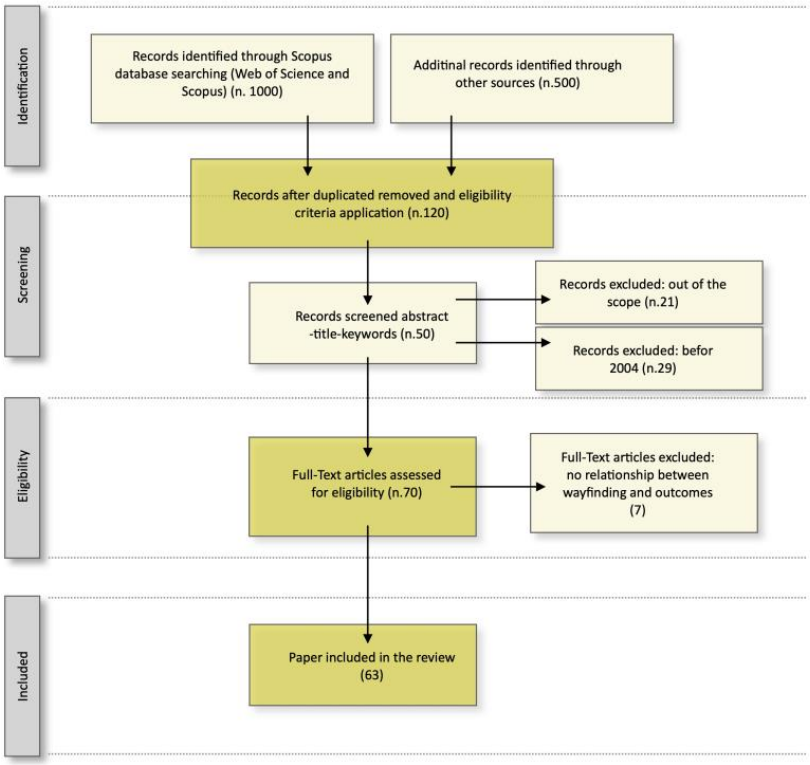

Figure 1. The Prisma Flow Diagram shows the process followed for the identification of the 63 papers selected through the literature review.

2.2. Material Libraries Review

Subsequently, the methodology used included a second phase focused on the mapping and filing of the materials used for wayfinding through an investigation conducted on the material heritage cataloged in national and international material libraries, including real and virtual archives of materials [33]. 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 in order to support choices that are appropriate to the specificities of the sites and also express the material characterization of the technical elements that configure internal spaces.

Screening and Eligibility

Specifically, the online databases of seven national and international material libraries were consulted to select potentially applicable materials, which were then compared with the environmental sustainability and accessibility objectives identified by a study of the scientific literature (Table 2).

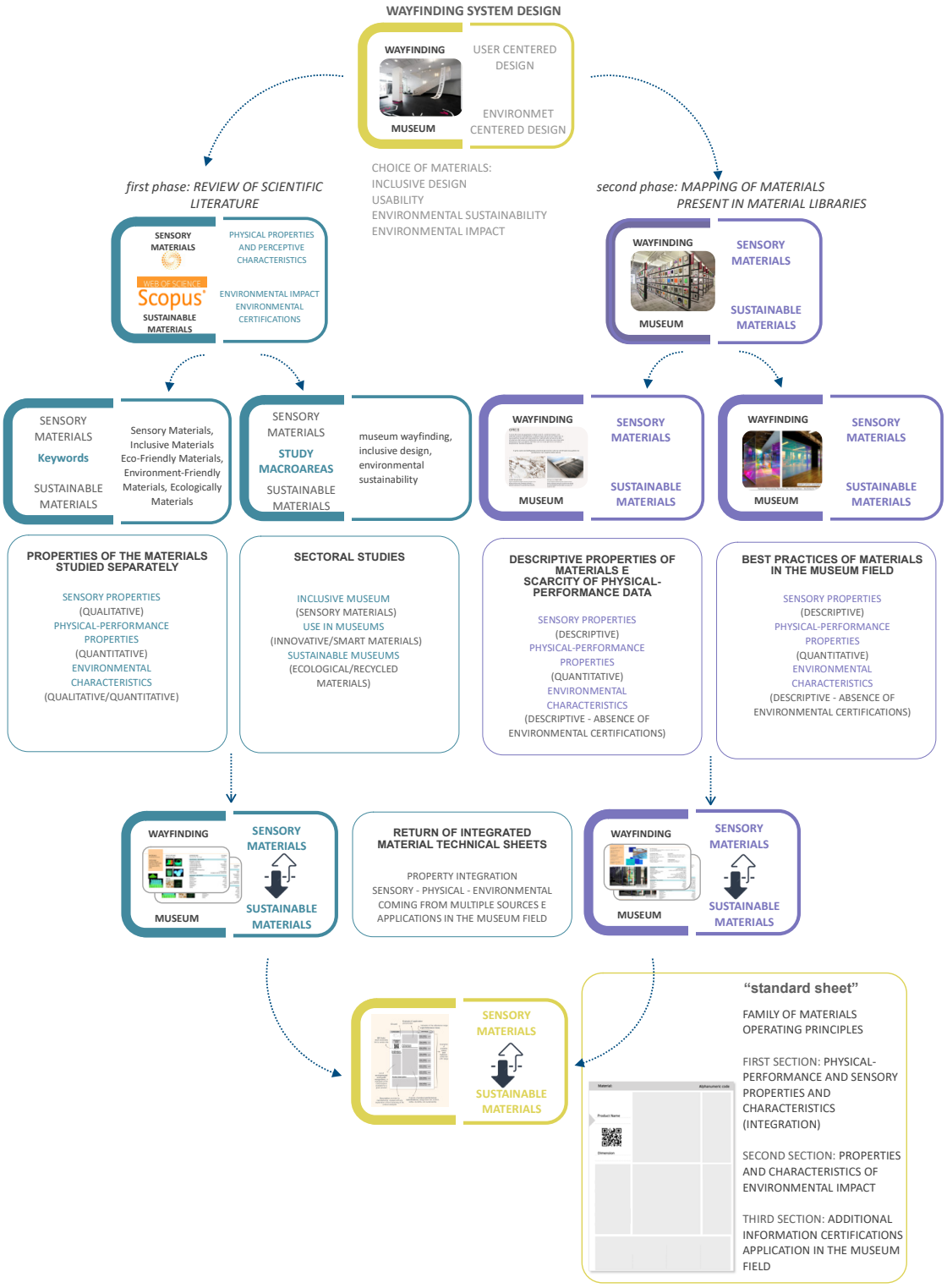

Figure 2. Methodological process.

Table 2. Participant list for material libraries survey.

Participant Number	Name	Link	Operational Profile	NA—National IN—International
1	Material Design Point	web.uniroma1.it/saperi_co/materialdesignpoint (accesed on 1 September 2023)	Educational	NA
2	ArTec	materioteca.iuav.it/ (accesed on 1 September 2023)	Educational	NA
3	Material Connexion	www.materialconnexion.com/ (accesed on 1 September 2023)	Commercial	IN
4	MATto	http://www.matto.design/it (accesed on 1 September 2023)	Commercial	NA
5	Materioteca Politecnico di Milano	opac.biblio.polimi.it/SebinaOpac/.do?locale=eng&sysb=materioteca (accesed on 1 September 2023)	Educational	NA
6	Materially	www.materially.eu/ (accesed on 1 September 2023)	Commercial	IN
7	MATto	www.matto.design/it/home-page/ (accesed on 1 September 2023)	Commercial	IN

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

This research highlighted some critical issues in the methods used to select materials and in updating the databases of the material libraries consulted. Materials are often searchable by their "raw material" (wood, steel, plastic, etc.) or application (roofing, structures, closures, etc.), and not by their connoting properties that would facilitate research aimed at their usability and application in specific contexts. Furthermore, information on their environmental impact and 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, and in a few cases, technical information is expressed, which allows for a real comparison in terms of performance; more frequently, there is an empirical perceptive approach.

However, the existing databases were useful as a starting point for the first research, which resulted in a direct interaction with the producers of the selected materials to verify their sensorial and environmental sustainability qualities, and with various actors involved in the museum field (superintendents, directors of museums, designers, curators, visitors, employees, and quality certification bodies) for the identification of best practices in the study of inclusive and sustainable wayfinding. This process led to the selection of around 100 products, cataloged by their distinctive properties and areas of application. 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 the addition of missing or additional information relating to the environmental impact). It also makes it possible to identify the possible application contexts, together with the possible user groups that could benefit from the properties of the material in terms of communication.

3. Results

The study question was addressed by conducting two phases of a systematic literature review and a Material Libraries review.

3.1. Results on the Systematic Literature Review

From the first phase of the research, which examined the literature related to the evolution of museums on the issues of inclusion and sustainability, as mentioned, attention to these issues emerged with separate and non-integrated approaches.

3.1.1. First Outcome: Materials Able to Scientifically Improve Users' Well Being

The first group of articles analyzed highlighted the need to strengthen and perfect the aspects related to inclusion in these structures, through targeted interventions to improve accessibility, ease of use and the visiting experience:

- Increasing the user's well-being and sense of welcome, checking the surroundings, maximizing usability and reducing so-called 'museum fatigue' [34,35], that is to say, the gradual loss of attention towards the exhibition due to the mental and physical tiredness caused by difficulties '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 [36]. Emotional design elements can be envisaged by visual stimuli (the use of various forms and appropriate colors can be fun and interesting); auditory stimulation (sound especially affects user's emotions, with a synergic effect on the visual effect, and an influence on interaction); tactile stimulation (the texture can increase interest by interacting directly with the touch, and it can give the person various feelings such as wet, dry, rough, or soft); and olfactory stimulation (when you smell something good, your mind becomes stable and emotional, and the smell and fragrance of the facility has a natural primordial and artificial fragrance that directly conjures memories and feelings) [37].
- Optimizing resources and design and material choices at a communication level, reducing the time spent by staff reassuring and helping visitors in difficulty [38], and transmitting the feeling of a well-organized and quality service in order to increase the number of visitors (economic sustainability factors). The materials of interest in this field are those whose communicative power is not exclusively based on visual perception, but on the possibility of integrating acoustic, tactile, vibratory signal, electromagnetic or infrared devices that interact with the subjective parameters of people (physical, perceptual and cognitive), allowing them to find autonomous and proactive forms of enjoyment among the possible options [39].
- Improving the dissemination of the cultural themes of exhibitions (cultural factor) [31].

3.1.2. Second Outcome: Materials with a Low Environmental Impact

A second group of articles dealt with the sustainability of museums in terms of the use of materials with a low environmental impact, involving not only the relationship between the material dimension and the project, but also the ability of the material apparatus to be reactive to external environment stresses. In this field, the research conducted in recent years on materials is emblematic:

- Bio-based materials: inspired by biological systems (biodegradable, compostable, recyclable) with "resilient capabilities" in terms of the optimization of the production process with respect to the consumption of resources and the impacts produced [40];
- 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 [41].

In this context, an interesting challenge concerns the transfer of design for disassembling logics, which are now widely tested in many industrial sectors, and long theorized and tested in industrial design [42] and in the design of museum displays, affecting the sustainability of these structures in terms of the ease of their maintenance, dismantling and repair.

3.1.3. Integrated Approach

Although there is no shortage of literature and concrete examples of the application of inclusive and sustainable approaches to the museum wayfinding project, there is a gap in the articulation of a unitary and complete framework for implementing the different aspects in an integrated and systemic way.

While the LCA methodology itself and EPD certifications have progressively included social aspects in the 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 the 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 [43], leaving aside the aspects of environmental well-being deriving from the easy, pleasant and safe use of a place regardless of one's abilities.

3.2. Results on Material Libraries Review

The same knowledge gap partly emerged in the second phase of research relating to the investigation conducted in national and international material libraries on materials already classified by family, physical–technical–mechanical aspects and applications. In the records analyzed, there are materials with perceptive characteristics, but only in a few cases are technical aspects addressed, and vice versa, it is possible to find quantitative data on different types of sustainable materials, but not information on perceptive characteristics.

Outcomes of the Materials Review

The first step of the investigation led to the selection of the cataloged materials with respect to their connoting characteristic in material libraries, defined as follows:

- Accessibility: Materials capable of ensuring usability by people with a wide range of abilities/disabilities;
- User experience: Materials capable of incorporating the user's needs and their functional and dimensional characteristics;
- Modularity and reversibility: Materials characterized by modularity, flexibility and assembly/disassembly to guarantee the possibility of obtaining different configurations, adapting to the variability of needs, and their easy replacement, repair or recycling;
- Sustainability: Materials characterized by high sustainability in terms of environmental impact, circular design, production, disassembly, and recycling processes.

The second step focuses on verifying the attribution of further connoting characteristics that can be found through reading the technical data sheets and via direct discussions with manufacturing companies. The study and collection of supplementary data to complete those already present in the material library databases are aimed at achieving the desired integration between sensorial/perceptive characteristics, performance characteristics and environmental impact.

3.3. Standard Sheet for the Classification of Materials and Further Development

The final step of the research involved the development of a "standard sheet" for the cataloging of materials in material libraries according to technical–perceptive–environmental data, in order to facilitate the consultation of the repertoire of technical and material solutions that 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 (Figure 3).

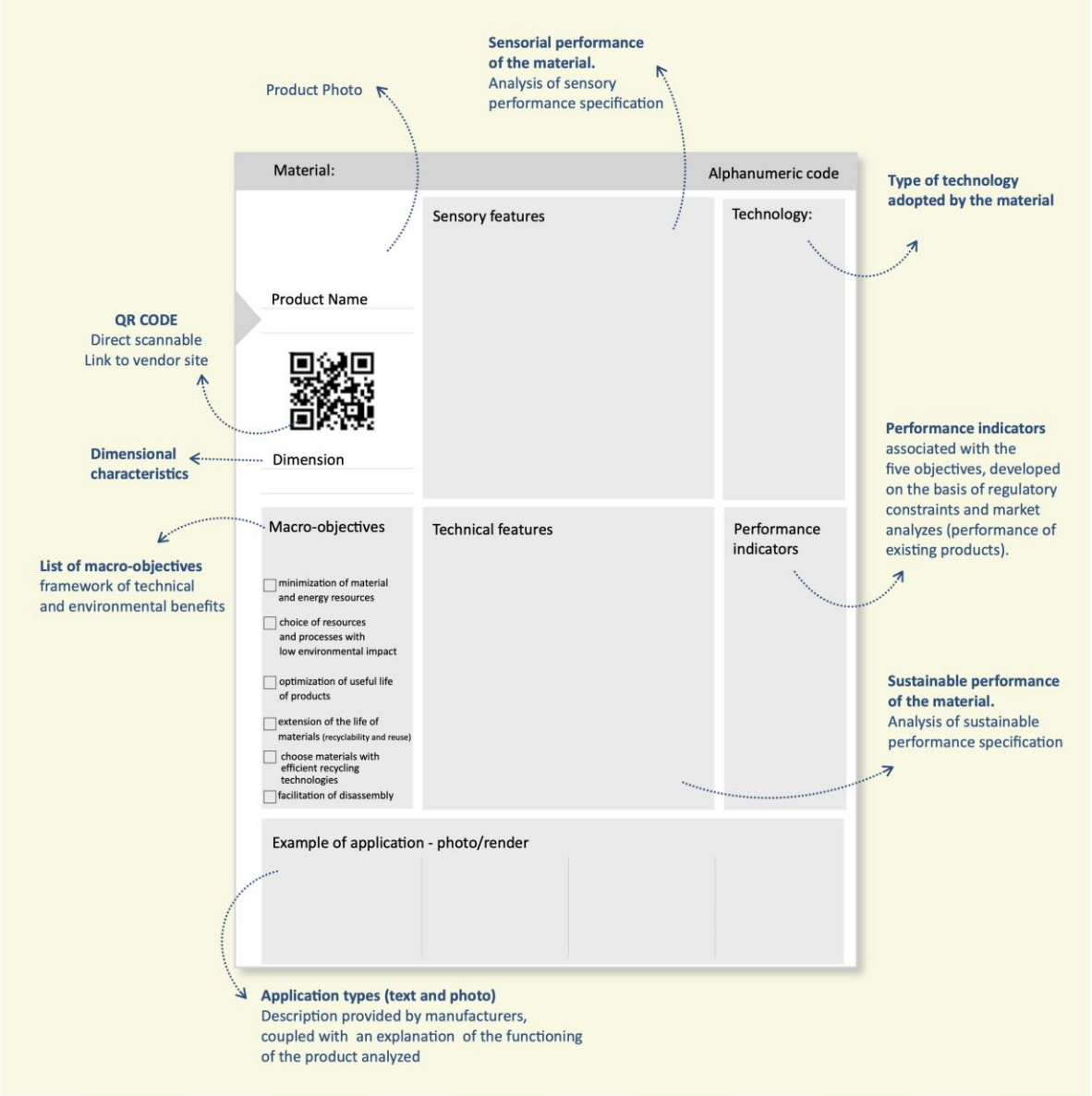

Figure 3. Standard sheet model.

The sheet summarizes the main qualitative/quantitative data identified as relevant in the analysis of the literature and Material Libraries, as explained in the Discussion section.

As a possible implementation of the results, the subject of future research developments will concern the structuring of the repertoire of sustainable and inclusive materials for the museum wayfinding project in the form of a flexible and interoperable database with BIM (Building Information Modeling), developing further methodologies based on the semantic approach. This will allow the implementation of standardized procedures for structuring the database, with the aim of making the information uniform, consistent, and easily consultable during the digitalized design process. Indeed, in some recent experiments, the use of information technologies within data structuring in a BIM environment can be found [44].

4. Discussion

The systematization of the information collected, indicated in the standard form, made it possible to obtain a univocal and integrated reading of the different properties and characteristics of the materials from the point of view of inclusion and sustainability. The form and the related fields it is made up of was designed as a tool for choosing technical and morphological alternatives to potentially appropriate materials for the project of environmental communication and the wayfinding system in museums. It also allows one to verify the compliance of the performances with the requirements of the client and with the higher-level ones of the community, such as attention to environmental impact.

4.1. Standard Sheet Layout

Starting from the consolidated selection processes in the engineering field [37] and the design field [45,46], the organization of the information proposed starts from the identification of the family of materials within which the operating principles are contained, and then dedicates a first section to outlining the combined technical and sensorial characteristics of the material.

Following the importance highlighted by [34,38,47,48] regarding the sensorial characteristics of materials and how it is possible to measure/verify them [36], and the results that the literature has explored regarding the influence that reference points [49,50] and the material characterization of paths [38,51] have on the orientation process, the sensory characteristics that can best be controlled from a quantitative and not just a qualitative point of view (for example reflectance, texture relief, glossiness) have been included in the information sheet.

A second section also reports information relating to environmental impact.

Following the identification of the performance characteristics referring to the environmental impact aspects found in some of the selected articles [52,53], six project macro-objectives were defined:

- minimization of material resources (minimization of the material content of the element in the assembly phase, of scrap and waste, and of packaging) and energy resources (minimization of energy for production, assembly and installation; minimization of energy consumption for transport and storage);
- choice of resources and processes with a low environmental impact (choice of renewable, bio-compatible, recycled or recyclable materials, and materials with minimal toxicity);
- optimization of the useful life of products (design appropriate durations, facilitate reuse, intensify use, e.g., through shared use);
- extension of the life of materials (adopting a cascade approach by facilitating the disassembly and recycling of component materials with lower aesthetic requirements);
- choice of materials with efficient recycling technologies (facilitate collection and transport after use, and facilitate composting);
- materials that facilitate disassembly (minimize and facilitate separation operations, and use reversible connections).

The macro requirements were chosen according to the framework used in the context of Life Cycle Design. The performance indicators were associated with these six objectives, developed on the basis of regulatory constraints and market analyzes (performance of existing products) [53].

A further step included a section open to the implementation of missing or additional information obtained from the various sources consulted (material libraries, product companies).

Given the relevance of some case studies (Field Museum of Chicago, California Academy of Sciences, the Prado museum in Madrid, Museu do Amanhã in Brazil, Liverpool Museum, Ningbo History Museum, Ningbo, China, Museum of art of Grand Rapids, Grand Rapids, United States) that describe sensorial materials and make it possible to understand, in addition to the performance characteristics, the expressive potential and

feasibility of such materials with respect to use, a section dedicated to the contextualization of the use of certain materials was introduced on the information sheet.

4.2. Inclusive Visual Approach

The material filing repertoire was designed with the aim of facilitating the use of the information contained within using the principles of information visualization [48], with the aim of improving the cognitive process necessary for understanding the contents of the simple spreadsheets that are generally used by material libraries; this was through a balanced use of visual code and textual code in order to achieve a different communicative effectiveness depending on the nature of the information to be transmitted (divided into qualitative and quantitative information) and the recipients, and to facilitate logical succession and correlation between the technical information.

The purpose of the proposed graphic organization is to allow designers and also clients (museum directors, exhibition curators, etc.) who want to improve the usability and inclusiveness of museum structures while respecting the principles of sustainable development (aligning with the ecological transition) to look through this information, which is also structured with greater completeness and a more immediate visual representation, to draw useful indications and to obtain adequate technical–perceptive and environmental information; this will allow them to make decisions about the type of wayfinding system and the technical performance, sensorial–perceptive and environmental characteristics of the materials, including references to certifications. This is in order to guarantee the quality of the creations with a view to communicating the material solutions, energy efficiency and sustainability, and visually identifying points of criticality (information gaps) so as to anticipate possible solutions also through application simulations (Figure 4).

In this way, exploratory data analysis benefits from visual representation by immediately communicating information that could otherwise remain hidden within spreadsheets, positively impacting the objective of making selection procedures and criteria replicable.

4.3. Future Developments

This information structuring, integrated with the experience of the recipients (primarily the designers), will be able to produce knowledge on the project objectives, on the specificities of the material solutions to be adopted, and on the most significant components of the building system in which to carry out inclusive and sustainable interventions. Integrated knowledge is therefore the main objective of the communication process chosen, to allow technicians to express a qualified judgment based on data and acquire the technical knowledge necessary for the replicability of the material solutions studied.

In order to evaluate, in the field, the effectiveness of the filing system thus structured, numerous online meetings are being held with museum designers and stakeholders, from whom it is possible to receive useful feedback to improve its completeness and communicative effectiveness, implementing contents and graphics.

In this connection, these sheets also represent prototypes on which to test the accessibility and effectiveness of the information and its actual use, checking compliance with the objective of consciously selecting the solutions collected.

The feedback obtained will also be crucial for designing the database of technical information to be built in digital form in future research developments; this will be downloadable from material libraries and be ready to be entered into the BIM (Building Information Modeling) environment, with the technical information on the materials therefore organized in a format that is interoperable with the software that manages the digital design process.

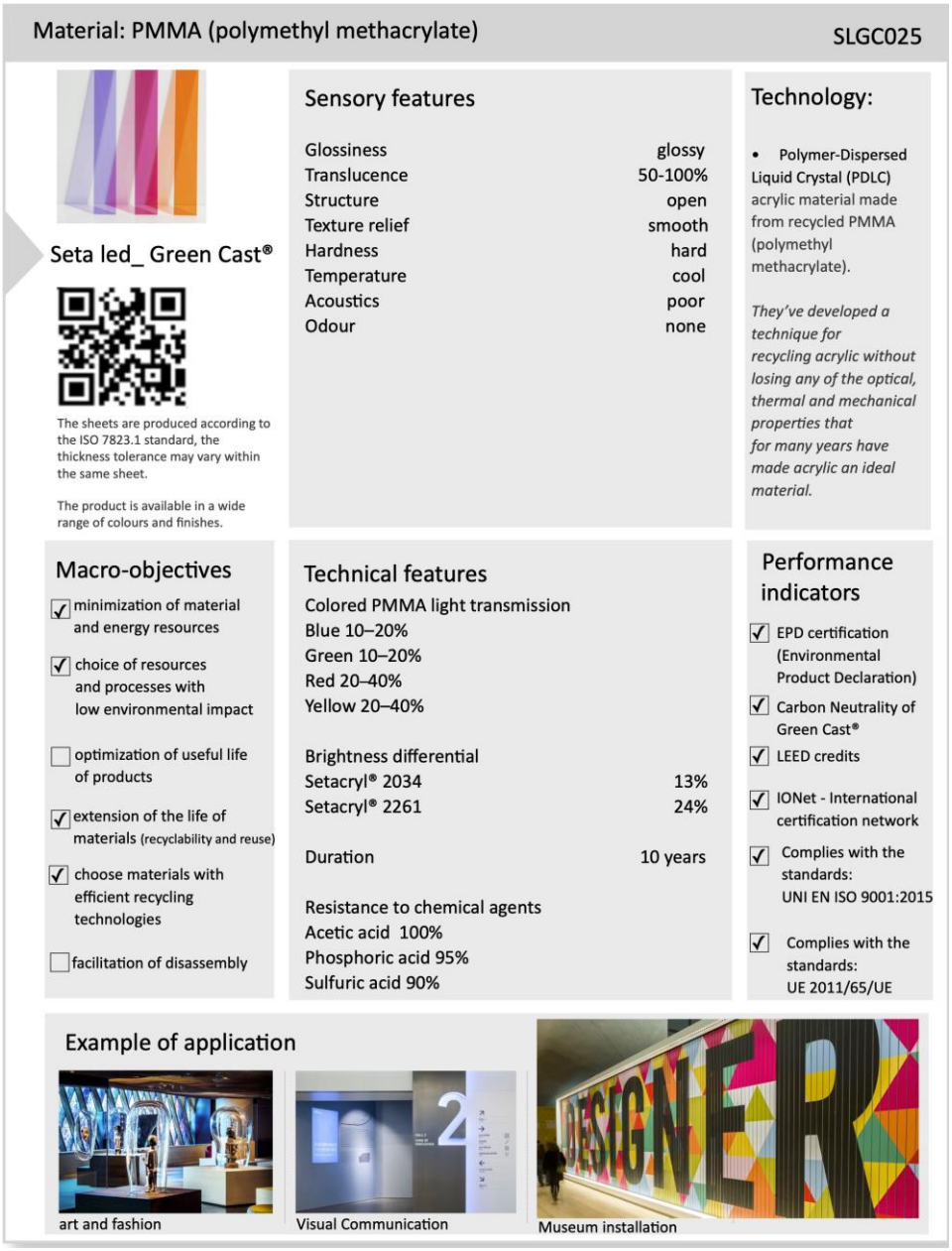

Figure 4. Example of standard sheet. Performance indicators refer to the technical standards provided by the producers [54–56].

The technical information structured within the standard form proposed to implement the information quality of the material libraries could therefore be transformed into real complete and interoperable BIM libraries that can be used through the IFC (Industry Foundation Class) standard.

5. Conclusions

This contribution started from the growing importance of museums in contemporary society not only as custodians of cultural heritage, but also as active actors in interacting with the public and in facing social and environmental issues. The importance of the "user-centred" approach together with the "environment-centred" approach in the museum wayfinding project was explored. This is not limited to the design of signage, but also considers the space's layout and its material characterization to promote the user experience and environmental sustainability. This article focused on how the key is adopt-

ing a balanced design approach, starting from the material selection phase, that considers both requirements.

Thus, designing the sensorial quality of the space in terms of communication by applying solutions that involve the use of innovative materials from a perceptive and environmental aspect aims to improve the usability of museum buildings and the development of sustainable communities for the benefit of people and the environment.

Through a qualitative methodology, a systematic review of the literature and information from national and international material libraries was conducted, and two main results were identified: the first is how the sensorial material characteristics of wayfinding in museums are treated separately from the environmental ones and the second is how the technical information quality of the materials filed in material libraries could be improved, lacking in terms of sensorial characteristics and even more in their environmental impact.

To fill this gap, we proposed the structuring of a "standard sheet" for the selection of materials that matches the technical information (sensory and environmental) and offers a material contextualisation within wayfinding application cases in well-known museums. This filing aims to facilitate the choice of suitable materials for the environmental communication and wayfinding project in museums, allowing a performance check with regard to the requirements of the client and sustainability standards.

In the discussion section, we explained the filing construction, highlighting how the integration of available data from different sources (material libraries, product data sheets and performance declarations from manufacturing companies, quality certifications) provides a simple way to quickly access important information for the wayfinding project in museums. Furthermore, the importance of an inclusive visual approach to improve the understanding and communicative effectiveness of the file system was emphasized.

We also addressed future developments concerning the integration of the data from the proposed material filing into a digital database that is interoperable with the most recent BIM-based digital design tools.

From the study conducted, it is possible to deduce that the information on the analysed materials is sparse and fragmented in the multiple and heterogeneous data sources consulted, and generally available in relational databases and text files. For this reason, the substantial amount of technical information obtained using the "standard sheet" could be transferred into a semantic repository that can be interrogated with respect to both the sensorial and sustainability dimensions of the material choices. Hence, this step will facilitate the definition of a materials database for wayfinding in museums that will potentially be able to perform the following:

- carry out a complete integration of data relating to sustainability and the sensorial/perceptive aspects of 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 material datasets to carry out (i) efficient simulations of the performance of the materials in use and perform (ii) selection with respect to the sustainability and sensorial objectives of the wayfinding project.

This study, conducted through the integration of different multidisciplinary fields (the technological approach to design, inclusive design, environmental psychology, materials science, visual communication, environmental protection related to people's well-being), offers a significant contribution in the context of the museum wayfinding project, providing stakeholders with practical tools to select materials that promote inclusion and sustainability. The value of this study lies in its ability to integrate technical, sensorial and environmental aspects in the selection of materials, thus contributing to improvements in the interaction of the various stakeholders (public clients, museum directors, exhibition curators, designers, financiers) during the design phase and promoting more accessible and sustainable museums for all.

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