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2025 January-March n°6

NEW FRONTIERS IN SCIENCE COMMUNICATION

INNOVATIVE MODELS, METHODOLOGIES, SKILLS FOR THE DIGITAL TRANSITION IN THE FIELD OF SCIENCE COMMUNICATION

SC+

n°6

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2025 January-March

The SCI-CO+ Magazine

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Sci·Co+ High Professional Skills for Advanced Scientific Communication

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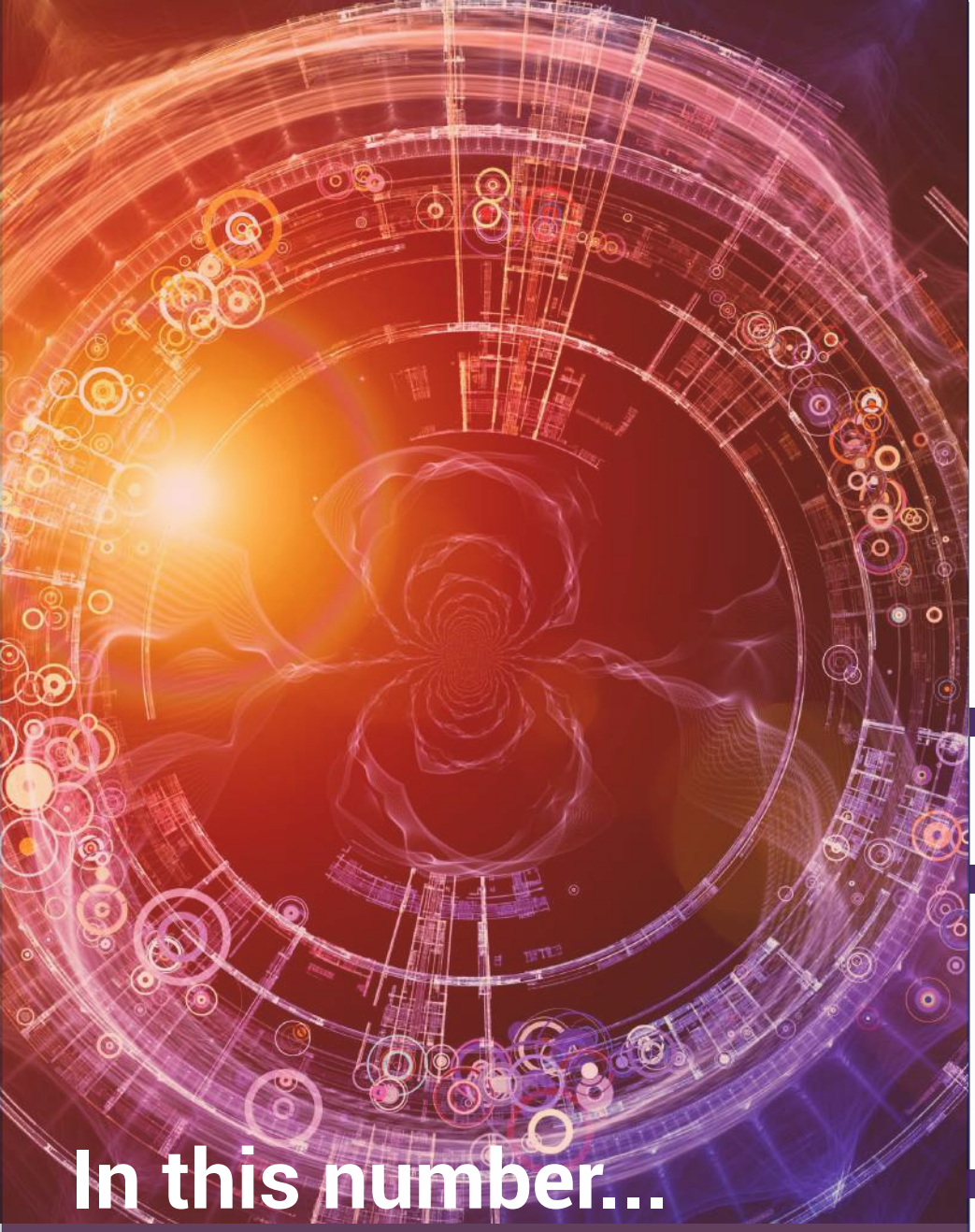


In this number...

The digital transition is playing a fundamental role in everything that concerns our life.
Popular science museums, which have now become a bridge between the scientific world and civil society, are implementing a whole series of changes to adapt to this transformation.

In this issue, we look at how Navet and Ciencia Viva have adapted to the digital transition.

The article **"Accessibility and Inclusion at Navet Science Center** considers accessibility to museums, also through digital technologies, as an example of equity and social justice.

The article **Virtual Reality and Public Engagement: Perspectives at Bragança Ciência Viva Science Center** illustrates how Virtual Reality represents a new approach to scientific exhibitions.

The special article **The intersection between design and digital technologies for scientific communication** explores the role of digital technologies and design strategies in scientific communication, highlighting how these can enhance the public's experience and facilitate the understanding of complex scientific concepts.

But the 'museum ecosystem, or rather the museum seen as a set of factors that operate in a functional manner, must also commit to sustainability not only by reducing its environmental impact, but also by clearly and effectively communicating to its visitors its commitment to a more sustainable future. This important aspect is analysed in the closing article entitled: **Beyond Exhibits: Leveraging Digital Tools for Sustainable Practices and Science Communication in Museums**

SUMMARY

NEW FRONTIERS IN SCIENCE COMMUNICATION

EDITORIAL

MUSEUM ECOSYSTEM *VERSUS* DIGITAL TRANSITION

by Alessandra Drioli

The global museum ecosystem is undergoing a profound digital transition, with the integration of technologies in every aspect of its existence, from content creation and presentation to communication and management. The global health crisis caused by Covid-19 has dramatically highlighted how crucial its level of digital maturity is. Institutions that had already invested in advanced technologies and staff training were able to maintain essential contact with their audience during the most critical moments. When digital content became the only means of reaching people, many organisations realised that they had not invested sufficiently in this field.

Strategic planning is still struggling to take hold and a significant number of museums have not yet adopted a strategic plan for digital innovation. Many organisations have started to include a section on the digital transition in other planning documents such as strategic plans.

Digital innovation projects are intrinsically interdisciplinary and present numerous technical and organisational complexities that require precise planning of economic and human resources, technologies, solutions, actions to be implemented and the time needed to achieve the set objectives. Institutions often focus their investments on the creation of online content and the digitisation of their collections. The adoption of digital tools to improve the visitor experience is also seeing considerable development. It is essential to develop a digital culture that permeates all the functions and activities of the museum, going beyond the vision of digital development as a series of isolated and disconnected projects.

In this context, the museum transforms itself into a sentient organism, capable of integrating new levels of interaction in innovative temporal and spatial dimensions. It is essential to promote awareness and critical thinking regarding the ongoing transformation process. At the same time, it is also necessary to have the integration of competent, operational and up-to-date professionals who can support the digital transition of our museum community. Although there has been a significant increase in the adoption of digital tools in recent years, more than half of cultural institutions have not implemented any mechanism to improve the digital skills of their staff. This situation highlights the need for a more targeted and structured investment in digital skills within the museum community.

Among the many aspects that could be explored in greater depth, we believe it is useful to focus in particular on two points: the redefinition of the relationship between visitors, exhibition spaces and their contents, and the role of digital storytelling. Museums that have invested in digitisation have not only improved their resilience during the pandemic, but also expanded their audience and the ways in which their content can be enjoyed, demonstrating how a well-planned digital strategy can radically transform the role and impact of these institutions in contemporary society.

A Chinese box approach forces us to look at the issue from different perspectives and, although the subject cannot be dealt with exhaustively here, it invites us to take an overall view but, above all, to always prioritise the content we want to convey and the objectives we intend to achieve.

Alessandra Drioli
Manager of the Science Centre of Città della Scienza

ACCESSIBILITY AND INCLUSION AT NAVET SCIENCE CENTER

by Christian Eriksson

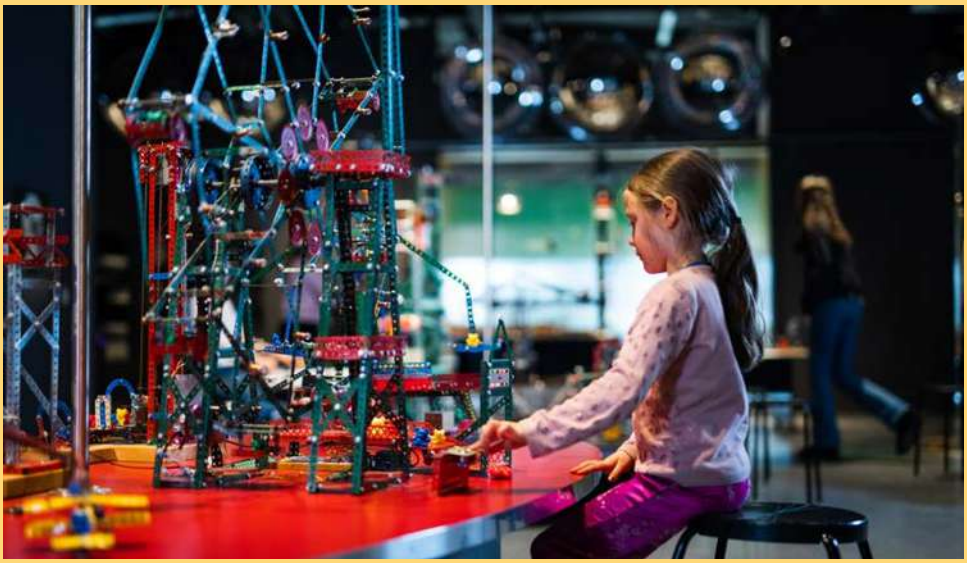
Museums act as vital hubs for learning, culture, and community engagement, reflecting and enhancing the diversity within society. Active efforts toward accessibility enable museums to not only meet legal obligations but also become paragons of social equity and justice. Accessibility should be seen as a social responsibility rather than a mere legal requirement, thereby fortifying an institution's inclusivity for diverse societal groups (Starr, 2016). Museums are uniquely positioned to pave the way for a more inclusive future.

Accessibility involves creating environments that are usable by as many people as possible, irrespective of physical, sensory, or cognitive abilities. Investments in accessible exhibits, programs, and spaces not only enhance the experience for individuals with disabilities but also benefit all visitors. Clearer signage, improved acoustics, and visual aids, for example, assist children, elderly individuals, and visitors from various linguistic and cultural backgrounds. Public spaces thus become central to fostering inclusive societies and celebrating cultural diversity (Pineda, 2022).

Creating accessible museums also involves recognizing and valuing the unique perspectives and needs of all visitors. As society evolves, museums must actively work to eliminate physical and social barriers, ensuring a welcoming environment for everyone.

However, implementing accessibility goes beyond merely setting goals and processes.

"I think that accessibility is also a state of mind. It isn't simply something that you do. It is something you have to think about, be committed to. It doesn't reside in one person or one department. It resides in a mindset of the institution." – Glenn Lowry, Director of The Museum of Modern Art (Starr, 2016).



Old style of user interface with Swedish text

UNIVERSAL DESIGN – A PATH TO INCLUSION

Universal design focuses on creating environments and products that are inclusive and accessible without the need for adaptation. This approach serves as a method of inclusion. Yet, universal design for inclusion is insufficient alone (Rappolt-Schlichtmann & Daley, 2013). To truly engage individuals with specific needs, a framework of Universal Design for Learning (UDL) is essential. UDL emphasizes providing multiple means of representation, expression, and engagement, breaking down barriers and fostering environments that cater to diverse needs and abilities.

When applied to museum operations, UDL might include offering digital guides incorporating visual, auditory, and tactile elements, benefiting individuals with disabilities and those who learn differently. By embedding UDL principles, museums can craft dynamic experiences that not only attract a broader audience but also set standards for inclusive societies.

NAVET SCIENCE CENTER AND ACCESSIBILITY EFFORTS

Navet Science Center provides an interactive and inspiring environment for exploring STEM (Science, Technology, Engineering, and Mathematics) and sustainability topics. Navet offers school programs designed to inspire interest and creativity. Through hands-on experiments, problem-solving, and modern technology, students have the opportunity to explore in an engaging and educational way. A typical school program often begins with a dramatized introduction where students encounter a contemporary or historical figure who provides an introduction and a mission related to a specific subject. (For instance, this could be Newton, Hypatia, Alan Turing, or Grace Hopper.) Following this, activities take place in Navet's exhibitions.

Navet aims to create an inclusive environment where as many visitors as possible can engage in learning and exploration. Starting in 2024, systematic efforts have been initiated to ensure accessibility, inspired by universal design principles.

Navet's accessibility initiatives are categorized into three main areas:

1. Interaction – Focusing on staff engagement with visitors and the design of activities.
2. Digital Environment – Adapting digital platforms and user-directed interactive experiences.
3. Physical Environment – Designing spaces and stations to ensure inclusivity and ease of access.

For example, in the Meccano exhibition, text-heavy interfaces have been replaced with symbols to make the content accessible to young children, individuals with intellectual disabilities, and non-Swedish speakers.

In the coming year, Navet Science Center intends to deepen its commitment to refining its digital and physical interfaces, drawing inspiration from Universal Design for Learning (UDL). These efforts aim to foster an inclusive environment where educational and interactive experiences are accessible to a diverse audience, regardless of their abilities or linguistic backgrounds. By integrating UDL principles, Navet aspires to create interfaces that not only accommodate but actively engage all visitors in meaningful ways. Navet aims to establish an annual review structure to maintain consistent progress in these areas. Additionally, school programs will be revised to ensure they are more accessible, incorporating interactive and individualized elements that cater to diverse learning needs. Efforts will also focus on improving the clarity of signage and maps, ensuring better navigation for all visitors.


New style of interface containing graphical elements

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Virtual Reality and Public Engagement: Perspectives at Bragança Ciência Viva Science Center, Portugal.

by Ivonne Fachada

Science exhibitions are an effective tool for tech research, education and public engagement in science centers and science museums. Innovative exhibits such as Virtual Reality can contribute to the improvement of purposeful activities and as new approaches to science exhibits for science education and communication.

INTRODUCTION

Over the past few decades, public engagement with science and technology has gained increasing attention, driven by a growing recognition of the need for more inclusive and socially responsive approaches to innovation [21]. This trend is exemplified by the case study presented, from the Bragança Ciência Viva Science Center (from now on referred to as CCVB), a prominent hub for scientific outreach and public engagement in Portugal. Science exhibitions are an effective tool for tech research and education, both in the production and design phase as well as in informal settings such as science centers and science museums, as they are used to promote informal learning in visitors. Many research in the past (and present) are focused on teaching and learning science in these environments, led by researchers in the area of Pedagogy and Education. But we also believe that in informal settings such as Science Centers and Science Museums, a specific approach from a technological point of view should be also profoundly studied. Educational virtual environments (VEs) are correlated with higher levels of cognitive performance and emotional development, factors that contribute to knowledge construction [13]. Technology can serve as a medium for visitors to feel connected throughout their museum experience. This creates an opportunity for both educators and museum facilitators to promote an interactive viewing experience [11; 12].

The CCVB's primary mission is to disseminate science and technology in society and promote educational and scientific literacy. It aims to become a more recognized pole of knowledge, in cross-cutting areas and of proven importance for society. This ongoing research is based on the analysis of exhibits innovation will unequivocally contribute to the development of attractiveness improvement of CCVB, offering purposeful exhibits and activities focused on young and adult education, based on consolidated projects aiming for an effective learning.

This mission is supported by the facilities that host a permanent exhibition, with interactive exhibits dedicated to major themes such as Environment and Energy, at the main building, and with the historical, cultural and ecological heritage of the Northeast of Portugal, at Casa da Seda (Silk House).

The CCVB bases the diversity of its offer both on the thematic and depending on the target audiences, in the most comprehensive scientific dissemination actions possible. It is recognized as an exceptional channel for communicating current issues and it is an ideal space to involve citizens in the democratization of knowledge and the promotion of favorable changes in their behavior, facing extremely pertinent issues, such as energy sustainability and the preservation of the environment (United Nations Framework Convention on Climate Change COP21). CCVB is also part of the Portuguese National Network of Ciência Viva Science Centers, consisting of 21 Centers spread across the continent and islands.

CCVB also belongs to the ECSITE (European Network of Science Centers and Museums) whose main objectives include inspiring and empowering science centers, museums and all organizations that involve people with science, to promote their curiosity and actions, and also to foster creativity and critical thinking in the European society, emboldening citizens to engage deeply with science.

CASE STUDY

Science center exhibits are typically highly interactive, involve a wide range of target groups, have a specific purpose of being educational and engaging, and set requirements for robustness and ethics. The exhibits open up for different modes of embodied interaction, where users can participate and collaborate in different forms and degrees, and where digital and physical design materials and spaces merge. Science centers can also work as a stage for transdisciplinary, where natural science meets arts and humanities [23].
A socio-scientific issue based exhibition should be designed with a focus on increasing public engagement with science and relevance science centers in society, and it should convey various kinds of information contextually and make visitors share their own opinions with others in an exhibition space [25]. Theoretical design research on science centers, summarized in the Design of Experience - DEX Framework [16;17], suggests that the visitor experience in a science center is based on five building blocks: physical, institutional, personal, relational, and social.

We are studying which exhibits are more effective in an informal learning experience. We also want to assess how the engaging process in a learning experience is directly related to its location and understand at what level and how everyone that has the experience values digitalization of contents. Interactive exhibitions which can be tried out by touching and playing, between space and technology themed exhibition areas, in science centers for visitors are among the places that make the greatest contribution in terms of informal education [20].
This ongoing research has as its main objective to contribute to the field of science communication as it can provide recommendations to the setting up of new exhibitions.
We will study this based in visitors' engagement experience, evaluating their experience. Staff facilitators and educators can also help visitors and families learn more from museum exhibits by giving them information about exhibits, as well as by concurrently challenging and encouraging visitors in their interactions with exhibits [19] and foster participative civic engagement in finding solutions to common challenges, as a society.
We can develop, with science-based projects, new approaches to exhibitions, recommending its production and design, considering the data collected with different target-groups of visitors and the specific context of our science center (geographical location, dimension, funding, resources – financial and human). Overall objectives also include in the long term:

- Improve the basic skills of individuals by managing new technology and information;

- Consolidate specific skills (in terms of cultural literacy, science and technology and community development);

- Integrate of experienced knowledge in their lives;

- Improve personal motivation and critical reflection in science issues.
The 2030 Agenda and the 17 Sustainable Development Goals (SDGs) are nowadays the main international reference framework linking human rights with sustainable development and in SDG 4 – Quality Education, is mentioned the role of global citizenship and education in developing individual competences to reach the defined targets of the Agenda, namely: "By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and of culture's contribution to sustainable development" [22].

As a result, the education process, either in formal or informal contexts, has been affirmed as an instrument against discrimination and exclusion, and their access has been facilitated as a mean of promoting justice, freedom, human rights and peace. Finally, this is in line with the Horizontal priority related to innovative practices in a digital era as it addresses innovatively the connection between reality–virtuality. It will sustain the taking up of digital and virtual or digital-based technologies and of innovative and open pedagogies in science education, training, tourism, social and cultural heritage.

METHODOLOGY

The Bragança Ciência Viva Science Center, where this case-study was made, offers 26 interactive exhibits focused on 3 major themes:

1. Presenting scientific principles connected to the production and manufacture of SILK, research of its properties and the silkworm ecology (n=6) [Exhibits: Metamorphosis, Magic Book, Inside the Silkworm, Legend of the Princess, The Silk Factory and Spinning and Playing]

2. Presenting scientific and technical principles and solutions connected to Sustainability (n=11) [Exhibits: Tech Platform Silkhouse, Silkhouse Interactive, SmartRiver, Rocket, Environment and Quality of life, Snails Race, Ecological Footprint, Birthday Cake & Wind Energy, Recycling, Facilities Tech and Electricity (outdoor)].

3. Presenting scientific principles related to Fundamental Sciences such as Biology (Biodiversity) Physics (Astronomy), Geology, Geography and Climate Science (n=8) [Exhibits: Virtual Douro, Natural Park Montesinho Timelapse, Tornado, Google Earth, Tree of Life, Natural Landscapes, Solar System and Origin of Life and Magnetism].

An exploratory questionnaire was carried out during 2021 (a pandemic year) by the team of the Bragança Ciência Viva Science Center on an exhibit using Virtual Reality to simulate a trip in the Douro Rover by boat.

FIGURE 1 AND 2: POPULATION.

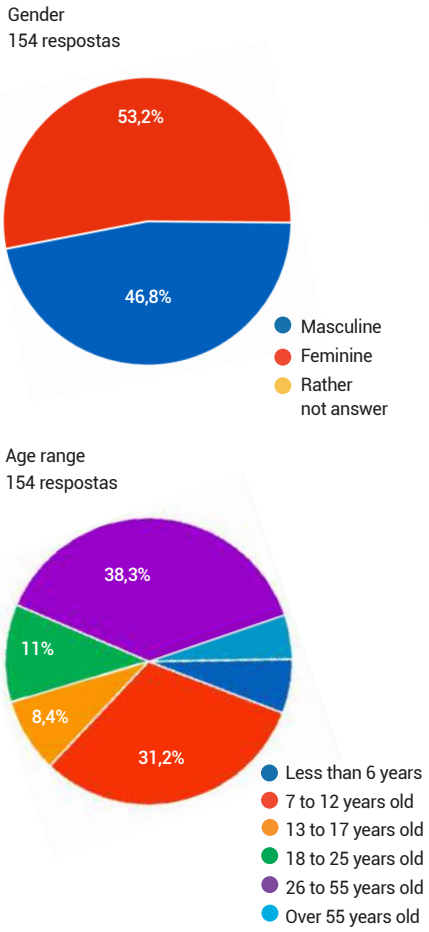


FIGURE 3, 4, 5 AND 6: EXPERIENCE WITH IMMERSIVE SYSTEMS.

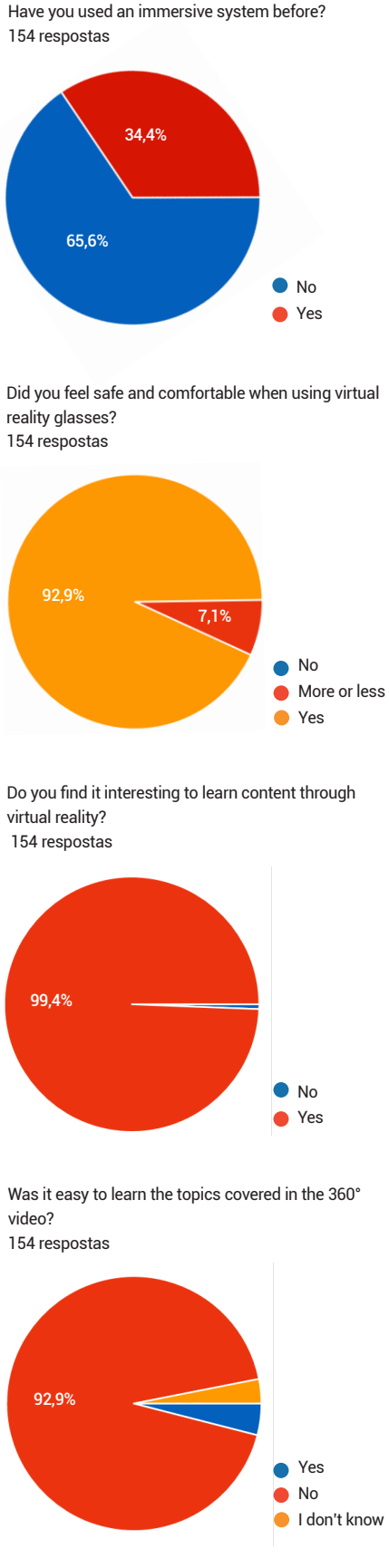
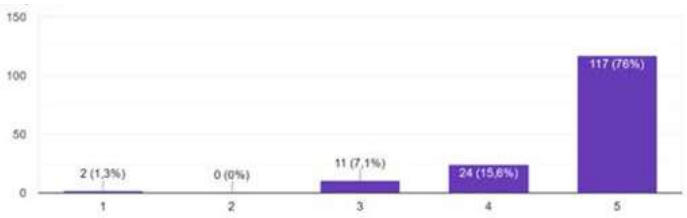


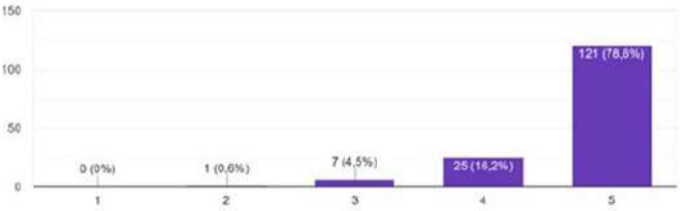
FIGURE 7, 8 AND 9: LEVEL OF SATISFACTION AND EASE AT USING THE SYSTEM

Scale: 1- Very Low 2- Low 3- Medium 4- High 5- Very High

Indicate the desire to visit the Duro's region
154 respostas



Indicate the level of satisfaction when interacting with virtual reality
154 respostas



Indicate the level of ease of use of the system
154 respostas

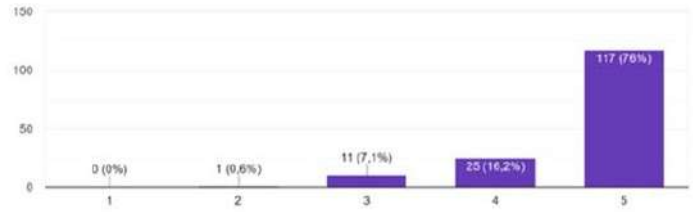
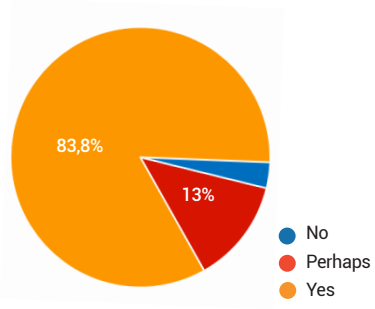
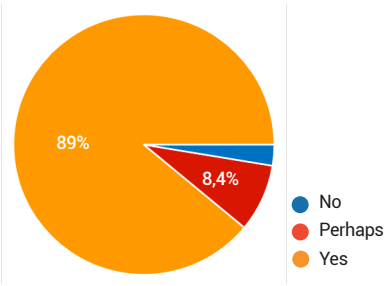


FIGURE 10 AND 11: OPINION ON USING VIRTUAL REALITY

In the current context of the Covid-19 pandemic, would you use virtual reality to visit places remotely?
154 respostas



Would you use virtual realityfor other occasions?
154 respostas



RESULTS

The results of 154 questionnaires are indicative of the public's perception of good acceptance of new approaches to science exhibits. These preliminary approaches are in line with what the literature indicates. Findings suggest that different resource designs are associated with different levels of engagement-related behaviors, and designs for guided exploratory learning in particular have the potential to support students' progress towards conceptual understanding [14].
Studies also show that the latest human-computer interaction (HCI) innovations have made many technologies, e.g., virtual reality, personal digital assistant, biometric authentication, e.g., fingerprint scanner available to us and have made our lives convenient, secure etc. [10]. Virtual Reality Environments can be means of enhancing, motivating and stimulating learners' understanding of certain events, especially those for which the traditional notion of instructional learning has proven inappropriate or difficult [18].

In museum settings, forms and techniques of digital interactivity have become a common practice directly impacting the visitors' experience of exhibitions and their content, arguably encouraging participation, empowerment, alternative approaches to engaging with dominant histories, on-going and controversial issues and a degree of liberation from didactic models of knowledge production [15].

CONCLUSIONS

CCVB and its partners are environments that promote educational and scientific knowledge dissemination. Providing access to scientific information and educational activities for people with different social backgrounds is part of Ciência Viva mission. This includes allowing less favored people to access recent technologies, such as people with less economic power or physical disabilities. Establishing contact between different social status audiences and recent technologies promotes inclusion by allowing unrestrained access and interaction with technology that otherwise would not be possible by people from disadvantaged layers of society.

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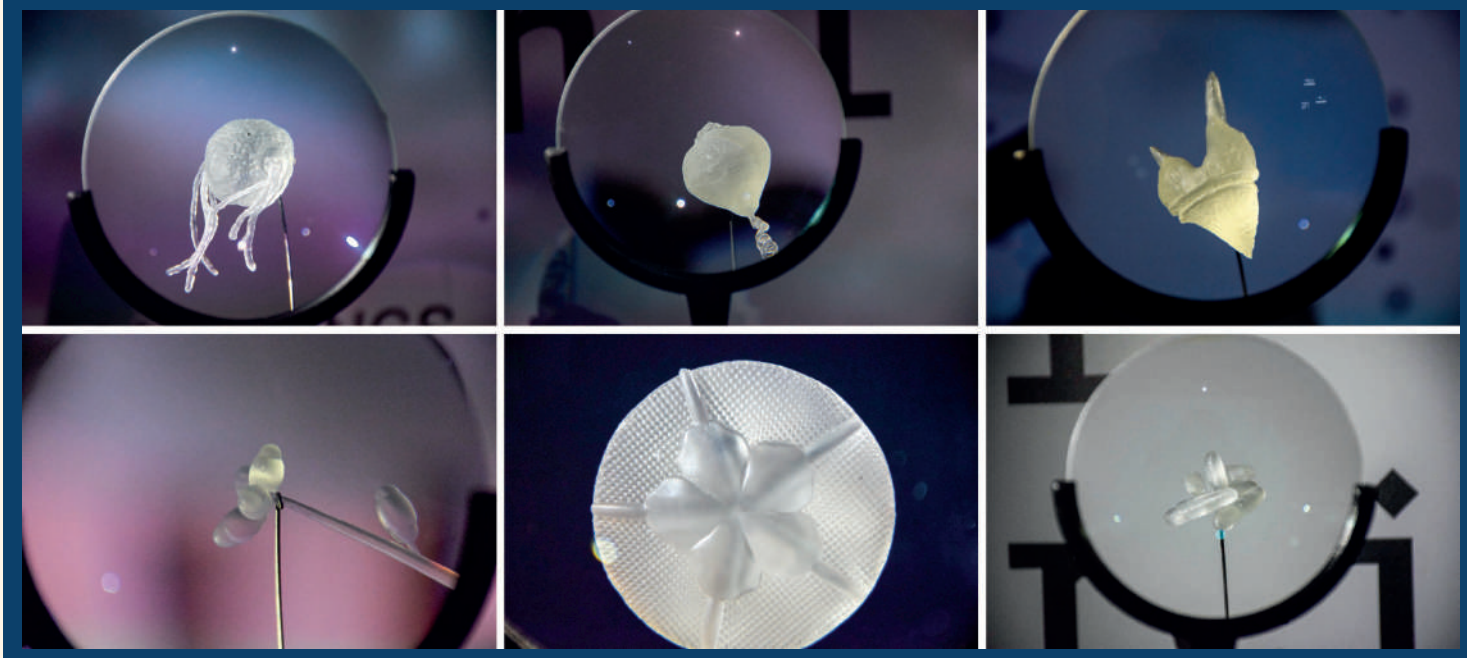
THE INTERSECTION BETWEEN DESIGN AND DIGITAL TECHNOLOGIES FOR SCIENTIFIC COMMUNICATION

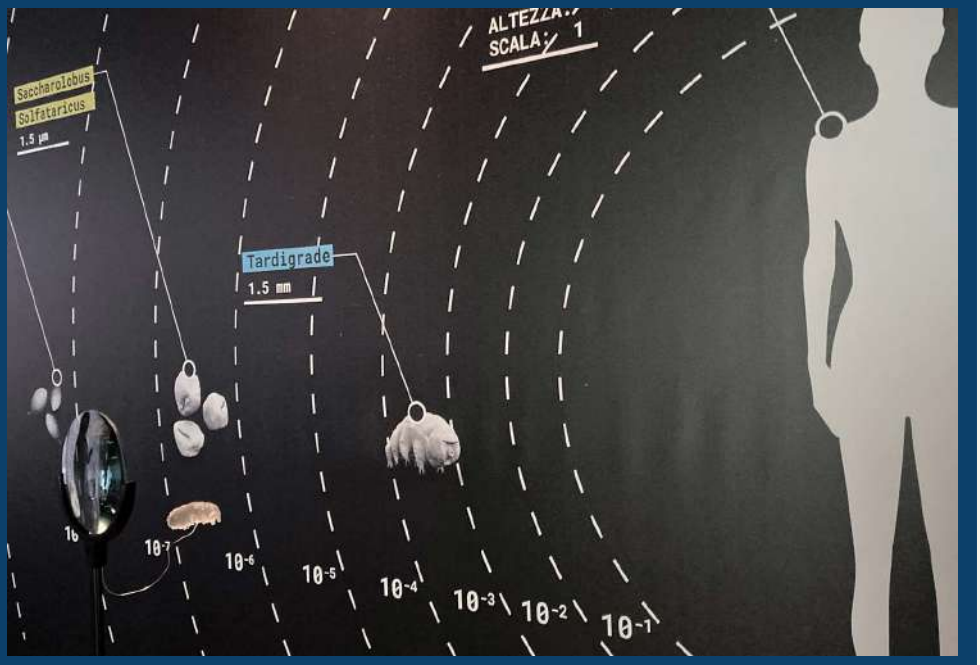
by Carla Langella

This article explores the role of digital technologies and design strategies in science communication, highlighting how they can amplify the audience experience and facilitate the understanding of complex scientific concepts. In a world such as today's in which most of the phenomena related to digitisation, the internet and the reign of technocultures have manifested themselves in unimaginable, unpredictable and boundless ways, society feels the need to find points of reference and seeks them in science.
Through the analysis of various case studies, the importance of the use of digital tools and technologies in the various phases of the design of peer-to-peer communication devices between scientists and in dissemination to society is illustrated.



1. INTRODUCTION

In the digital age, science communication faces new challenges to engage an increasingly demanding and diverse audience and adapt to new communication contexts such as the web and social networks (Langella, 2019). Cooperation between design and digital technologies is increasingly recognised as an effective way to make scientific content more accessible and understandable (Latour, 1987).
In particular, User Experience design (UX) applied to scientific communication and dissemination allows abstract concepts to be transformed into tangible and interactive representations.
These principles apply to the communicative artefacts used by scientists to share their research results with the relevant scientific community such as: graphical abstracts, cover pages, graphic processing of instrumental images, and presentations at conferences. The intervention of design in the representation of scientific data and information aims to make them effective and clear to the target audience that scientists address (Thiel et al., 2015). Furthermore, the use of design and digital technologies can help to make content more attractive to the scientific advertising market, which is increasingly focused on attracting readers with appealing images and visual artefacts. Thus, design intervention using digital enables an increase in the number of cover pages accepted by the most prestigious journals, the ability to attract corporate funding, media attention, effective internal communication between researchers, and even citations.
At the same time, digital tools are increasingly being used in dissemination to society through infographics, social media materials, animations and illustrations for science dissemination tools.
After the Covid emergence, on the other hand, society's demand to understand and learn about the latest health-related scientific findings has grown considerably (Langella et al. 2022).
The visual representation of scientific principles has also become a useful tool to present the research content of products such as drugs, biomedicals, cosmetics or technical and sports accessories to the market. It can also be used by the media to inform the public about specific avenues of science and development policies, particularly when significant economic and ethical-social impacts are anticipated. For all these uses, digital tools such as graphics, three-dimensional modelling, and animation software together with interactive technologies such as Augmented Reality, Virtual Reality, 3D Mapping and, the possibility to disseminate content without boundaries through digital spaces, applications and platforms are invaluable opportunities that still require much research and experimentation. Such a wide



spread of this phenomenon requires in-depth studies that enable a systematisation of the research conducted in this field from different perspectives and with different objectives.
The intensification of collaborative experiences between designers and scientists and the growing awareness of the contribution that artefact design can make to science have led to the emergence of new professional figures, both in the field of designers for scientific communication and in that of popularising scientists.

2. THE DESIGN FOR VISUALISATION OF SCIENCE METHOD

The scenarios of the convergence between design and science, the opportunities offered to the field of design by the intersection with scientific research, and the possible implications in terms of design culture are the areas of research and experimentation of the Hybrid Design Lab (Langella, 2007), a research, teaching and experimental design laboratory set up in 2006 and dedicated to the various forms of intersection between design and the biosciences, which is currently included in the Department of Architecture of the University of Naples Federico II.

In the course of the research and teaching experience carried out in the laboratory, various types of communication artefacts popular in the scientific field were developed, such as: graphical abstract, cover page, infographics, 3D model, 3D animation, popular illustration, graphic processing of instrumental images. From this experience emerged the definition of a method for designing scientific artefacts (Langella, La Tilla, Perricone, 2019) involving the following steps:

The method applied requires designers, in collaboration with scientists, to address the

following aspects:

- Scope of communication research and actors, which involves identifying the thematic area of reference, researchers and institutions to be involved in the visualisation project.

- Reference scenario and innovative scientific aspects to be brought to the fore, which requires a discussion with the researchers involved in order to get to know the international scenario, the research groups that have the greatest impact and the elements of research innovation that it is deemed useful to highlight and convey in order to improve the awareness of the target audience of the communication and, more generally, of society.

- The type of users to whom the communication is addressed is of primary importance for scientific communication, because the general and specific communication objectives, languages and communication strategies derive from it. With respect to the subject matter, it was decided to target the design at very broad user areas, because the need to know more about the virus and how to deal with the emergency is common to all. This does not detract from the fact that some projects, such as those on the usefulness of washing hands or the impact of asymptomatic people in the spread of the virus, specifically target children and young people.

- Communicative objectives, which are established with the scientists and in relation to the users. To define the objectives, it is important to know the most interesting results obtained by the scientific partners involved, especially those that are more innovative, original and have a greater impact on the type of users identified. In the case of the project described, the choice of communicative objectives was conditioned by the most frequent questions that emerged in the first months of the pandemic's spread, which were then made explicit in the virtual exhibition.

- Communicative hierarchy, constructed on the basis of the hierarchy of objectives,

the contents and concepts to be communicated must be placed on different hierarchical layers according to the prominence that scientists and designers intend to give to the different information and data in order to demonstrate the progress made with respect to the state of the art. The criteria for constructing the hierarchical structure are strongly bound not only to the importance of the content, but also to the type of users and what the scientists intend to communicate to them most emphatically.

- Communicative constraints: the limits imposed by the context and the modes (analogue and digital) through which communication is delivered.

- Images of relevant scientific literature and communicative artefacts produced by scientists: i.e. those artefacts, such as brochures, diagrams, videos, etc., already developed by scientists to represent concepts similar to those addressed.

- Representational challenges and strategies most useful for pursuing the objectives as effectively as possible, in relation to the users, hierarchies and constraints identified. For example, facilitating the adoption of appropriate behavioural patterns to reduce the spread of the virus indicated by doctors and scientists, making the indications intuitive and very easy to understand, as well as memorable without effort, so that they can be easily translated into lifestyles.

- Expressive language, not to be considered as strictly related to technical/scientific language, since the choice of expressive language taken from contexts more linked to everyday life and its more light-hearted and pleasant moments, allows the message to be more easily conveyed through association with the most pleasant and positive experience.

- Concept and design in which final designs are developed and data and representation verified with the help of scientists. Through the described method, designers learn to use various critical, expressive tools, software and technical solutions, which are unusual in the common profession of designer, but useful in meeting specific needs to represent abstract, dynamic concepts, linked to invisible or very complex factors.

Linked to this are certain peculiarities of the scientific visualisation project that have emerged in the course of the research and projects developed in the HDL, such as modularity, which allows the artefact to be declined and moulded according to the different types of supports and contexts in which to place them; reference to neuroscience, which allows visualisation to be modelled as a cognitive experience and an intersection between perceptive, sensorial, cultural, evocative, cognitive and emotional aspects; finally, the responsibility and awareness that designers, as visualisers of the invisible, must recognise, in order to identify forms that through cross-references, evocations, abstractions and analogies are able to return the data concealed behind microscopes and infinitesimal scales.

3. MAKING THE INVISIBLE VISIBLE THROUGH DIGITAL TOOLS

Design integrates with science to visualise complex data and processes through graphic models, infographics and digital simulations (Tufte, 2001). The use of visual metaphors and analogies makes it possible to simplify complex concepts and bring the public closer to scientific topics that would otherwise be difficult to understand (Ware, 2012). A significant example is the use of 3D modelling to represent microscopic and nanoscopic structures.
The use of visual metaphors is a key strategy for translating scientific language into comprehensible images. One example is the representation of the brain's perivascular spaces as an enchanted forest, an approach that transforms a microscopic structure into an accessible visual narrative (Lupton, 2017). Even in pharmaceutical communication, design has been employed to visualise the drug delivery process through grape cluster analogies, facilitating the understanding of their cohesion and functionality.

4. HYBRID INTERACTION WITH SCIENCE

Digital technologies not only enable the processing and visualisation of scientific data, but also the creation of immersive experiences involving multiple senses. Augmented reality (AR) and virtual reality (VR) are used to transform science exhibitions and displays into interactive environments, making learning more engaging (Milgram & Kishino, 1994).
The integration of digital installations into

museum exhibits allows the educational and sensory impact of science dissemination to be amplified. Multisensory experiences that, through digital devices, include the use of sounds, lights, smells and tactile elements are very useful to immerse the visitor in the scientific context of reference, creating more tangible and less virtual experiences. In these cases, the digital, surprisingly, proves invaluable in making visitors better appreciate the materiality of things, through the involvement of the more material and analogue senses and the translation of abstract concepts into physical experiences.

5. THE FUTURE OF DIGITAL SCIENTIFIC COMMUNICATION

Il design e le tecnologie digitali stanno Design and digital technologies are redefining the way science is communicated to the public. The integration of tools such as augmented reality and 3D modelling enables the barriers between research and dissemination to be overcome, promoting a more inclusive and participatory approach (Norman, 2013).

The adoption of design and digital technologies in science communication represents an opportunity to make communication more effective and engaging. Through immersive experiences, visual metaphors and multisensory interactions, it is possible to transform the way the public perceives and learns about science. Technological innovation will continue to offer new possibilities to amplify knowledge and foster a more emotional and intuitive approach to science communication.

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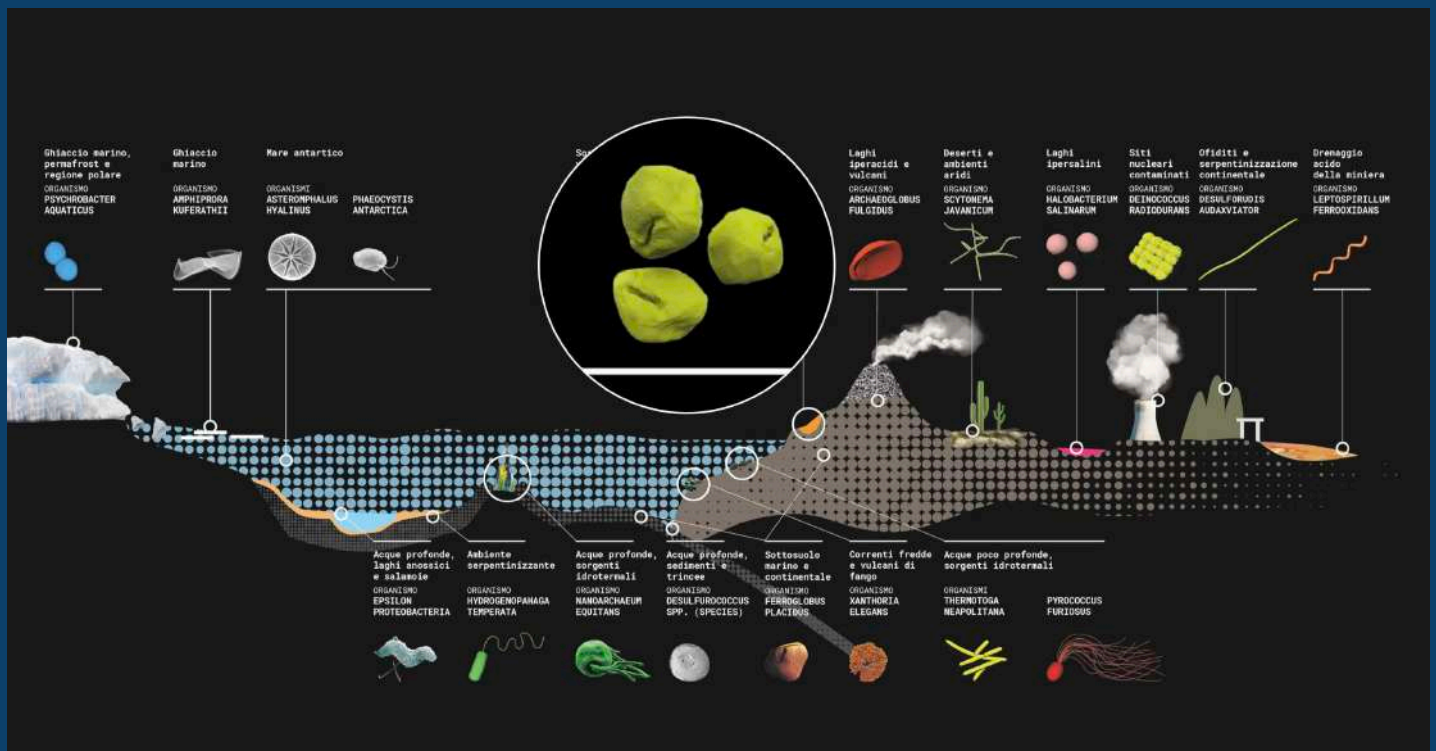


BEYOND EXHIBITS:

Leveraging Digital Tools for Sustainable Practices and Science Communication in Museums

by Guido Guarino

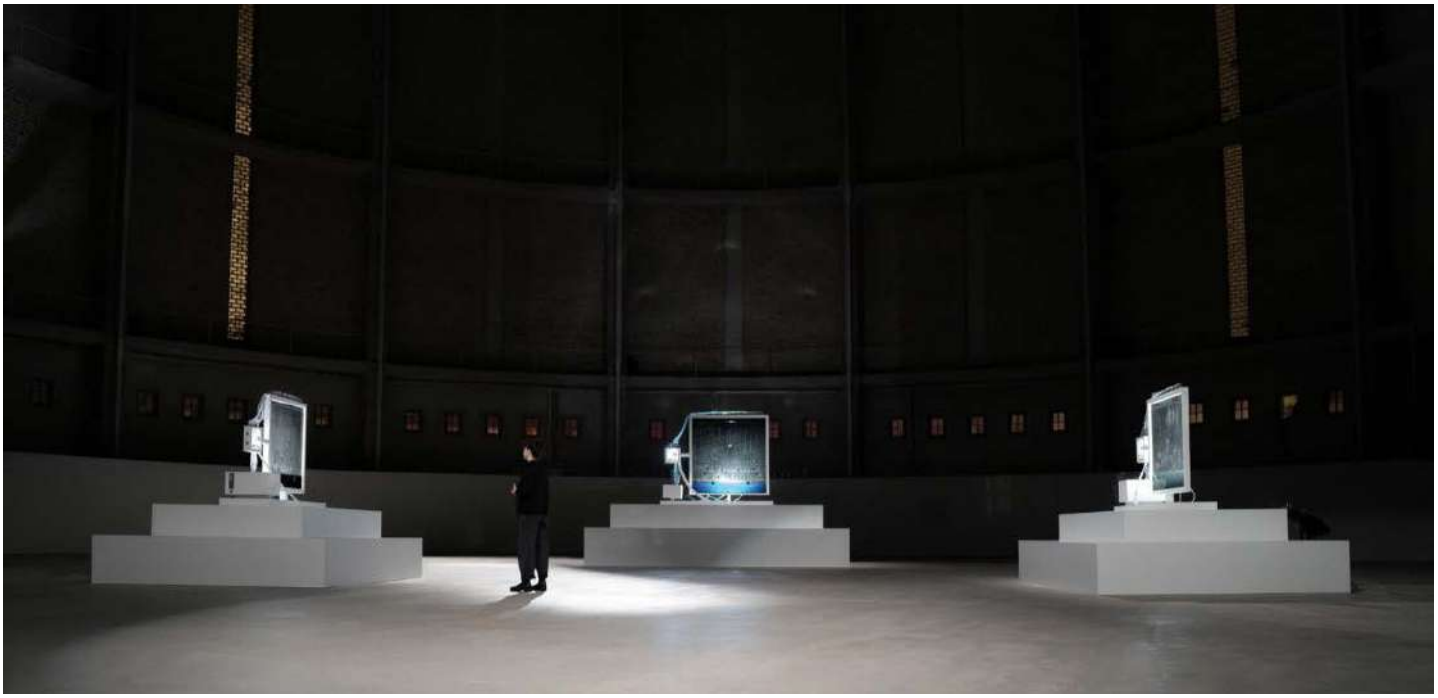
The global imperative to combat climate change has placed cultural institutions, including museums, at the forefront of sustainability efforts. Museums are uniquely positioned to lead by example, not only by reducing their carbon footprints but also by communicating these efforts to the public. This article explores how museums are leveraging digital tools to calculate their emissions and employing digital platforms to communicate sustainability. It highlights the role of carbon calculators, and it then showcases how museums can integrate digital transformation into their sustainability and outreach strategies. The findings underscore the importance of digital science communication in fostering transparency, engaging audiences, and inspiring collective action toward environmental responsibility.

INTRODUCTION

Museums are custodians of cultural heritage and play a critical role in shaping societal values. In the face of the climate crisis, they have a dual responsibility: to minimize their environmental impact and to educate their publics about sustainability. Recent advancements in digital tools have enabled museums to measure their carbon footprints with precision, while digital communication platforms offer unprecedented opportunities to share these efforts with a global audience. This paper examines the intersection of digital transformation, sustainability measurement, and science communication in museums.

CARBON CALCULATORS: TOOLS FOR MEASURING EMISSIONS

Accurate measurement is the foundation of any sustainability strategy, therefore carbon calculation tools are crucial for museums to identify and quantify their emissions across various operational aspects. These tools provide a systematic and standardized approach to measure carbon footprints (i.e. the total amount of greenhouse gases, primarily carbon dioxide, emitted directly and indirectly), allowing institutions to pinpoint specific sources of emissions, such as energy consumption, transportation, or material use, to mention a few. By establishing this detailed baseline, museums can prioritize areas for improvement, set targeted reduction goals, and track progress over time. Moreover, the data generated by these software solutions enables museums to make informed decisions about sustainability initiatives, allocate resources effectively, and demonstrate tangible results to stakeholders, ultimately laying the foundation for meaningful action in reducing their environmental impact. A diverse array of carbon calculation software tools is readily available online, offering museums a range of options to measure and analyze their greenhouse gas emissions across various operational domains. The Carbon Calculator, specifically designed for art institutions by the Gallery Climate Coalition (GCC), a non-profit organization whose aim is to create an environmentally responsible art world, allows its users to calculate emissions from travel, shipping, energy use, and materials. It features annual and project-specific reporting modes that enable detailed analysis of an institution's environmental impact. Other noteworthy tools are Julie's Bicycle Creative Climate Tools and Beyond Carbon Impact Tracker, used by over 2000 organization across more than 20 countries, which provides a comprehensive platform for arts organiza-

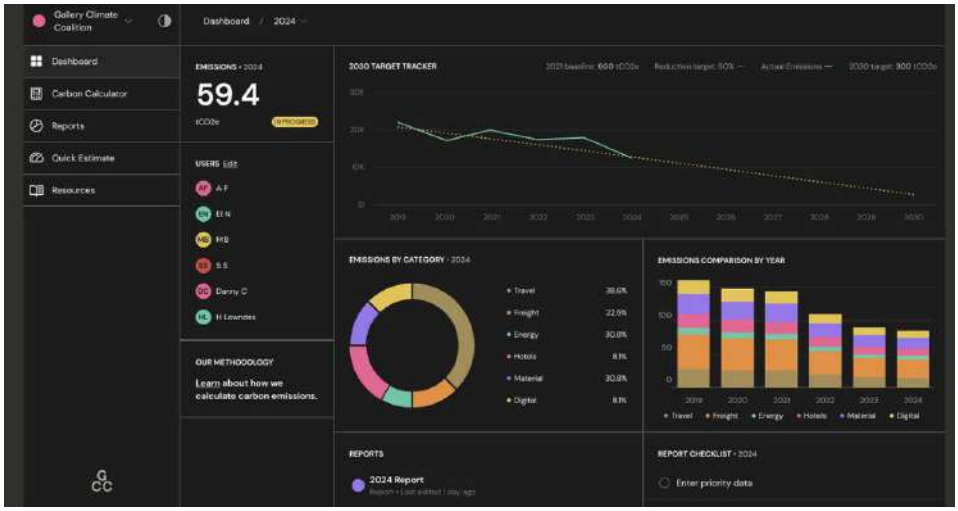


tions to measure emissions from various activities such as energy use, waste management, water consumption, travel, and freight. These tools include benchmarking features that allow museums to compare their performance against industry standards, record progress and make strategic changes. Another remarkable software, The Impact Model Carbon Calculator, was developed by the Design Museum London for the exhibition "Waste Age: What Can Design Do?". It measures emissions across multiple categories including object transport, building materials, and museum operations. In 2023, The Impact Model Carbon Calculator was made available online by the museum to support other institutions in the process of tracking and calculating their carbon emissions. Lastly, the STiCH Carbon Calculator is tailored for cultural heritage institutions and assesses material choices alongside their carbon emissions. As stated on the project's website, the easy comparison of the carbon footprint between products allows users to lower the environmental impact of their action by making educated choices. The above-mentioned tools empower museums to systematically quantify their environmental impact and provide data-driven insights for decision-making. While carbon calculators serve as invaluable implements for museums of all sizes to quantify their emissions, it is important to note that major institutions and scientific museums often collect extensive environmental data through research and other activities, and that this data can be shared with wider audiences not only through formal reports and scientific papers but also by integrating them into displays and exhibitions, thereby enhancing public engagement with environmental issues.

DIGITAL COMMUNICATION STRATEGIES FOR SUSTAINABILITY

Once emissions are measured and actions to reduce them are undertaken, museums can employ digital platforms to communicate their sustainability achievements and the results of their extensive research effectively. Social media campaigns serve as a powerful avenue for outreach: museums can create engaging content such as infographics and videos that highlight key metrics related to their sustainability efforts. By utilizing platforms such as Instagram, TikTok and X, they can provide real-time updates on ongoing projects and initiatives that resonate with their audiences. Several museums are already going in this direction, and, namely, the Natural History Museum in London has pledged to become the first museum globally to set a science-based carbon reduction target, sharing this commitment on its website and social media channels, the same applies to the Design Museum in London that regularly shares sustainability data and findings through its website and social media. Virtual exhibitions represent another innovative approach to communicating sustainability initiatives. Museums can design online exhibitions that focus specifically on their sustainability journey, utilizing interactive storytelling techniques that engage visitors in meaningful ways. Augmented Reality (AR) and Virtual Reality (VR) technologies can enhance these experiences by allowing users to visualize behind-the-scenes sustainable practices or explore the impact of specific initiatives in an immersive environment. An interesting example of this approach is the 2022 digital exhibition "SDGs: Innovations for Sustainable Future", by the Czech Center in New York, that offered an innovative approach to showcasing the UN's 17 Sustainable Development Goals through AR. Visitors experienced a unique blend of art and technology as they explored pictograms scattered throughout the space. Using a dedicated app on tablets or mobile phones, these static images would transform into dynamic, interactive displays, bringing the SDGs to life in a visually engaging manner.

The exhibition space was then transformed into a dynamic showcase of scientific progress and innovation through digital technologies. By merging scientific perspectives with creative visualization techniques, "SDGs: Innovations for Sustainable Future" offered its visitors a compelling and immersive exploration of current global challenges and potential solutions.



Digital reporting is also crucial for transparency in sustainability efforts, museums can, in fact, publish annual sustainability reports that include interactive visualizations of their progress over time. This not only allows stakeholders to track improvements but also fosters accountability within the institution. QR codes placed strategically in the physical exhibition spaces can link visitors directly to detailed online reports or specific sustainability projects, bridging the gap between in-person experiences and digital information. Educational content delivered through digital channels further enhances public engagement with sustainability issues. Museums can develop webinars, podcasts or online courses that educate audiences about their sustainability practices and broader environmental concerns.

Collaborative initiatives involving multiple institutions can amplify sustainability messages across broader networks, this is the case of the artwork 'GASP' by the artist Thijs Biersteker, realized in collaboration with the World Health Organization (WHO). The artwork visually represents air pollution by magnifying PM2.5 particles 4000 times, making the invisible visible. The installation uses real-time data from air quality sensors to create a dynamic display of oil droplets in water, illustrating the concentration of harmful particles in the air. By comparing pollution levels from different locations – the place of the exhibition, a nearby busy road and a forest – 'GASP' provides a tangible representation of air quality differences. This artistic approach aims to raise awareness about the severe impacts of air pollution, which contributes to millions of deaths annually. The artwork serves as a powerful tool for environmental communication, transforming abstract data into an experience that encourages viewers to consider how much the air they breathe is influenced by human activities and the urgent need for action against pollution.

Conclusions

Museums are at a pivotal moment where digital transformation intersects with environmental responsibility. By utilizing advanced carbon calculators alongside innovative communication strategies rooted in digital science communication principles, they can not only reduce their own emissions but also serve as leaders in promoting sustainable practices globally. When science communication is integrated with digital tools effectively, museums can engage audiences meaningfully while inspiring collective action against climate change.

The integration of digital tools into museum operations represents a paradigm shift in how cultural institutions address sustainability challenges. By adopting carbon calculators tailored for their unique needs, museums gain actionable insights into their environmental impact that inform strategic decision-making processes aimed at reducing emissions. However, measuring emissions is only part of the equation; effective communication is essential for inspiring public trust and action toward sustainable practices within the communities served by these institutions. Digital platforms enable museums to reach diverse audiences with tailored content that demystifies complex data while fostering a sense of shared responsibility among their publics and stakeholders. Challenges remain regarding equitable access to these technologies across institutions of varying sizes and resources; smaller organizations may struggle with funding or expertise necessary for implementing advanced carbon measurement systems or engaging audiences digitally at scale. Collaborative initiatives such as shared platforms or open-access tools could help bridge this gap by providing resources that support all types of cultural institutions in their journey toward sustainability.

Further research should explore long-term impacts of these strategies on public behavior regarding environmental issues while investigating how smaller institutions can adopt similar practices affordably without compromising quality or effectiveness in outreach efforts aimed at fostering greater awareness around climate change challenges faced by society today.

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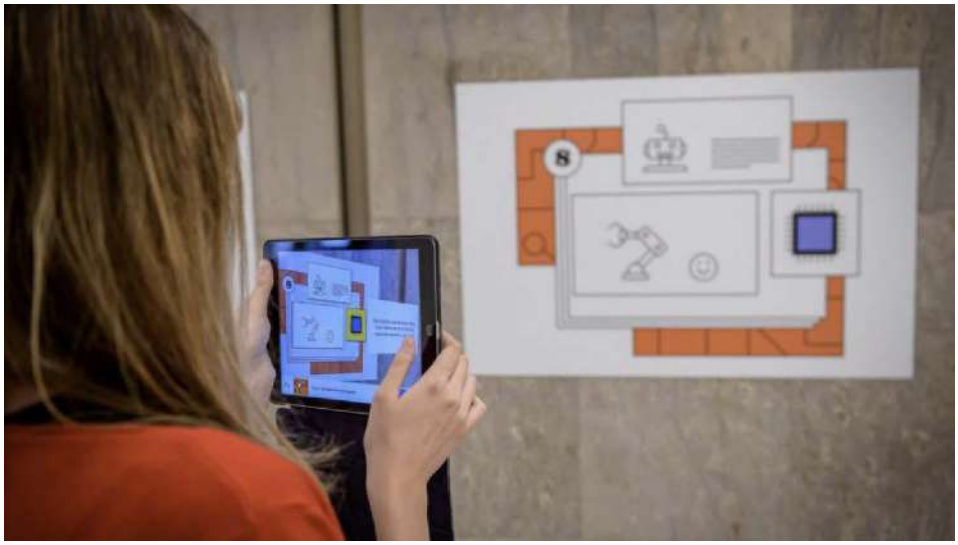
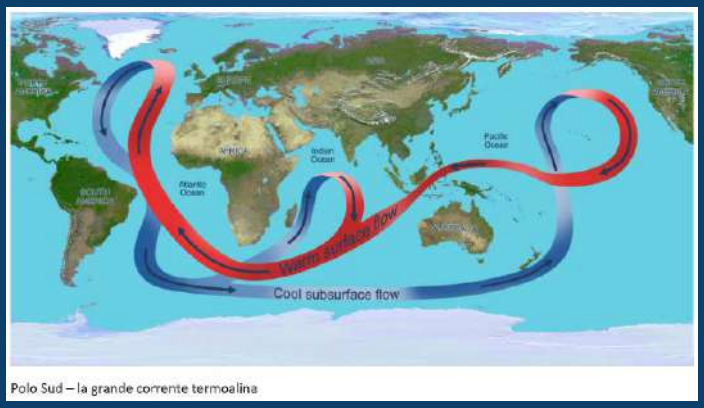


14 MARCH - 16 APRIL 2025

PADUA - ITALY

SPERIMENTANDO 2025
H2O, A MOLECULE FOR LIFE
WHAT, HOW, WHERE AND WHEN?

The interactive scientific exhibition on physics, chemistry and natural sciences 'Sperimentando 2025' will have as its subtitle "H_2O a molecule for life". It will be open to the public from 14 March to 16 April 2025 in Padua at the former slaughterhouse cathedral at 1 Via Cornaro.



Polo Sud – la grande corrente termoalina

https://sperimentandoaps.wordpress.com/sperimentando-2025/

15 - 17 MARCH 2025

CENTRO CONGRESSI FAST - MILANO - ITALY

I GIOVANI E LE SCIENZE 2025

The I giovani e le scienze event promotes and enhances the scientific and technological skills and potential of young Italians, offering them significant opportunities to interact, grow and realize their potential in science and its applications. The fundamental objectives of the initiative are: to bring young people closer to science and research, to identify and encourage the most deserving and promising, and to stimulate the spirit of innovation and collaboration among students.
Starting in 2008, I giovani e le scienze is part of the MIM program for identifying and promoting excellence in science and technology, Io merito.

https://fast.mi.it/events/i-giovani-e-le-scienze-2025/

FAST
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fondata nel 1897

13 APRIL -13 OCTOBER 2025

OSAKA - JAPAN

EXPO 2025

Expo 2025 is the Universal Exposition that will be held in Japan from April 13 to October 13, 2025.
Twenty years after the Aichi Expo 2005, Expo 2025 Osaka will bring the international community back to Japan.
Around 150 participating countries and 28.2 million visitors are expected.
“Designing future society for our lives” is the theme chosen for Expo 2025 Osaka
This theme aims to guide the international community’s participation in designing a sustainable society that supports individuals’ ideas about how they want to live.
“Saving lives”, ‘Empowering lives’ and ‘Connecting lives’ are the three sub-themes of the Expo.

https://www.expo2025.or.jp/en/

7-9 MAY 2025

AMSTERDAM - PAESI BASSI

DATA SCIENCE CONFERENCE NEXT 2025 (DSC NEXT 2025),

The International Data Science Conference 2025 (DSC Next) is the leading global platform for professionals and researchers in the field of data science and machine learning. This year’s conference will bring together leading experts from the academic world and industry to explore cutting-edge advances, innovative solutions and ideas that will shape the future of technology and analytics.

https://dscnextcon.com

27 - 29 MAY 2025

ABERDEEN - SCOTLAND

PCST 2025

Using science communication to bring about positive change: exploring transitions, traditions and tensions

The University of Aberdeen is pleased to invite you to participate in PCST 2025. The theme of the conference will seek to explore the transitions (change vs. stability), traditions (the old, the present and the new) and tensions (dispute vs. consensus) that influence all of our work as science communicators.

In this context of climate emergency, global health imperatives such as food and water security, and poverty alleviation, the PCST will meet in 2025 to discuss how science communication can and should be used to positive effect in our changing world.

https://www.pcst.network/conferences/upcoming-conference/

3 - 5 JUNE 2025

COPERNICUS SCIENCE CENTRE - WARSAW - POLAND

ECSITE 2025

The Ecsite conference is the world's largest gathering of science communicators from over 50 countries. It is a unique opportunity to share knowledge, learn and establish valuable professional contacts.
Ecsite connects, inspires and empowers science engagement organisations and professionals, extending the reach and strengthening the impact of their work.
Through Ecsite, members have the opportunity to participate in collaborative projects shaping the future of science engagement. Ecsite runs projects funded by the European Commission as well as initiatives in partnership with other organisations.
The Conference will be held in the Conference Center of the Copernicus Science Center, in the Planetarium and in the recently restored Copernicus Revolution Lab.

https://ecsite.wildapricot.org/conference

4 - 5 - 6 JUNE 2025

BOLOGNAFIERE - BOLOGNA - ITALY

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An accelerator of culture, training and innovation that operates as a tool at the service of society, connecting Italy and the world.
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Albert Einstein

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