Traditions for a Sustainable Future

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International Committee for Museums & Collections of Science & Technology

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ICOM- CIMUSET: International Committee for Museums and Collections of Science and Technology
ICOM, Maison de l'UNESCO, 1 rue Miollis, 75732 Paris Cedex 15, France
Tel: +33 (0) 1 47 34 05 00/ Fax: +33 (0) 1 43 06 78 62
http://network.icom.museum/cimuset

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CIMUSET 47th annual conference, Kyoto 2nd -4th September 2019

Within the ICOM's general conference Theme "Museums as Cultural Hubs: The Future of Tradition", the International Committee for Museums and Collections of Science & Technology (CIMUSET) established its own program for the triennial, in cooperation with the National Museum of Nature and Science, Tokyo. CIMUSET 47th conference in Kyoto debated around a topical theme witch concerns all technical-scientific museums and science centres in the world: "Traditions for a Sustainable Future." : How can science and technology museums advance ecological, economic, cultural and social sustainability? What is sustainable scientific and technical heritage? How can science and technology museums be spaces for change? What is the role of traditional know-how and techniques in the future?

It was noted that this topic stimulated a particular interest among ICOM Kyoto 2019 participants, during our 6 sessions we had 22 presentations with more than 400 participants.

CIMUSET off-site meeting: 5th September 2019

Our guests spent also an intense moment, during our off-site meeting in Nagoya region, the third-most-populous urban area in Japan, with many museums of traditional handicrafts, industrial high-tech and nature and science museums.

CIMUSET participants benefited from a wonderful guided tours in Toyota Commemorative Museum of Industry & Technology and Nagoya City Science Museum.

CIMUSET 2020 conference:

Our next 48th conference will be in the Iranian National Museum of Science and Technology in Teheran, from 26th to 30th October 2020.

Theme: "Museums & Environmental Concerns, New Insights".

Conference web site, call for paper and registration: http://cimuset.inmost.ir/

See you soon !

Ech cherki DAHMALI
CIMUSET Chair

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Scientific Exhibitions for Historical Buildings: How Traditional Fiocruz Collections Serve Contemporary Science Communication

Diego Vaz Bevilaqua[1] and Marcos José de Araújo Pinheiro[2]

Casa de Oswaldo Cruz, Oswaldo Cruz Foundation, Rio de Janeiro/RJ, Brazil

Abstract The Oswaldo Cruz Foundation (Fiocruz) is a scientific institution devoted to public health which is highly active in heritage preservation and science communication. Fiocruz was founded in 1900 and has a long tradition in museums and collections. The Foundation is home to a historical site that is listed as a Brazilian national heritage site, partly accessible to the public through Museu da Vida (Museum of Life), the institution's science museum. This paper presents the plan for requalification of this historical site, a master plan that will reshape Museu da Vida and enlarge its exhibition galleries, with an emphasis on the museum's relationship with the public, the city, and Fiocruz collections. The plan aims to expand access to the historical buildings, make the Fiocruz collections more accessible to the public, renovate the long-term science exhibition at Museu da Vida, strengthen the relationship between the institution and its territory, and enhance the popularization of knowledge produced by Fiocruz. A major challenge for this project is to communicate contemporary scientific research at Fiocruz, integrating interactive devices with collections and historical perspectives in galleries located in the heritage buildings. A key element here is to understand the institution's tradition as a gateway to contemporary innovation and as an element to spark public engagement with the subject. We present the plan's principles and guidelines and its approaches to the new long-term exhibitions, and conclude by discussing the project's sustainability.

1. Introduction

The Museu da Vida (Museum of Life) of the Oswaldo Cruz Foundation celebrated 20 years in 2019. The museum was created through a collective aspiration to innovate in the institution's tradition of harboring museums, bringing new concepts at the time of its development to enhance interaction between the public and science. Following the model that was characteristic at the time of its inauguration, Museu da Vida incorporated various aspects from the Science Centers movement, while valuing its own collection. Another characteristic is that the museum occupies several historical buildings whose value stems precisely from their role in the history of science, and where science continues to be produced. Museu da Vida is thus a science museum in which science is alive and is produced constantly by Fiocruz, sharing space with the public that want to interact with this

[1] diego.bevilaqua@fiocruz.br
[2] marcos.pinheiro@fiocruz.br

science. This close relationship between heritage preservation and science communication gave rise to the Plan for Requalification of the Manguinhos Historical and Architectural Heritage Site (NAHM), whose principles and main exhibitions are described herein.

2. Fiocruz: 120 years of tradition in museums and collections

The history of museums at Oswaldo Cruz Foundation is nearly as old as the institution itself. The Federal Serotherapy Institute (the institution's first name) launched its activities in the year 1900, installed temporarily in the houses on the Manguinhos Farm, on what was then the outskirts of the city of Rio de Janeiro, with Oswaldo Cruz as the founding scientific director.

The years 1904 to 1922 witnessed the construction of the buildings designed by Portuguese architect Luiz Moraes Jr. to house the institution's scientific activities: the Stable (1904), Dovecote (1904), Plague Pavilion or Clock Building (1905), Teahouse (1905), Moorish Pavilion (1918), Oswaldo Cruz Hospital (1918), Quinine Building (1921), and Vaccine Pavilion (1922). This ensemble, part of which is listed by Brazil's National Institute of Historical and Artistic Heritage (IPHAN), features as its grand symbol the Moorish Pavilion (or "Castle"), built to house the institution's first research laboratories and now home to the Office of the President of Fiocruz

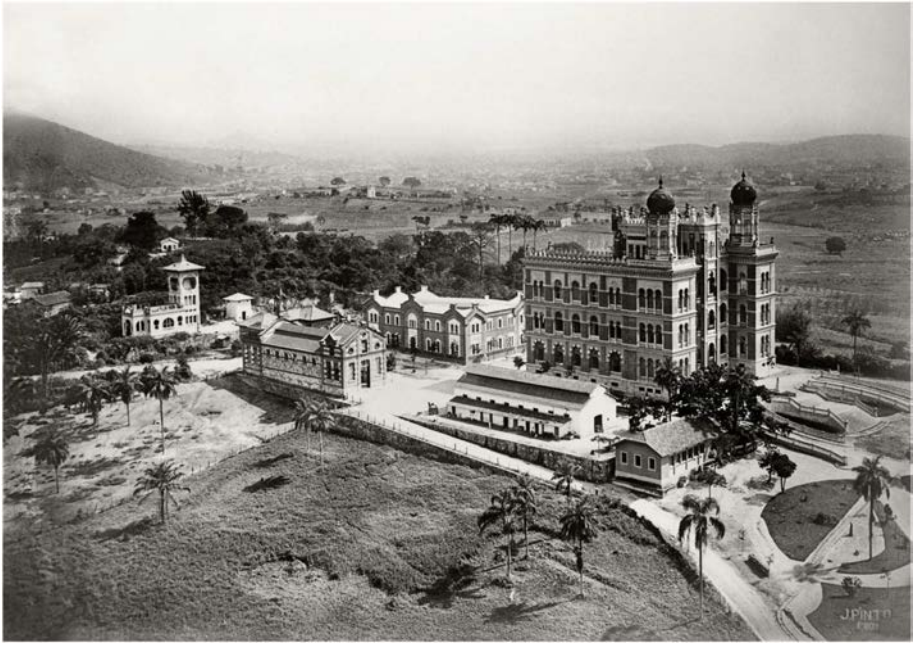

Figure 1. Buildings on the historical site around the Castle at the Oswaldo Cruz Foundation, c. 1920. Source: DAD/Fiocruz Collection.

(OLIVEIRA, 2003).

Already in its inaugural decade, the institute began to form its first in-house scientific collections, as was the practice in such institutions at the time. From the beginning, these featured the entomology and anatomical pathology collections. The Castle's original floor plan already had a scientific museum, conceived along the lines of early 20th-century museums of natural history. The collections were transferred to the Castle as soon as construction was concluded, and the museum opened its doors and became a place for research, exchange among researchers, and reception of distinguished visitors (especially scientists) (NOGUEIRA and ROCHA, 2018). In the 1960s and 1970s, the institution suffered an intervention by the military government installed in Brazil by a coup d'état in 1964, and many scientists were stripped of their positions and parts of the collections were destroyed. After Brazil's re-democratization in the 1980s, many collections were recovered and reorganized, and they now comprise the rich body of collections of the Oswaldo Cruz Foundation. There are now 33 biological collections, many of which are international references, whose tradition began in the early 20th century.

Following Oswaldo Cruz' death in 1917, his office on the Castle's second floor was preserved and maintained as a memorial room with the purpose of extolling the man who went down in history as the institution's founder and patron. His office came to be known as the Oswaldo Cruz Museum and became the memorial setting for visitors to the institution to learn about Oswaldo Cruz' feats. Over time, personal objects were added to the room, which became the original nucleus of the Fiocruz museum collection as a whole (NOGUEIRA and ROCHA, 2018).

Brazil's re-democratization in the 1980s also created new forms of democracy inside the institution. Since then, the relationship between Fiocruz and society has been reclaimed according to democratic values. From that moment on, museums at the institution have been redesigned through the proposal for the creation of Museu da Vida, which has added its museum collection to the proposal to communicate science through dialogue and innovation.

3. Museu da Vida: innovation in science communication

The proposal for the creation of Museu da Vida emerged in the early 1990s with the aim of expanding the Foundation's educational activities and establishing a bridge between specialists and a wider audience. The new museum is organized by Casa de Oswaldo Cruz, the unit of Fiocruz created in 1986 with the aim of preserving the memory of health and science, health's cultural heritage, and science communication, adding the experiences from previous museums and their historical collections, but with the perspective of introducing innovations in the models.

First of all, the idea was to build an interactive museum along the lines of the experience with the *Exploratorium*, inaugurated in San Francisco in 1969, with a focus on understanding scientific processes as part of humankind's immaterial heritage. This movement intended to lend a historical view to scientific knowledge, seeking a critical vision of the scientific process itself. The goal was ultimately to create a living museum inside an institution in full operation, coexisting with, contrib-

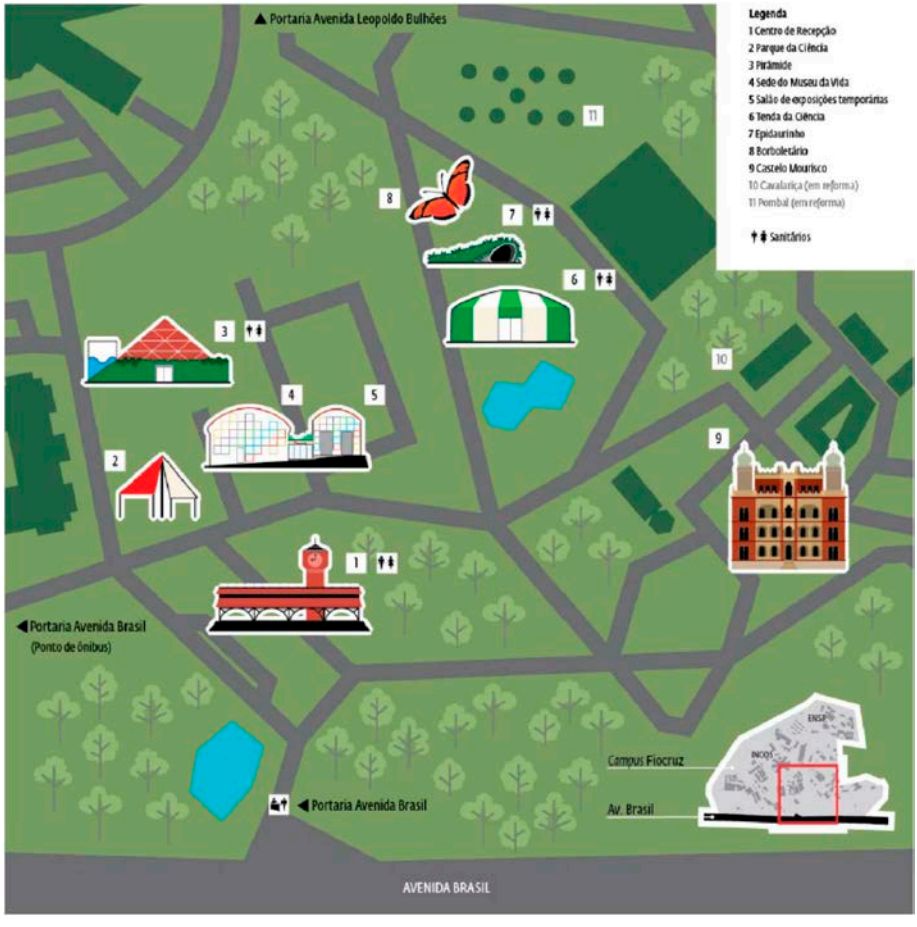

Figure 2. Schematic map of a visitor's tour to Museu da Vida. Source: Museu da Vida/Fiocruz.

uting to, and being fed by this living science.

Museu da Vida thus opened its doors to the public in 1999. Rather than occupying a single building, the Museum was structured in various spaces on the Manguinhos campus, including both indoor and outdoor spaces, interactive exhibitions, historical buildings, ecological trails, a tent for theatrical shows, and more recently a butterfly house and an archeological site, among other attractions. The Museum's exhibitions been worked with different languages and resources, with human mediation as an important part of the educational proposal (BEVILAQUA *et al.*, 2017).

Preserving history and reflecting on the current context also help light the way for the future. Museu da Vida now needs to strengthen itself as a space for dialogue between different forms of knowledge, linking discourses capable of associating scientific knowledge with personal interpreta-

tions and local contexts, as an actor capable of influencing the social territory it occupies in the city of Rio de Janeiro.

In this context, the Plan for Requalification of the Manguinhos Historical and Architectural Heritage Site (NAHM) features a proposal to reposition the Museum in the territory it occupies, aimed at lending a broader meaning to this occupation, expanding the exhibiting spaces and linking more to preservation of science communication's own cultural heritage.

4. The plan for requalification of the historical site

History has shown that ever since Fiocruz was founded, the institution has taken an innovative and active stance to its activities in research, education, production, and services, with a focus on public health and the reduction of social and health inequalities. This reveals an institution engaged in preserving and making accessible the different cultural and scientific collections built throughout the Foundation's history, understanding its memory and cultural heritage as strategic and structural elements in its organizational culture and the fulfillment of its mission. This stance led Fiocruz to take a step ahead of the state and municipal agencies in charge of overseeing cultural heritage, proposing the recognition of various cultural assets under the Foundation's custody, which led the National Institute of Historical and Artistic Heritage (IPHAN) to list the Moorish Pavilion, Clock Pavilion, and Stable as national heritage buildings in 1980. In 1985, Fiocruz requested IPHAN to extend the listing to include the green area around these buildings and other buildings from the eclectic period, the Quinine Building and the Dovecote. The polygon corresponding to this green area served as the reference for the Campus Master Plan in 1988 and for subsequent plans. This proactive approach was repeated over time, resulting in the Rio de Janeiro state heritage listing of two modernist buildings in 2001, and more recently in the Moorish Pavilion's candidacy as a UNESCO World Heritage Site, based on its value as cultural heritage of the sciences and health.

The year 2013 witnessed the conclusion of the Plan for Occupation of the Preservation Area of the Fiocruz Manguinhos Campus (POAP), an institutional planning and management tool for the architectural, urban, and landscape heritage of the Fiocruz Manguinhos campus, aimed at guaranteeing the integrity, visibility, and legibility of the relevant assets for preservation on the site's area and consolidating the campus' calling as a "Campus-Park", seen "as a healthy, safe, comfortable, and culturally enriching campus for its employees and visitors". (Casa de Oswaldo Cruz, Instituto Brasileiro de Administração Municipal, 2011, pp. 18–19)

The NAHM site was recently favored by the expansion of new areas for occupation by Fiocruz, capable of housing administrative functions that are currently installed in the historical site. This created challenges that had to be dealt with and that might otherwise jeopardize the conservation and valuation of the NAHM site, since the lack of appropriate projects would leave the historical buildings at the mercy of improvisation and occupations resulting from lack of planning. This also allowed elaborating a project for new uses of the historical spaces as they were vacated, which led to the Plan for Requalification of the Manguinhos Historical and Architectural Heritage Site, under

the coordination of Casa de Oswaldo Cruz, based on recommendations in the POAP. The Requalification Plan seeks to value the historical site through interventions that preserve its identity and uniqueness, besides generating a greater supply of sociocultural activities for society at large, especially the population in the territory of the Manguinhos campus.

5. Guidelines

Based on the participatory management model adopted by Fiocruz in its corporate decision-making process and the election of its leaders, which assumes that the decisions, guidelines, and planning result from collegiate deliberations, the first working group was set up in 2011 in Casa de Oswaldo Cruz, consisting of professionals from the areas of cultural heritage, science communication, research, and education. The working group's first task is to discuss and draft a reference document defining the values, objectives, and orientation for all the projects and activities needed to develop and implement the Plan. Joining the working group were external guest specialists from the fields of preservation of architectural heritage, museology, museography, and museum communication. The working group's composition was revised and expanded in 2013 under a ruling by the Office of the Director of Casa de Oswaldo Cruz, and strategies were created to expand the project's visibility and participation.

The working group's attributions involved the definition of uses and occupations, needs schedules, management model, and the internal and external target publics. The plan's development used project management models as the basis for its macroplanning, in order to take the various scenarios into account and to establish, for each model, the associated risks and possible alternatives. The underlying principles were defined as the project's full accessibility and sustainability, and different programs were created to lend greater autonomy and agility to the processes needed for the Plan to materialize, focused on communication, cooperation, fundraising, exhibitions, restoration of the buildings, and institutional management.

The Requalification Plan includes the buildings that comprise the institution's original site, namely the buildings constructed in the early 20th century (except for the Oswaldo Cruz Hospital and the Vaccine Pavilion): Moorish Pavilion, Clock Pavilion, Quinine Building, and Teahouse, plus the Pasteur Square, the Oswaldo Cruz Path, and the Henrique Aragão Pavilion, thus shaping a continuous intervention area. After defining the space for intervention, the working group produced a reference document, which required listening and establishing consensuses in the institution on the principles and guidelines capable of translating the values and identity of Fiocruz and intensifying the institution's relationship with the territory where the Manguinhos campus is located and with the city of Rio de Janeiro as a whole. According to the reference document, the requalification of the NAHM site incorporates the POAP in its entirety and is an integral part of the master plan that orients the occupations and interventions in the Manguinhos Campus as a whole. The central principle in the Plan's development is that the interventions should be based on the cultural, social, ethical, and scientific spheres that translate human action in that specific place over time. It means that

all the activities should be centered on the institution's artistic and historical values; symbolic aspects and memory; the right to transmission and enjoyment, from one generation to the next, of the testimonies, daily life, and individual and collective memories; and the centrality of the recognition that this is a noteworthy place for generation of knowledge, building relevant cultural and scientific collections, and living in the production of new research in different areas of science (FUNDAÇÃO OSWALDO CRUZ, 2014). The Requalification Plan should be oriented by strengthening the relationship between Fiocruz as an institution of science and technology and society in the field of health; by sustainable requalification; by preserving the institution's uniqueness and identity; and by valuing the Foundation's daily reality and work.

6. Sustainability strategies

To address the principle of sustainability, the orientation is comprehensive, integrated conservation and sustainable requalification, the latter as a more expanded concept in the issue of rehabilitation of historical areas, considering that a project of this nature should not be limited exclusively to the search for efficient use of natural resources and lower environmental impact, which are necessary but insufficient conditions. This concept was taken as a reference in the studies produced by Rehabimed[3], an interdisciplinary network in the Mediterranean Region, oriented to sustainable rehabilitation, restoration of heritage, and urban upgrading, aimed at socioeconomic revitalization of the historical centers in the Mediterranean, and these experiences are intended to back activities in other regions. It is thus necessary for the Requalification Plan to focus on improvements in the quality of work and life for staff and users of the NAHM site and the Manguinhos campus as a whole; valuation of the campus' cultural and natural heritage; improvement of social cohesion by promoting citizenship and valuing diversity; and promotion of the territory's socioeconomic vitality.

As described previously, a favorable factor is the institution's history with its active and proactive position in the preservation of its cultural assets and training teams with the skills to conserve its cultural collections and develop projects with this approach and size. Such action has been acknowledged by various national awards and the fact that three of its archival funds and a manuscript have been acknowledge by the UNESCO Memory of the World Program, at the national and regional levels. In addition to this component of institutional culture, it is necessary to act on various strategic fronts, in special two of these fronts. On is focused on production of the project's core narrative, its principles and values, and on the methodology in its development. Another focuses on the political commitment by the top management of Fiocruz. One of the lines successfully organized for the project's sustainability is the Cooperative Program, essential for the project's visibility and for sharing experiences and knowledge, having established cooperation with international institutions (such as the Museum National d'Histoire Naturelle and Universcience from France and the Science Museum Group from the United Kingdom), motivated by the interest in sharing experi-

[3] http://www.rehabimed.net/

ences in the field of heritage preservation and science communication and demonstrating the credibility built by the project. This was reinforced by the Fundraising Program, described previously as relevant for obtaining supplementary revenue to the regular budget, and which has achieved noteworthy success, for example with the agreement signed in late 2018 with the National Economic and Social Development Bank (BNDES, an important Brazilian public investment bank) for financing the services planned in the Stable and Dovecote. Fundraising from external sources is a strategic element in the institution's internal affirmation, enabling the Requalification Plan politically by minimizing the perception by other parts of the Foundation that the Plan is competing for internal resources with the research departments, education, services, and production at Fiocruz.

These components add to sustainable requalification as one of the project's underlying principles, thereby affirming the sustainability of the Requalification Plan for the NAHM site, based on the following (PINHEIRO *et al.*, 2019, p. 86):

- The Foundation's tradition in the preservation of its cultural heritage
- Recognition and attraction of core competences
- The proposal's social acceptance
- Adoption of sustainable standards in the architectural and urban planning projects
- Public-private partnerships
- Commitment by the institution's administrators

7. Thematic lines

A dialogue between staff members at Casa de Oswaldo Cruz and Fiocruz and external consultants resulted in the definition of crosscutting themes (DEAN, 2003) that will be developed in the new exhibitions that will occupy the historical spaces that are being requalified. Importantly, in principle, these themes will cut across all the new exhibitions, rather than each one materializing in a single exhibition. Each exhibit gallery's narrative seeks to connect the building's history to a cross-section of these themes.

- **Public health in Brazil**
  This thematic line deals with the history of health in Brazil, with a focus ranging from the First Republic to the history of the present.
- **Science and Technology in Health**
  This thematic line deals with contemporary research, scientific innovation, and technological development in the field of health.
- **Health, Environment, and Sustainability**
  This thematic line addresses the relations between health and the environment, with a focus on the sustainability of human development.
- **Cultural collections in Health**
  This thematic line aims to lend visibility to the wealth and diversity of cultural and scientific collections under the custody of Fiocruz.

· **Fiocruz and Cities**
This thematic line discusses the relationship between the Fiocruz campuses and its territories, with a special focus on the Manguinhos campus and local urban development.

8. New exhibitions and their buildings

Among the various buildings on the Fiocruz historical site, we selected those that will house new long-term exhibitions with their respective themes already defined.

Stables

The Stable was originally built to house healthy horses that were used to produce antisera, and particularly bubonic plague antiserum, which was produced in the adjoining building, the Plague Pavilion. The outer design was inspired by an imposing stable in English architectural style and an ornate façade, while inside it is characterized by a concern with typical laboratory and hospital hygiene, with the walls covered in while porcelain tile. The construction used state-of-the-art sustainability technologies, such as reuse of wastewater to irrigate the pasture and the manure for fertilizer and to produce biogas for lighting. The Stable was listed as a national heritage building in 1981. Since the 1970s, the Stable has housed various museums and exhibitions, the most recent of which was the Biodiscovery exhibition, one of the original long-term exhibitions of Museu da Vida.

Under the new proposal for occupation, the Stable Building will house an exhibition that will

Figure 3. Stable Building. Photo: Celeste Souza.

discuss health in its different scales and components (historical, biological, cultural, and social). The proposal is for the public to enter the exhibition and to able to explore the theme of health in its microscopic and macroscopic dimensions through different exhibit tours. The exhibition will draw on a wide variety of techniques and languages, using audiovisual modules, interactive multimedia, collections, hands-on interactivity, etc.

Dovecote

Situated at a short distance from the main historical site, the Dovecote was also known as the Small Laboratory Animal Facility. It was built to house the rearing of birds, rats, rabbits, frogs, and other small animals for research purposes. At the center of eight circular buildings, there is a ninth building originally used to house homing pigeons that were used to send messages between the institute and the Rio de Janeiro city center. There is a wall around the ensemble, surrounded by a garden. The Dovecote is now in the process of national heritage listing and enjoys the status of interim listing.

Under the new proposal for exhibitions, the Dovecote will serve as an area with a mix of museum, urban planning, and environmental interventions. The space will host activities for the open-air Museum, allowing free exploration by visitors as well as leisure activities, alongside interactive equipment to facilitate visitors' communication with nature. The built areas will present narrative tours on the Manguinhos campus' environmental history, animal experimentation in the sciences, and the use of homing pigeons. The Dovecote will also be the starting point for the historical-environmental trails to be promoted on the campus by Museu da Vida.

Plague Pavilion

Also known as the Clock Pavilion, the building was built from 1904 to 1905. As a response to

Figure 4. Dovecote. Photo: Peter Ilicciev.

Figure 5. Plague Pavilion or Clock Building. Source: COC Collection.

the bubonic plague epidemic that had struck Brazil, the Pavilion was designed for research on the plague bacillus to produce antisera and vaccine. It was built to house horses inoculated with the plague bacillus and two laboratories, one each on the north and south wings. The Pavilion was also listed as a national heritage building in 1981.

An exhibition will be installed in the Plague Pavilion to discuss the technological and social processes in the production of antisera and vaccines, from the early 20th century to today. The proposal is to feature an early 20th century laboratory for the production of antisera and vaccines in one of the wings with historical objects kept at the storage at Museu da Vida, and modern-day vaccine production in the other wing, thus establishing a 120-year journey crossing the building from one wing to the other.

Moorish Castle

The Moorish Castle or Pavilion is the third building from the national heritage listing of 1981. Considered the main building on the historical site and the symbol of Fiocruz, floor plans for the Castle began in 1903, but the construction was not finished until 1918. It was built with the most advanced technology of the time, with electrical installations and an eclectic style featuring an important Moorish influence. Located on a hilltop, the Castle is an imposing structure on the surrounding landscape. It was designed personally by Oswaldo Cruz together with Portuguese architect Luiz Moraes Jr. to house the institution's research laboratories and to be identified as a symbol of Brazilian science. It has five stories in addition to a ground floor and two towers standing out on each wing. The building now features monumental lighting for it to be visible from different points in the city.

3rd Floor

Ever since the Castle was first built, the third floor has featured an area dedicated to collections.

Figure 6. Moorish Pavilion at dusk. Photo: Peter Ilicciev.

One wing housed the institution's library, now a Rare Works Library, and the other wing housed the Museum of Anatomical Pathology in the early 20th century. The wing where the museum was located is now occupied by Museu da Vida and serves as a gallery for temporary exhibits.

Under the current project, this exhibit will feature the Fiocruz collections, exemplifying the importance of science collections in the process of science production, but also illustrating the different research subjects today in the field of biomedical and health sciences. This exhibit will mix historical objects, documents, biological specimens, digitized collections, and interactivity using new technologies to approach the theme.

2nd Floor

The Castle's second floor originally held various laboratories and the office occupied by Oswaldo Cruz. Thus, since his death, this space is dedicated to institutional memory and was occupied for most of the 20th century by the Oswaldo Cruz Museum. Since the creation of Museu da Vida, the space has been dedicated to an exhibit on the lives of Oswaldo Cruz and Carlos Chagas.

In a new reformulation proposal, the exhibition will discuss the history of public health in Brazil, emphasizing the contribution by Fiocruz in this scenario. Both Oswaldo Cruz and Carlos Chagas appear as key characters in this history, which will discuss the consolidation of the idea of a public health system, the need for the system's nationwide expansion, and the importance of technological production in this scenario, particularly vaccine production.

9. Final remarks

The Plan for Requalification of the Manguinhos Historical and Architectural Heritage Site (NAHM) provides for greater use of the historical spaces at Fiocruz by the population, shifting many activities to other locations and expanding the exhibit areas, while actively pursuing the preservation of this heritage. This will allow Museu da Vida to rethink its own relationship to its territory. This project is thus an opportunity to view the historical site as integral part of a place that experienced enormous changes in the 20th century. It is important for this Plan to be a vector for the institution to act in local social development, integrating the site in the cultural map of the city of Rio de Janeiro. In addition, through the approach between the science exhibitions and historical areas, it will foster a greater dialogue between traditional history exhibitions, with their objects and collections, and contemporary science communication, seeking to diminish these tensions and view a history that deals with both the past and the present.

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Connecting Past and Present: Transforming an Iconic Power Station into a Modern Science and Technology Museum

Jacob Thorek Jensen

Danish Museum of Science and Technology, Helsingør, Denmark

Abstract This paper is addressing how we are trying to rethink the role of a museum of science and technology. It is about connecting past and present, and together creating a more sustainable future. Science and technology have such a huge impact on the world today. Everyone is affected by technology on a daily basis and its significance is evident in most aspects of society. So, there is no question in regard to the relevance of our museums, but maybe we need to rethink *what* we do and *why* we do it in order to be relevant for more people today. That is what we are experimenting with at the Danish Museum of Science and Technology.

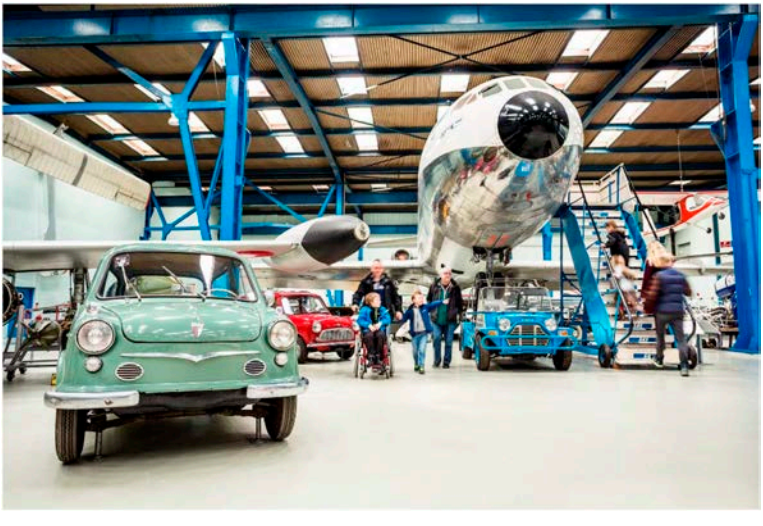


Photo 1 View of the current exhibitions at the Danish Museum of Science and Technology. Credit: Christoffer Askman.

The resurrection of a museum

The Danish Museum of Science and Technology is an autonomous museum with a national responsibility to deal with the technological and industrial development of Denmark. We receive support from the Danish government to carry out this work.

At the moment, the museum is located north of Copenhagen, the capital of Denmark, in a medium sized town, but will move to Copenhagen when the new museum opens within the next 5–7 years. The museum is visited by approximately 60–70,000 people a year.

The museum was established in 1911 by the Confederation of Danish Industry and the Association of Craftsmen in Copenhagen. The diversity of the collection is enormous; from steam engines to smartphones; a Soyuz-space capsule; the original LEGO; production facilities; and Denmark's first car from 1888, which is the world's oldest functioning car. There are more than 30,000 objects in the collection. The unifying term is innovation. Every single object in the collection is an example of new ideas or new discoveries.

Even though the museum is more than 100 years old, it has been somewhat neglected in recent years with falling visitor numbers and a collection in poor condition. The museum is at the moment located in an old industrial facility, which is not suited for a modern museum. Large parts of the museum are not heated for instance. So, the development of the new museum is in fact also the rebirth of the old museum. It has now been decided to transform the museum and relocate it.

Five reasons for a new museum

Why do we even need a new museum? We have identified five main reasons why Denmark needs a new museum of science and technology.

Photo 2 The relationship between humans and machines will be at the core of the new museum. Credit: Mads Høbye.

1. Technology is the future

The world as we know it is changing rapidly, and might altogether collapse if we continue as we are living today. We need to act and come up with new solutions for a more sustainable future. Here we want to discuss the challenges and potentials, which the technological future brings. Robots, digitization, artificial intelligence, biotechnology, and other advanced technologies are changing the way we work, live, and communicate—that is the very core of social and cultural aspects of human beings.

2. Denmark is a high-tech society

Denmark is a high-tech society with a unique industrial and technological history, which is not properly dealt with in the country at the moment. The museum will deal with the stories about the creation of the modern Danish society—in other words the DNA of the Danish model and way of living. We want to explore the challenges and potentials, which science, technology, and innovation create for Denmark and the world.

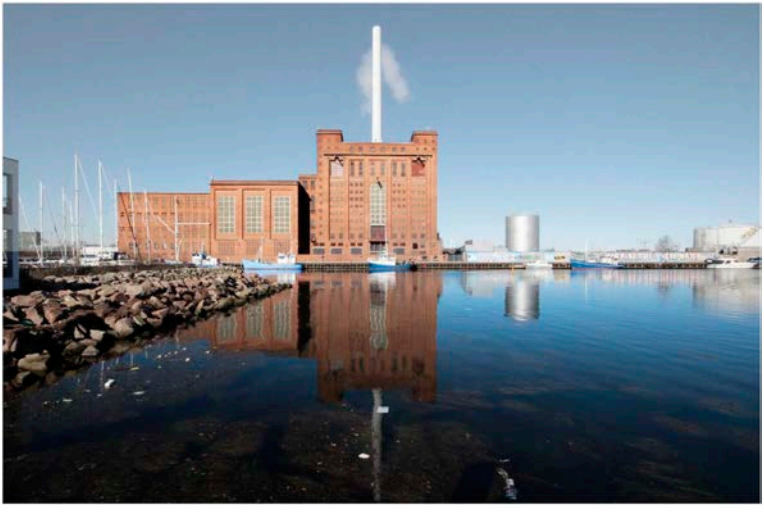


Photo 3 The Svanemølle Power Plant in Copenhagen will be the site of the new museum.

3. A cultural powerhouse

We want to engage citizens, researchers, institutions, companies, and others in the shaping of a more sustainable future by developing new perspectives on our collection and unfold new potentials, which lies in rethinking the history of Denmark seen from an industrial and technological perspective. We will do this by creating a platform or meeting place for many different activities, such as exhibitions, talks, events, festivals, discussions, learning, digital content, and so on. We have a

broad approach to our subject, so it includes everything from science, technology and innovation to design, art, and ethics.

4. A power station for everyone

The museum will be placed in one of the most iconic industrial sites in Copenhagen, the Svanemølle Power Station, a power plant from 1953. The power station is a landmark in the northern part of the city, which has been closed to the public because of its functions. When the turbines move out within the next years, it will be transformed into the museum in part of the building. The vision is that the remaining part of the building should house start-ups, co-working spaces, educational and research institutions, or other players within the fields of science, technology, and innovation and thus making the entire plant a hub and incubator for new sustainable ideas and solutions.

The plant is located in Nordhavn, an old industrial area of Copenhagen. The area is being transformed into a new sustainable neighborhood in Copenhagen, where 40.000 people will live, and 40.000 people will work.

5. Strong partnerships

The plans of creating a new national museum of science and technology can only be accomplished with strong partners. The project is supported by key stakeholders such as the Confederation of Danish Industry, the Association of Craftsmen in Copenhagen, the Corporation for Development of City and Port Copenhagen and the Municipality of Copenhagen.

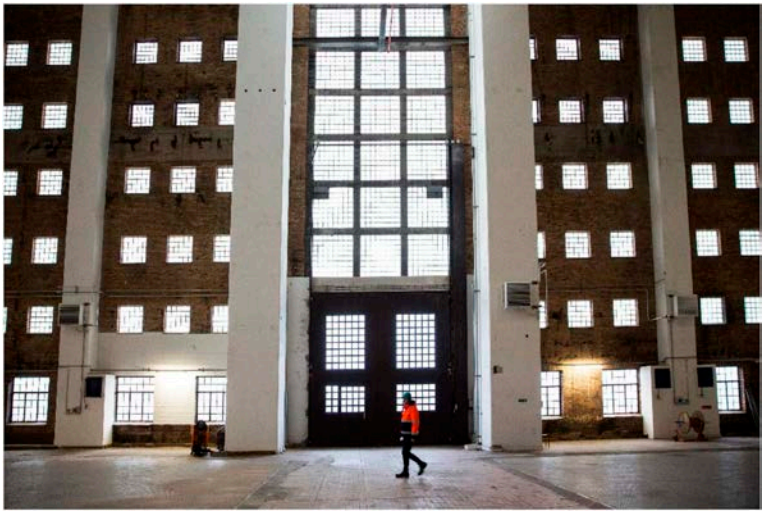


Photo 4 View from the inside of the power station.

Transformation

We are still working on the plans and identity and concept of the new museum. It is a process that is carried out in dialogue and collaboration with stakeholders such as citizens, educational and research institutions, companies, politicians, communities, and artists.

The aim is to link the museum with the history, aesthetics, architecture, atmosphere, and intangible heritage of the building itself. It's about preserving the industrial look of the plant, but still make it a dynamic sustainable museum fit for the future.

From coal to culture

The museum will be placed in the kettle hall, which is the main facility in the plant. Based on a market analyses the museum will, when fully developed, take up 12,000 square meters of the 22,000 square meters in the building.

Photo 5 Visualizing of how the rooftop garden might look when the museum opens.

Facilities

There will be a wide selection of activities in the museum with of course exhibitions, where the main space will be the large kettle hall with 40 meters to the ceiling.

The museum will host a studio, which is a hub or incubator within the museum with a large number of interlinking cultural, tech and science-related activities, such as talks, makerspaces, economic and social innovation, start-ups, residencies, digital culture production, and art. This space will also play a key role in the educational programs, which we will provide at the museum.

There will be flexible spaces that can be used to host all sorts of events and activities such as festivals, seminars and conferences, presentations, and talks. This is where key stakeholders around

science, technology, and innovation get together and share experiences, insights, and knowledge about new future solutions and ideas.

The 'Himmelrummet' is the rooftop garden of the museum. The garden and the green houses will function as a reflective space for the visitors to enjoy and discuss topics, which are raised in the museum. This is also a space where we can discuss and present future foods and production methods such as vertical farming. The garden also provides a unique view of the northern part of the city making it an attractive hangout for the local inhabitants in Nordhavn.

A museum about science, technology and innovation

The frame of the new museum can be divided into three:

- Technology and industry: the possibilities of technology and the drivers behind it
- Humans and culture: the interactions between technology and our civilization, values and existence
- Local and global challenges: everything between the very near and the future of the planet

The core of this frame, and what the museum will be dealing with is:

- Curiosity
- Science
- Creativity
- Innovation
- Design
- Production
- Entrepreneurship
- Sustainability

This means that we have a very broad perspective on science and technology and want to focus not just on what, but why. This is of course part of the paradigm shift in museums from the modernist paradigm to the socio museologic paradigm; and maybe the hybrid museum paradigm, which I believe is what characterizes most museum practice today.

It's all about people

The technological development raises questions about how we live our lives and how we are organizing our societies. There is a need to develop new citizen skills that are reflecting the technological and digital revolution.

New technologies have endless possibilities. There is almost no limit to the capabilities of human beings. But what are the consequences on the social and cultural well-being of citizens of these new

technologies? The same goes for the digital revolution. Digital technologies have restructured the power balance of the world and are questioning the future of democracies and our basic human rights.

Science and technology might have created a lot of the problems we are facing today, but we also need to look for new ideas and discoveries within these fields to solve the challenges our world and its inhabitants have.

We need institutions that can facilitate an open and honest discussion about these important issues with all kinds of people in society with no regard to age, gender, educational background, ethnicity, sexual orientation, spirituality etc. We want the museum to take on this important role. We want to be a platform for discussions, dialogues, reflection, and meetings about the challenges and potentials of science, technology, and innovation in an equal frame between past, present, and future.

Photo 6 The Bits & Beers event at the museum is an opportunity for different people to engage with science.

Engagement

How do we engage more different kinds of people in science and technology? We are looking at the concept of science capital to engage a variety of groups in science, technology and innovation.

Science Capital is developed by the Science Museum in London and Kings College. It is a tool to give insight into why some people engage with STEM, and why a lot of people don't. It is an approach that is looking at every single individual and what they know about science, what they think about it, what they do, and who they know. We have found it to be a very inspirational tool for organizational change, so we can facilitate experiences that engage more different kind of people with science and technology.

Creating a better future together

Museums of science and technology are dealing with the very core of the creation of the modern world and how we need to develop a sustainable future together for everyone. That is why we believe that museums of science and technology—in the many shapes they come—are among the most important museums that exists. Because of this we have an obligation not only to deal with the past, but we need to have our focus on the present and future.

More of the same will not do

I want to conclude this paper with a quote from the former UN secretary general, Ban Ki-moon as he before the agreement of the new UN sustainable development goals said: "More of the same will not do". He called out for a sustainable turnaround for our globe on a social, economic and environmental level. But we believe that museums, as part of a cultural level, also need to change. "More of the same will not do" also applies to museums.

That is why we need to rethink what we do and why we do it in our museums. And that is what we are experimenting with at the Danish Museum of Science and Technology.

47th Conference of CIMUSET, pp. 28–31, 2020

New Ways to Interpret Your Museum Collection

Julie Leclair and Monique Horth

Ingenium—Canada's Museums of Science and Innovation, Ottawa, Canada

Abstract Ingenium–Canada's Museums of Science and Innovation oversees Canada's three museums of science and technology: the Canada Agriculture and Food Museum (CAFM), Canada Aviation and Space Museum (CASM), and the Canada Science and Technology Museum (CSTM). Located in Ottawa, Canada's national capitol, these three national museums celebrate creativity, discovery, and human ingenuity, focusing on the stories of people. In 2016, the Government of Canada funded Ingenium $150,000,000 to build a state-of-the-art collection and conservation centre. During the design and build of this new institution, Ingenium took advantage of this unique opportunity to develop a new research strategy as well as develop the Ingenium Research Institute, driven by the Corporation's extensive experience and knowledge in unique ways to interpret a museum collection.

In 2016, Ingenium embarked on the development of the Ingenium Centre, a 36,000 square meter building dedicated to the research and care of the national science and innovation collection. Ingenium was committed to building a place where Canadians can be inspired by the science, technology and innovations that transformed Canada and had an impact on the world. The following 3 goals were set in place as markers for success.

- *Access = Knowledge Creation*
- *Adding diversity to the knowledge economy*
- *Strengthening Ingenium's role (and voice) in the arts, sciences, education and policy*

The heart of the Ingenium Centre is its collection, with over 85,000 3D objects and over 2 million pieces of archival material. The collection includes artifacts of different shapes and sizes, from locomotives and tractors to porcelain plates, seeds, and medical and scientific instruments. As Ingenium's three museums can only display around 12 percent of the collection at any given time, the Ingenium Centre will allow visitors to explore the collection with accessible guided tours. The Ingenium Centre also houses 150 dedicated and inspired staff.

Artifacts began to move into the new building in 2019, and will be completed by the end of 2021. The complexities of the artifact move cannot be understated and Ingenium wanted to share this exciting time in the organization's, and Canada's, history. Public engagement with the move has been very important, as well as successful. For example, at 7:00 am on July 25, 2019, Ingenium invited the public to come and see staff hard at work moving one of the collection's largest, and most iconic artefacts into the building: the 1201 locomotive. The success of this event was amazing and surprising. Enthusiasm for an early morning event was gratifying for the public and for staff

Photo credit: Ingenium – Canada's Museums of Science and Innovation

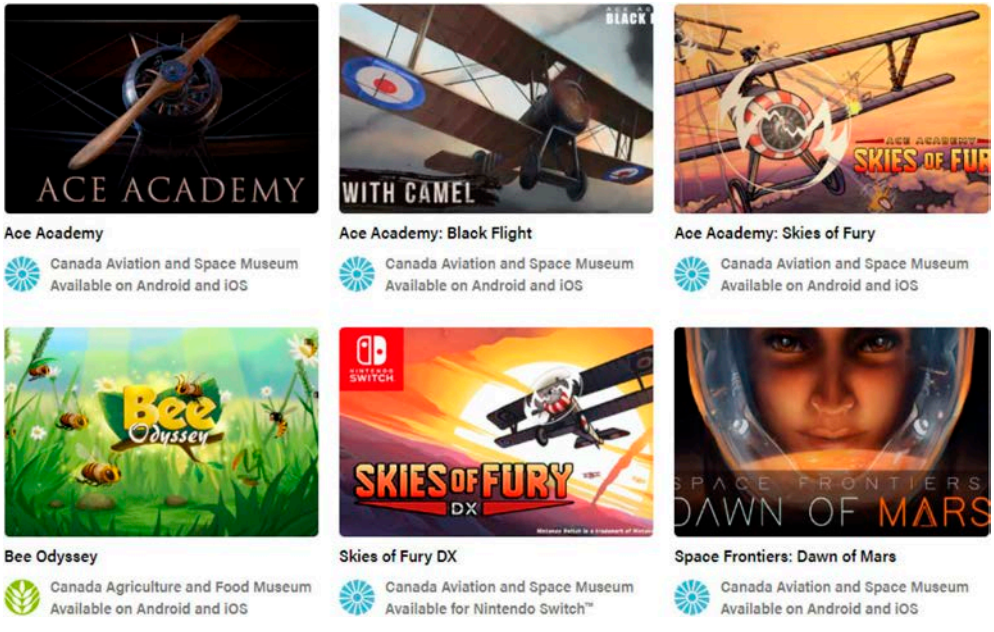
Photo credit: Ingenium – Canada's Museums of Science and Innovation

who had been working tirelessly on the logistics of this complex task. Creating the hashtag #IngeniumBigMove along with a strong social media presence provided excellent earned media uptake.

Building on a strong social media presence and seeing a gap within the online community of science communication, Ingenium created The Channel. The Ingenium Channel is a digital hub featuring curated content related to science, technology and innovation. Its goal is to facilitate science enthusiasts, teachers, parents, and curious Canadians to share and engage with innovative stories

through focused news, articles, blogs, podcasts, and videos. The Channel is just one aspect of the many digital assets that Ingenium develops in support of the collection.

A tremendous success on the digital front for Ingenium has been the creation of a number of gaming apps. To date, Ingenium has created 7 gaming apps based on its collection, and available on both iOS and Android platforms. These apps are both educational and fun, and have been a key component to the organization's international outreach, having been downloaded over 3.5 million times and in over 175 countries worldwide. Using the Ingenium collection and research has brought a level of authenticity and creativity to these games that often game developers to not have access to. The latest game is StarBlox Inc., launched on the Nintendo Switch platform, which combines incredible game play along with fun and educational facts about Earth's Solar System.



Gaming apps developed by Ingenium and available on iOS and Android platforms

Another innovative way in which Ingenium is providing access to the collection is through 3D scanning. A number of artifacts from the collection have been 3D scanned at a very high resolution. These wire frame files are offered for free download, along with full educational programs. This allows teachers and educators to 3D print the artifact and have a full lesson plan around it to use in the classrooms and educational workshops. Knowing only a fraction of Canadians will be able to visit their national collection in person, Ingenium aims to bring the collection to Canadians in as many diverse and accessible ways possible.

As staff begin to get settled in the new Ingenium Centre, the Ingenium Research Institute is tak-

ing shape. This Institute invites Canadians, and people from around the world, to change how they think about science and technology by cultivating a better understanding of the material culture of humanity's past, present and future. The Institute will use the national collection to explore the many ways that science and technology are embedded in society, culture and history.

The Ingenium Institute consists of: a fellowship program for university and college students at all levels; digital multi-media labs and collaborative spaces to put research into practice; an artifact examination room for hands-on research, symposia and seminars on material culture; a library and archives; an extensive online collection; and opportunities for researchers to engage with visitors at Ingenium's three museums.

Ingenium is committed to diversifying its approach through the reciprocal exchange of ideas with people of diverse culture and ethnic background, as well as exploring gender studies and the role of women in STEM (Science, technology, Engineering and Mathematics). But this cannot be achieved in a vacuum. Collaborations with researchers and curators from around the world will be sought out. And strong relationships will be built with Indigenous communities to learn about Indigenous science, technology and Ways of Knowing from them.

Exploring new ways to interpret a museum's collection can be challenging, but the rewards and outcomes are worth it. Encouraging staff to be creative and to take some risks can have surprising and incredibly rewarding results.

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Postmodern Museology—Study Museum Approaches to Improve Informal Education from the Past to Modern Times

Mehran Norouzi and Parvaneh Asghari

Iranian National Museum of Science and Technology, Tehran, Iran

Abstract Museums as educational centers play a key role in the progress of informal education in societies. This informal education forms more than 90% of all the knowledge a person obtains throughout his or her life. To have a better understanding of museums' function we need to know museums and their stand through history.

- What is the role of museums in the informal education of societies?
- How are museums effective in promoting informal education?
- How do museums interact with their visitors in the process?

Through this paper, the place of the museum during the history- especially from the Renaissance era to modern times- and the role of these multidimensional institutes in the progress of informal education are studied

Key words: Museum, Informal Education, Postmodernism

The paper theme intends to study informal education in museums. The quantitative and qualitative role of museums in this regard has a historical background, hence the paper's main purpose is to describe how museums reach this goal and achieve this place. Undoubtedly museums' activities and programs for informal education have changed over time. These changes even capture the museums goals. As far as today, education is museums main purpose. Understanding how museums achieve educational goals is the main motive for this paper.

Alexandria, the beginning of the quest for modern education?

The Musaeum or Mouseion at Alexandria, which included the famous Library of Alexandria, was an institution said to have been founded by Ptolemy I Soter. This original Musaeum ("Institution of the Muses") was the home for music or poetry, a philosophical school, and a library such as Plato's Academy, also a storehouse of texts. It did not contain a collection of works of art, rather it was an institution that brought together some of the best scholars of the Hellenistic world, analogous to a modern university. This original Musaeum was the source for the modern usage of the word museum. However, this museum cannot be regarded in the same sense of modern museums and cultural heritage, but the main question is that does the quest for a new type of education lead to display objects that were not necessarily historical? It seems that this attitude distinct it with its other contemporary examples.

Renaissance, New Attitude, New type of Education

Since the late fourteenth century, by the Renaissance, enlightenment period, a new way of looking at society, we see fundamental changes in human attitudes. What shapes a mutual chapter between this revolutionary phenomenon, museum and museology are the fundamental influences led to the emergence of the definition of museum and museum in the modern sense through the renaissance.

The intellectual changes and the materialistic and spiritual attitudes transformation toward art and culture, the prevalence of the spiritual and cultural dimensions of artistic works in comparing to materialistic dimension all le to a fundamental impact on collecting and displaying artistic works by different social classes.

Other chain developments like civil and spiritual reforms and the empirical science development, national governments' formation, new approach to the concept of nationality or nationalism, humanistic movements and Romanticism tendencies, and the intellectual thoughts and achievements in enlightenment centuries led to collect cultural objects, natural samples and the accumulation of private collections and royal art galleries and artistic aristocratic centers and the remnants of the Ancient, especially ancient Roman-Hellenistic objects and remnants paved the way for the emergence of modern museums that we see today. The term "gallery" meaning showroom, formed at that time. Using special architectural space and the emergence of galleries to display objects led to preserve and protect these objects as a profession (Curating). The two other important events resulted from this archeological approach are Museumification and Muzeolization.

These activities originated from capitalist families and the owners of the Renaissance period like Medichi family who invited people to visit their collections. On the other hand, allocation of a particular architectural space "gallery "to display artistic works is also an important step toward step by the community toward the museum.

Moses sculpture by Michelangelo

After all, in spite of opening art galleries in the Renaissance, there is no accurate reason to show that these activities were done to promote informal education in societies.

In the fifteenth century, Florence, the biggest center for supporting art and science, dedicated the term "museum" to the rich collection of the Medici family. this gallery had various collections up to 200 years later that public museums became popular.

17th century:

In the 17th century, some important events changed the attitudes toward museum objects and

their status. The most important event is opening Ashmelon Museum by Oxford University in 1683. Elias Ashmole acquired his collection from two gardeners: John Tradescant, father, and son. The Tradescants were no ordinary gardeners; they were employed by the wealthy Earl of Salisbury. The Tradescants voyaged overseas, traveling the known world and shipping back new and exotic plant specimens for the Earl's gardens. In the course of their travels, they also acquired a remarkable collection of curiosities that included botanical, geological and zoological items as well as man-made objects. Ashmole gifted this collection to the University.

This museum is unique for 2 reasons. First, it had an entrance to receive money for visiting its collection and second the Tradescant collection gives an opportunity to scientists to produce natural science, therefore Ashmelon is the first natural science museum in the world. We see a new approach; people pay to visit precious collections and it is a new chapter in museum evolution.

Against the Renaissance period that objects were demonstrated to show the political and economic power, at this time education is an important element and the primitive way of it is to sell information through a ticket. As museums had income, the number of museums increased. by this increase the number of museums, a competition occurred among them which led to producing knowledge and informal education among the communities that have museums.

18th century:

By the 18th century, however, 'cabinets of curiosities' gave way to different types of collections prized for their comprehensive ranges of plants, animals and various other types of artifacts. Europeans had come to recognize that nature itself offered enough diversity to delight the observer without recourse to the marvelous. In 1753 century the British Museum was founded and the main core of this museum was a collection by Hans Sloane, the successful English physician, and naturalist who left in his will some 71,000 plants, animals, antiquities, coins and many other objects of the time.3 years later in 1756, The Vatican Museum was established.

Painting: France situation in European revolution (www.rieke.tk)

People who were interested to visit had to write their requests two and after two weeks they could visit the museum and this procedure continued till 1800. Private collections and museums were inspired by two influential groups. Artists and natural science researchers one of the most important is the French Natural History Museum opening. This expansion and the improvements in attitudes toward museums attitude are the beginning of the competition to achieve success and social popularity.

It should be noted that although there were

restrictions to visit museums at that time, the most significant movement to form museums was shaped by England, and the result of it was a revolution in the history of museums in which transformed into public and it is referred as European Revolution in museums. This process had a profound effect on the museolization of European societies. Even as we study the evolution of museum architecture, we also discover the remarkable transformation of private collections into public museums. On the other hand, the museums with educational role had more chance in this new market. In America, the first official museum is Charleston Museum, which was opened in 1773 in Southern Carolina.

Charleston museum
(www.charlestonsouthernhomes.com)

19th Century

The first half of the nineteenth century was influenced by the France great industrial revolution. A revolution that needs researches to know its roots. It started with a few simple inventions but ended up with great social movements. Over time this revolution became a social revolution and it created social, legal and mental equality that formed the basis of our modern life. We still live amid this industrial revolution, and we cannot judge the effects of it well, but the future will prove its importance sublimity of humans. It is somehow comparable to the Renaissance. The Renaissance promised personality, dignity, and respect while the Industrial Revolution established a kind of monotheism in nature.

By industrial revolution emergence, wealth came back to Europe, Copernicus was rejected, business routes created new cities, universities emerged in the cities. Science improved by universities and it brought industry. The impact of the revolution is tangible on museums and it was so powerful that it has affected all aspects of human thought.

The emergence of specialized academic disciplines is one of the most significant effects of the Industrial Revolution on the world of museums. The specialized people in these majors moved toward museums. This led to a mutual relationship between museums and academic disciplines, leading to the promotion of museums in the academic world.

Among various museums formed at that time, the science and technology museums had a special place. London Science Museum (1851) is a prominent example. The main reason for the emergence of this particular type of museum was to train new technologies to a 19th-century man. Maybe a folding cabinet bed, a stereoscope machine, a mechanical elevator made up few pieces were called machine. These items along with other simple and complicated devices were displayed in science and technology museums to reflect the modern and artificial history of humans and stimulate visitor's minds to design something that can be found in the museum. At this point, museums knew

their role in informal learning and moved in this direction.

The theory of evolution by natural selection, first formulated in Darwin's book "On the Origin of Species" in 1859, aroused people's interest to visit natural history museums and it was an educational step by the museums.

London science museum
(www.sciencemuseum.uk.org)

But another aspect of Darwinism was the impact of museums on community education and the educational role of the museums in general. If by the late 19th century, families and educational systems did not force children to go to school more than half of them refused to go to school. In spite of this fact, these children and adults had a keen interest to visit natural history museums and even other types of museums. This social attraction and motivation for museums was another reason to rise museums as a powerful social media. Museums' pervasive role in promoting informal education.

Twentieth Century, rise and decline of education in museums

Arising out of the rebellious mood at the beginning of the twentieth century, modernism was a radical approach that yearned to revitalize the way modern civilization viewed life, art, politics, and science. By definition of 20th-century museums, we find that museums are the product of modernism.

The museum's role to arouse audience curiosity, convey ancestors' experiences through visits, provoke a sense of inspiration for visitors and audiences, is an important form of education in museums. Considering this unique type of education in museums led to the formation of classrooms in the museum environment. The **École du Louvre** (1882), the Pennsylvania Academy of Sciences in Philadelphia (1900) and the University of Chicago (1919) are examples of this movement.

But World War II in twentieth century became the decline of the museums. The overwhelming trend of museums in physical dimensions (increasing number of museums), research (publication specialized museum researches) and international relations due to the war stopped and it was the darkest image in the history of the museums.

In the 1960s the path of museums in different parts of Europe was separated. In the Mediterranean region of Europe by the expansion of tourism, the museum was partially restored, and interestingly, it served as a place to attract groups of people. But in northern Europe, they shifted toward education in museums that led to establishing museums. In the United States, too, the process of developing a museum network accelerated more than ever, and according to the statistics.

In 1964 in every 3 days, one museum was opened. The same trend has led to an increase in the value of artistic works in the US art market. Documents show that many objects came to New York

through London, Paris, and Zurich. The emergence of human-centered museums in the face of object-centered museums, in the years after World War II, their ascendance due to postmodernism all occurred in the second half of the last century. But the peak of this generation of museums can be traced in the last third of the 20th century. At this time human-centered is a type of thinking that can dominate all kind of museums. The set of policies that affects the attitudes of the museum managers, the museum ranking in compare with other, and these principles can be applied to any natural and scientific historical, anthropological and eco-museums.

Human-centered museums do not deny object-centered museums. They emphasize on visitors. Since human is the target of modernism and the museum of these decades is a showcase of the prevailing thought in human societies, the influence of museums on the ideas of modernism has led to the formation of human-centered museum. Museums.

Getting more comfortable with modern machinery has captured the human of the modernism era, and the tendency of visitors shifted to museums with more attention to welfare and satisfaction. At this time the leading role to define museums was by ICOM and academic museological centers.

The museums of modernism were moving simultaneously in two opposite directions. Large cultural collections on one side and small museums for a particular subject increasingly became popular on the other side. We have witnessed the evolution of two opposing trends: multi-purpose and specialized museums.

At that time, the museum was not only a place to preserve and display valuable objects but also the focus and attention of professionals and curators on using technologies, creating comfort for visitors - as a major goal of museums, defining amusement spaces in museums and even shops and restaurants. This was all due to increasing number of museum visitors, the preservation and promotion of museums in societies, and the multifunctionality of these institutions, which was directly influenced by modernism. This modern atmosphere had directly influenced the quality and quality of museum education.

Twenty-first Century and Museum-Based education:

During this period museums were not just a place for preservation or display objects and in many cases, they became regional, national, and sometimes religious and political. Apart from the cultural and social role of museums, their economic role in tourist attraction is worth mentioning. such as increasing museum construction and its impact on the growth of cultural tourist populations in countries such as Germany, Spain, and the United States. The political role of museums in promoting certain ideas should also be mentioned, such as museums built by Jewish investors in major cities in the world, such as Berlin and San Francisco, by famous architects' reputation. As architecture was an important element in museum success, the type of museum had a significant impact on museum architecture. although in a general sense, museums are divided into two categories of artistic and non-artistic to have their architectural principles.

Postmodernism

Postmodernism is largely a reaction against the intellectual assumptions and values of the modern period in the history of Western philosophy (roughly, the 17th through the 19th century). Indeed, many of the doctrines characteristically associated with postmodernism can fairly be described as the straightforward denial of general philosophical viewpoints that were taken for granted during the 18th-century Enlightenment, though they were not unique to that period. Post modernists believe that:

> "Our world is rebuilt. Mass production, mass consumption, and the big city are all on the decline, and flexibility, diversity, differentiation, mobility, communication, decentralization and internationalization are on the rise. In this process, our own identities are on the rise. Our understanding of ourselves and our minds is also changing."

Museum, Museology, Postmodernism:

The rise of modern museums in a sense is due to postmodern museums. These museums are due to their form and content do not deny modern museums and they supplement museum parts of their museums. The main important issue in this era is the way to convey information to visitors.

New educational methods and approaches for museums lie in this attitude. postmodern museums are considered educational institutions rather than political, economic and national institutes; thus, contemporary museums are education-centered.

In the postmodern world, museums act as powerful and influential media to give awareness to the public about their surroundings. The most important manifestation of postmodernism in the world of museums and museology is applying concepts in museums' social structure. Therefore, the ultimate goal of new museology is to explain museums' social role. As a reason today we have more museums and social media that socially and culturally are developed. Due to postmodernism museums can show the communities cultural growth.

In New museums, the curatorship is modern and incomparable to the past. The twenty-first century- curator acts as a teacher. He does not only convey knowledge to the students but also teaches the scientific method of thinking to visitors. Before responding to him, he asks him questions to provoke thinking. This is vital for visitors. Visitors' evaluation is in three phases: before display, during the visit, and after the display to ensure how successful this visit is. Postmodernism also had a special impact on museum objects. Today visitors do not go to museums just to see magnificent dishes and ornaments of the nobility. The main reason is to know the creators' ideas. While it is important to understand the process of building a two-thousand-year-old metal idol, recognizing the thought behind it is the reason of attraction toward museums in the postmodern era. The direct and free expression education, without censorship, is the main achievement for museums in informal education in history. Museums independence from economic, political and national contexts on one hand, and their focus on the scientific, educational and ethical contexts on the other, is another rea-

son for promoting informal education.

Conclusion

- In the Alexandria Museum, we see a new event. A great change in educational methods.
- Chain developments in various social, cultural, economic and political dimensions led the aristocratic tendency to collect and display collections. In this way informal education occurred in a particular community, the visitors of galleries.
- In the seventeenth and eighteenth centuries, museums expanded in numbers but education in museums was not profound and in almost every country in this period there was a museum. America was one of these countries.
- The Great Industrial Revolution in the 19th century and its various scientific, cultural, economic and social dimensions were major steps to change the quality of informal education in museums. Science museums were opened rapidly, and education was the center of their attention. The Role of Museums in informal education by pioneering natural history museums to define and disseminate Darwin's theory reached a new level which is a modern approach in this regard.
- In the twentieth century, by World War I and II, the quality of informal education declined in museums. 3 decades after World War II, human-centered museums were formed and they focused on visitors. Fun and amusement besides education was the main activity of them. It also influenced on museum architecture.
- The role museums in informal education reached the highest point in the late 20 and early 21 centuries. Education in this phase goes beyond scientific fields and moves toward ethical issues and outlines contemporary social problems and in this way the educational role of the museum is highlighted more than any other social media. Certainly, this position is due to postmodern theory and thought-centered museums. Therefore, museums tried to design galleries based on thought-centered approaches. They ask questions from visitors' questions rather than answer their questions and this is the main role that museums in informal education.

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47th Conference of CIMUSET, pp. 41–47, 2020

Low Budget, High Impact Festivals for a Sustainable Future

Tal Bar-Lev

The Bloomfield Science Museum Jerusalem (BSMJ)

Abstract The Bloomfield Science Museum Jerusalem was established 27 years ago under the auspices of the Hebrew University and the Jerusalem Foundation. Each year, we serve more than 300,000 visitors and participants from all over Israel and from all sectors of Israeli society. Our activities are operated in our official languages-Hebrew, Arabic and in English.

The museum aims to foster curiosity and interest in the fields of science and technology, presenting them as part of our daily culture, encouraging the making of the decision to study these fields, and promoting excellence in them.

The museum's activities focus mainly on the following:

- Developing and producing **exhibitions**, **festivals and events** with interactive exhibits that encourage seeing, touching, and learning, as well as the understanding of scientific phenomena and the development of engineering solutions.
- Developing and operating together with the Israel Ministry of Education **educational programs in science and technology** for students and teachers, that take place both in the museum and in the schools.
- Promoting a culture of **'thinking with your hands'**, while encouraging creativity and innovation that integrates the fields of science, technology, and crafts. Activities in the international Maker spirit are held both within and outside the museum, while emphasizing the integration of diverse populations of all ages. Emphasis is placed on developing educational programs that encourage problem solving.

Museum 'products'

In this lecture I will introduce three categories of 'products' of our museum, that are aimed mainly at the general public. I will then drill down and talk about one of those three categories in more detail–'Festivals'.

Every year the museum curates and produces approximately 3 EXHIBITIONS. Exhibitions are the 'bread & butter' of museum life but they require investment of a lot of resources and they demand high maintenance, especially in a highly interactive museum such as BSMJ since we are not a 'collection' museum.

Why do we develop exhibitions if they are costly? Firstly, because we are an officially recognized museum and as such, we are expected to present exhibitions, which for us are a major contribution to science communication and science culture. The exhibition for us is like 'hardware', on top of which we can add the 'software'. What do I mean by that? For each exhibition — whether it is a self-curated exhibition or a rented one — our content development team develops additional activities to accompany it. For example: science encounter for the educational system; scientific

demonstration; building workshop etc. All are geared to enhance the visitor experience and understanding.

As you can see in the pie chart, our exhibitions account for about 65% of our audience attendance.

So, what products account for the remaining 35% of our audience attendance?

The answer is museum EVENTS and FESTIVALS.

When I refer to Events, I mean a *very* short duration happening that might last from a few hours to a maximum of two to three days. These museum Events provide an agile response both in terms of the theme as well as the production with limited resources. For example: Space Day, National Science Day, evening lectures for adults etc.

However, today I'd like to talk about the museum Festival that fills the gap between agile very short-term museum Events and long term museum Exhibitions. These museum Festivals now account for approximately 25% of our audience attendance.

The Nature of a Festival

Festivals always have a single well defined theme. This helps to focus the development process as well as the communicating of it to the target audiences through publicity and public relations.

It can relate to, BUT NOT NECESSARILY BE DEPENDENT ON, an exhibition. There are some examples in the past where we had a museum Exhibition that correlated to a museum Festival. In this case it supported the Festival and enriched its content, but it wasn't the focus of the Festival.

A museum Festival typically will have a 'stand-alone' theme, that addresses a specific topic which is on the agenda of your museum and is part of public debate. The museum Festival does not involve a large amount of investment, resources and massive production. It should involve a high level of interactivity and experimentation, supporting one of the focus areas of the 'thinking with your hands' culture. Like in any festival, there is A LOT to do and try out.

The museum Festival is of limited duration — 3 to 4 months — which has the marketing benefit of encouraging the target audience to act quickly, and visit the museum, so as not to miss the relatively narrow window of opportunity.

For BSMJ, the museum Festival is also one of the ways to smooth out the overall museum attendance highs and lows by focusing on bringing visitors in between the big waves during school vacations. We start our museum Festivals around the beginning of school break and 'pull' its 'tail' once the vacation is over.

Top Level BSMJ Festival Themes: MATERIALS

For the last few years BSMJ has focused its Festivals on the general theme of materials, looking in-depth at one kind of material each year.

This spring (2019) we focused on PLASTIC, as a major global ecological problem. We didn't address the subject only from the ecological angle, but also from the scientific point of view. As a relatively new material in human life, plastic is already very central to our economies and we probably couldn't imagine life without it. However for the sake of future generations, we have to take responsibility today and think carefully about our use and consumption of plastics. In our museum Festival, we took the approach of educating on how to cut our consumption of plastics and reuse rather than one-time usage, at the same time developing eco-friendly plastic or substitutes.

In this presentation, I will 'drill down' into a case study of our 2018 festival which dealt with a simple, low profile material, handy to all and consumed everywhere – CARDBOARD.

Case study: Only Cardboard

- **Budget:** $40,000 + in-kind (~$30,000)
- **Duration:** Spring, 3 months
- **Activities:** All/most were developed in-house
  - Building workshop: Cardboard animals – Make & Take (age 4 +)
  - Scientific demonstration: The Story of Cardboard (for the entire family)
  - Theatre show: Cardboardella (age 3 +)
  - Accumulative workshop: Cardboard City (for the entire family)
  - 24 hour Hackathon-Makerthon: Temporary shelters (for Design students)
  - Cardboard Maze: Mazes & Boxes (age 3 +)
  - Design & Build Make workshop: Illuminating Cylinders (Age 12 +)
  - Festival's interior design and huge artworks

The 'Only Cardboard' museum Festival lasted three months starting with the spring break through to a couple of weeks before the summer break.

BSMJ made the 'Only Cardboard' Festival a part of its yearly workplan, and allocated very carefully chosen and limited BSMJ museum resources for its development and production. However, we managed to almost double allocated resources with proactive requests to relevant major stakeholders in the industry. Recognizing the potential in Israeli industry we targeted major companies, including the largest Israeli consortium of paper and cardboard manufacturers. This enabled us to significantly reduce costs for materials we used for both activities and interior design. These industry partners were so committed to our scientific story, that they shared with us their expertise, as well as their pride in locally developed innovative solutions and their corporate social responsibility.

This museum Festival was very rich in content, addressing a wide range of audiences both in terms of age and sectors.

- Building workshop: Cardboard animals — Make & Take: Visitors constructed surprising and amusing imaginary animals from cardboard. They put together different cardboard shapes to create elephants, mice, and everything in between.

Photo 1 Building workshop Cardboard Animals. Photography: Adi Kofman

- Scientific demonstration — The story of cardboard: How long does it take to 'grow' a cardboard box? What is a template? How many tons of weight can a cardboard box handle? During the demonstration visitors learned surprising things about cardboard, including what are the traits that make corrugated cardboard the world's most popular packing material.
- Scientific Theatre — Cardboardelle: Original museum production in collaboration with a young artist and graduate of The School of Visual Theater in Jerusalem, Ms. Anat Bosak. The play tells the story of Cardboardella, a girl who lives in a cardboard world. One day she receives a message that a strange phenomenon called Rain is expected to reach her world. Cardboardella immediately packs a bag and goes on a journey to save the cardboard kingdom. Cardboardella meets strange and interesting people along the way and has strange and amusing adventures.

Photo 2 Cardboardella Theatre show. Photography: Idan Vaaknin

Photo 3 Cardborad City Accumulative workshop. Photography: Adi Kofman

- Outdoors, we offered the visitors the opportunity to get lost in a self-constructed cardboard maze in the shape of a cactus field, or to jointly build their imaginary cardboard city with a parking lot, houses, city center, zoo and more.
- Accumulative workshop — Cardboard City: Cardboard is much more than a box; it is the material dreams are made of! Using plastic screws and tools designed especially for cardboard, visitors built a variety of structures that they wished to find in the city of the future. They built buildings in the Cardboard Court neighborhood, animals for the Live Cardboard zoo, and vehicles for the Cardboard Parking Lot.
- 24-hour Hackathon-Makerthon — Temporary Shelters: For many years we have collaborated with the Bezalel Academy for art and design. In the 'Only Cardboard' Festival we hosted a

Photo 4 Students Hackathon. Photography: Adi Kofman

Photo 5 Interior decoration of museum. Photography: Adi Kofman

24-hour Hackathon in which more than 50 students from all the academy faculties had the challenge to design and build temporary houses for disaster areas, all made out of cardboard.

- Experimental construction building arena — Mazes & Boxes: Visitors took part in building a puzzle maze by connecting cactus pads to prickly pears. Visitors built hedges serving as the borders of the maze, in which one can walk and get lost without being pricked by even one thorn...
- A design and construction workshop — Illuminating Cylinders: Youth were invited to design, plan, and use a laser cutting machine to create individually designed light fixtures. The workshop combined digital planning and design skills alongside work in the maker space and use of the laser cutting machine. Participants took home their creations.
- Interior design: The indoor and outdoor areas in which the festival took place were decorated with huge cardboard creatures and constructions all made by Ms. Elian (Lula) Kaczka, cardboard art designer and artist, who works mainly with cardboard.

Festival Impact

- Directly in BSMJ: 30,000 visitors
- Outreach: > 200 kindergarten teachers and indirectly to thousands of children
  > Science Celebrations in community centers – thousands of beneficiaries

* Public relations raised the awareness of the public regarding recycling, ecology and sustainability

The impact of this festival was obvious in the number of visitors and the interest it raised. We were invited by the Ministry of Education to present a 3-hour workshop for kindergarten teachers. In this very successful workshop teachers became familiar with the material and the possibilities it has as working material for young kids in kindergarten. Handy, available, cheap and ecological material which develops imagination, motoric skills and STEAM orientation from a very young age.

The public relations the museum Festival generated has benefitted BSMJ with high demand from all around the city to hold Science Celebrations in community centers and schools in the weeks following the festival's peak. This outreach has brought a wider exposure for the museum to thousands of new participants and a wider exposure and awareness among the general public to the material itself as well as to the importance of recycling it to benefit the environment.

Resourcing

- Partnerships with leading companies (in-kind and professional knowledge)
- In-house development
- Collaboration with academia
- Museum allocated budget

As briefly mentioned previously, museum resources were deliberately limited from the beginning, but effective planning doubled the available and the resulting impact of the Festival.

√ We managed to raise in-kind funds from industry partners and stakeholders, which saved the museum significant costs.

√ We enhanced our collaboration with local academia, and 'stretched' the students experience to new horizons.

√ We exceeded our target numbers for visitors.

√ We developed most of the activities, which are now available to be shared with others.

Advantages

- Good platform for increasing STE(A)M interest among children and youth.
- Relations with related stakeholders in the economy/business sector
- Cost- and resource-effective
- Easy to produce and modular in operation
- All materials and forms of activities are available to share with other museums

Contact me!

This event template can be adapted to your needs and resources.

Tal Bar-Lev, Deputy Director-General, Business Development
The Bloomfield Science Museum Jerusalem (Israel)
tal@mada.org.il
mada@mada.org.il

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An Analysis of a Dialogue between a Parent and a Child in the Hands-on Exhibitions at Science Center

Saya Mori (Anzai)[1] and Motoko Okumoto[2]

[1]Sapporo Science Center, Sapporo, Japan
[2]Hokkaido University, Sapporo, Japan

Abstract Science museums and centers are used by visitors of various ages. Especially, families with preschool children are one of the major visitors. Sapporo Science Center has many hands-on exhibits to make visitors feel science more familiar. The hands-on exhibitions make it possible for visitors to understand the exhibition sensuously, while enabling them to interpret and explore the exhibition on their own initiative. However, when hands-on exhibition operations are complicated, or tangible actions are not link to scientific information directly, visitors can not fully utilize hands-on exhibits. When family visitors experience hands-on exhibits, the parents' supports for children are indispensable. In this research, we recorded and analyzed qualitatively a dialogue among mother and child in the hands-on exhibition to clarify their unenviable points to use it. As a result, the family's learning in museum had been developed when the mother became able to understand the mechanism of hands-on exhibition.

Key words: Science center, Conversation analysis, Hands-on, Minds-on

1. Introduction

In science centers that are used by a wide range of age groups, family visitors are one of the main visitor groups, and in particular, there are many families whose children range from preschool children to younger children. In the type of museums frequently visited by the age of youngest child, 69.1% of the children who are not yet in school use the science museum (Matoba, 2006).

1.1 Background of Hands-on exhibit

Hands-off exhibits are traditional forms of museum displays and are intended to look without touching the exhibits. On the other hand, with hands-on exhibits, you can touch the exhibit. Hands-on exhibits are used in many museums, especially in science museums and children's museums.

'Hands-on' implies that visitors physically interact with an exhibit, whether this is simply pushing buttons, using a computer keyboard, or engaging in a more complex activity with a multiplicity of outcomes. However, a hands-on exhibit that simply involves pushing a button is not truly interactive, rather it is reactive, in that the exhibit simply follows a predetermined outcome. When the term "hands-on" is normally used there is an assumption that hands-on activities will also involve

[1] Present address : Hokkaido University, Sapporo, Japan

Hands-off Exhibit Hands-on Exhibit

interaction and provide added educational value, that hands-on will lead to "minds-on", although the term itself does not suggest this (Caulton, 2000).

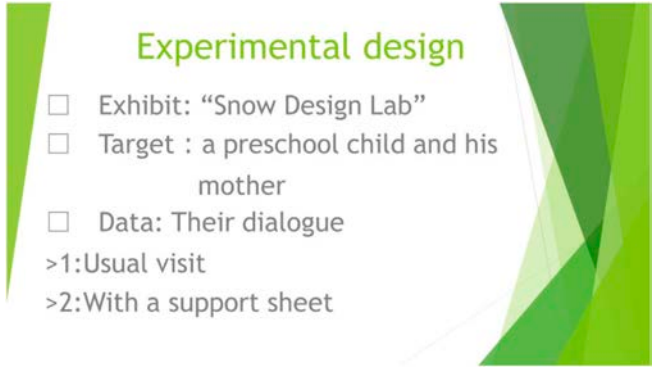
I work at science center, and it is not always the case that the hands-on exhibits reached mind-on. This is because it is difficult for preschoolers to learn from the exhibits created based on the educational level of primary schooler, and that the intention of the exhibits is not transmitted to the parents who experience with them, and it is difficult to understand how to experience the exhibit in the first place.

In this research, we studied how to support preschoolers and parents to experience hands-on exhibits and develop their experiences to minds-on.

2. Methods

I choose "Snow Design Lab" which is one of hands-on exhibits at the Sapporo Science Center.

Experiment cooperator is a preschool child and his mother. First, I observed their usual experience during this exhibit without any support and I recorded their dialogue. I analyzed the dialogue to identify where visitors were struggling to learn from the hands-on exhibit. Then I considered what kind of support I can give to them and how they can actively think about it.



At their second visit, they experienced the same exhibit, this time with a support sheet. I recorded their dialogue too, and analyzed the difference between the first and second time.

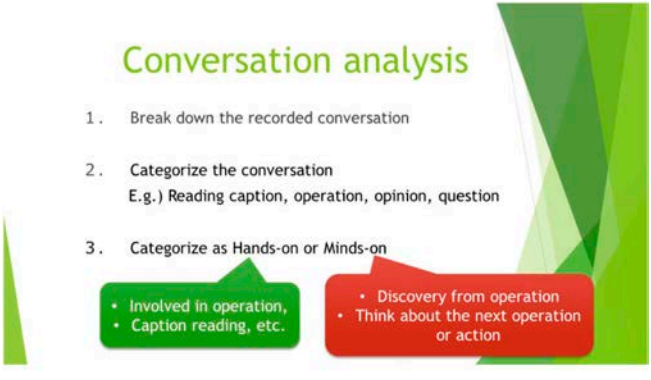
At the Snow Design Lab, the visitor can set temperature and humidity

Snow Design Lab

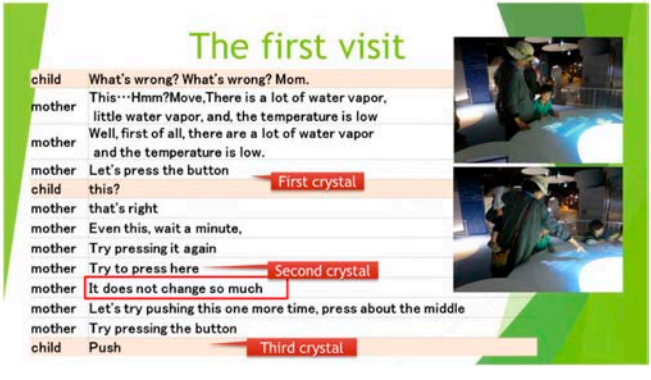
conditions freely on the screen to create a snow crystal. Visitors can create different shapes of snow crystals by changing the temperature and humidity conditions. Visitors can name their snow crystals they created. Afterwards their named snow crystals will be appeared on the wall of the next exhibit.

3. Results and discussions

First, I divided the conversation into sentences. Next, I categorized them according to their meaning. And I divided these categories into hands-on or minds-on.



It is a part of the conversation of the first inspection. A parent and a child had to try three times to make the shape they wanted to. They failed to make crystal and finally succeeded on the third try. His mother didn't know the relation among temperature, humidity and shapes of the crystal. Therefore, they failed twice.

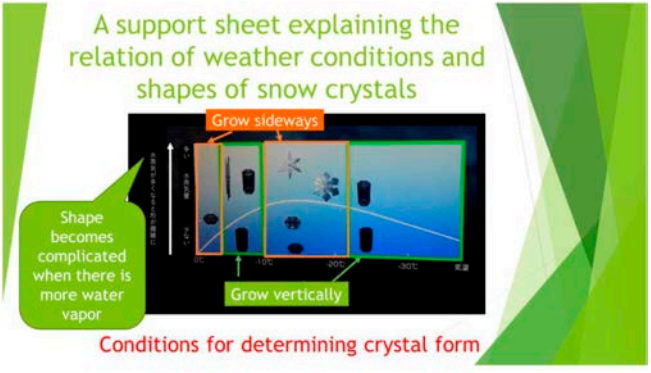


After the first experiments, this is what I found out. The mother could not understand the relationship between the shape of snow crystal and weather condition. It took time to create a snow crystal they wanted with the hands-on exhibit. As a result, a child was bored with this exhibit.

I understood that it is necessary to know the relationship between weather conditions and crystal shapes for the success of this exhibit experience. And the exhibit to learn about it was actually nearby. There was the quiz-type information exhibit called "Snow Crystal Secrets" on the same table as "Snow Design Lab". However, it was difficult for visitors to notice because their designs were very similar. I understood that visitor need to know "Snow Crystal Secrets" to understand "Snow Design Lab".

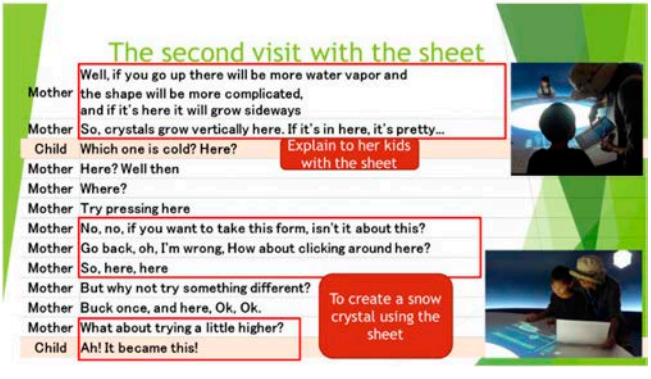
Therefore, I put a sign by the "Snow Design Lab" to be able to notice "Snow Crystal Secrets".

I made this support sheet and handed it to the mother at the second visit.



As a result, the mother understood that the form of the snow crystal changed concerning water vapor and temperature. And she explained it to her child.

They noticed the sign of Snow Crystal Secrets" and succeeded in understanding the relation between weather conditions and shapes of snow crystals.



I analyzed the conversation of the first and the second.

I divided the category into hands-on and minds-on.

And I counted the number of remarks.

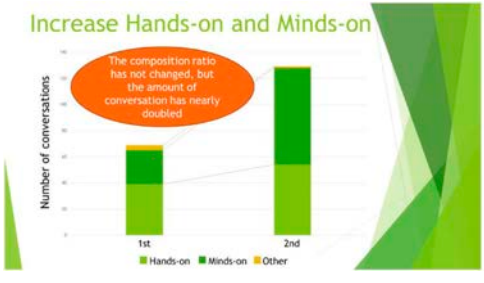
The result is this. In many categories, the number of categorized statements increased at the second visit.

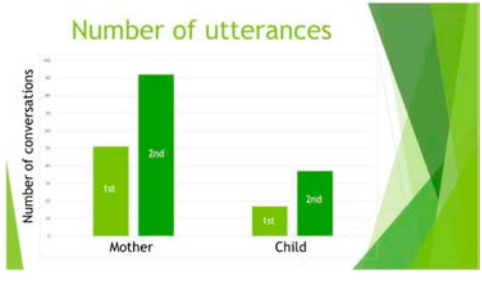
The numbers increased in most categories. I found that it increased particularly in the opinion category for minds-on.

Increase or decrease by category

Classification	Category	1st	2nd	Change
Hands-on	Caption reading	8	16	+8
	Confirmation	1	1	0
	Children's anxiety	1	0	-1
	Introduction	1	1	0
	Action	3	4	+1
	Operation	25	32	+7
Minds-on	Motivation	3	7	+4
	Commentary	2	9	+7
	Asking	5	9	+4
	Analysis	1	6	+5
	Positive impression	6	7	+1
	Consultation	6	11	+5
	Opinion	3	25	+22
Other	Other	4	1	-3

The next is quantity of hands-on and the minds-on conversation and a result about the ratios. The composition ratio has not changed, but the amount of categorized conversation has nearly doubled. Conversation between the mother and the child increased approximately two times.





4. Conclusions

We found the problem by observing visitors' dialogue and we provided the suitable support tool the second time. The effect of the exhibits could be improved by the device that could be put into practice immediately. Most of hands-on exhibits are permanent exhibits, thus we tend to consider it to be difficult to improve these exhibits. But I found that we can make visitors experience effectively using suitable supports. We need to consider how it can be installed as a permanent exhibition in the future.

In the first experience, we did not support visitor to understand hands-on exhibits sufficiently. In the second experience, I found that the Minds-on increased through suitable use of hands-on objects by handing support tools to the visitors. Not only did minds-on increased, but this shows that this is a success of the hands-on exhibits.

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Practices of Sustainable Development in Science and Technology Museums: Taiwan Experiences

Shang-Ching Yeh

Tainan National University of the Arts, Tainan, Taiwan, R.O.C.
Email: sanching@tnnua.edu.tw

Abstract Facing challenges of rapidly changing social, cultural and economic environment as well as climate change, museums are responding by devoting themselves to sustainable development. Museums, especially science and technology ones, play an important role to advance sustainable development. This study introduces museums' practices of sustainable development in Taiwan, especially a successful one, the National Science and Technology Museum (NSTM)'s "Green Museum Initiative". The author first illustrates four pillars of sustainable development in relation to museum. An overview on the practices of sustainable development of museums in Taiwan will then be stated. One successful example, the National Science and Technology Museum (NSTM)'s "Green Museum Initiative" will be introduced. Finally, the author makes a brief conclusion.

Key words: Museum, Sustainability, Sustainable development, Green museum

1. Definition and pillars of sustainability in relation to museum

Sustainable development has been defined in many ways, but the most frequently quoted definition is from the Brundtland Report: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs." (World Commission on Environment and Development, 1987). One particularly prevalent description of 'sustainability' employs three 'pillars': economic, environmental, and social sustainability (Giddings, Hopwood & O'Brien, 2002; Purvis, Mao, & Robinson, 2019; Strange & Bayley, 2008). Scholars have expanded conventional sustainable development discourse by adding culture as a fourth pillar (Dessein, Soini, Fairclough, & Horlings, 2015; Loach, Rowley, & Griffiths, 2017).

Museum, in the service of society and its development, holds a unique and important position in promoting sustainable development. Four pillars (environment, economy, society, and culture) of museum's sustainable development have been proposed by museum communities. Table 1 summarizes policy papers issued by four museum communities, including Museums Australia, Museums Association (UK), Canadian Museums Association as well as American Alliance of Museums and the PIC Green Professional Network, regarding "museum and sustainability". From Table 1, all pol-

Table 1 Policy papers issued by four museum communities regarding "museum and sustainability"

Association	Policy paper	Definition of sustainable development	Pillars of sustainable development
Museums Australia	*Museums and Sustainability: Guidelines for policy and practice in museums and galleries*	Brundtland Report	environmental, economic, social, and cultural sustainable development
Museums Association (UK)	*Sustainability and museums: Your chance to make a difference; Sustainability and museums: Report on consultation*	Brundtland Report	environmental, economic, and social sustainable development
Canadian Museums Association	*A sustainable development guide for Canada's museums*	Brundtland Report	environmental, economic, and social sustainable development
American Alliance of Museums and the PIC Green Professional Network	*Museums, environmental sustainability and our future: A call to action from the summit on sustainability standards in museums 2013*	Brundtland Report	environmental, economic, and social sustainable development

icy papers adopt Brundtland Report's definition of sustainable development. Three of them mention three pillars of sustainable development (environment, economy, and society), while Museums Australia's policy paper covers the fourth pillar (culture). In fact, environmentally sustainable development is the most emphasized one among four pillars in all policy papers. To have a holistic view of museum's sustainable development, four pillars are discussed in this paper.

The concept of each pillar of museum sustainable development is briefly illustrated as follows.

(1) Environment

Museum's environmental sustainable development concerns that museum adopts an environmentally friendly attitude. Museum can do a variety of things in this regard, such as going green, energy saving, carbon reduction, waste reduction, 4Rs (reduce, reuse, recycle, reclaim), hazardous materials management, air purification (Canadian Museums Association, 2013), sustainable architectural design (including using renewable energy, collecting and using rainwater, reusing wastewater, using local materials, natural light illumination, natural ventilation, etc.), waste management, energy management, vehicle management, etc. (Museums Australia, 2003).

(2) Economy

When it comes to economic sustainable development of museum, maintaining museum's financial soundness is critical. Some policy papers suggest that museum can diversify sources of income (including governments, NGOs, enterprises, etc.) to avoid over-reliance on a single source of public funding. Some promote museum works in close partnerships with other museums, or other types of organization, to share resources (Canadian Museums Association, 2013; Davies & Wilkinson,

2008). On the contrary, reducing expanses needs to be taken into consideration. Davies and Wilkinson (2008) suggest that museums need to be clear about their purpose and ensure that their most important activities are sustained. 'By restricting activities to "core business" operating costs can be greatly reduced' (Bradburne, 2007). And they state that 'the sustainable answer may be to do less, but do it better.' In addition, actions of tapping new resources could be taken, such as membership, corporate sponsorship, gala, catering services, etc. (Wang, 2015) .

(3) Society

The definition of museum by the International Council of Museums (ICOM) is: 'A museum is a non-profit, permanent institution in the service of society and its development, open to the public, which acquires, conserves, researches, communicates and exhibits the tangible and intangible heritage of humanity and its environment for the purposes of education, study and enjoyment' (International Council of Museums, 2007). The definition indicates that a museum exists for the purpose of serving society. As a result, the social pillar of museum sustainable development concerns service of society, including local and global communities. That is, social sustainability in relation to museums means involving community into the core activities of museum. In this day and age it is of vital importance for museums to be socially inclusive and relevant for their communities. Museums need to actively concern the accessibility and inclusive representation of ethnic minority groups and communities.

(4) Culture

Museums play a unique role within cultural sustainability by preserving the tangible and intangible heritage of humanity and its environment. Preserving heritage makes museums core mission different from that of any other institutions (Loach, Rowley, & Griffiths, 2017). In addition to preserving heritage, researching, communicating as well as exhibiting heritage are foci of cultural sustainability. Consequently, museums act as an access point to cultural heritage, and by emphasizing the integrated nature of it, they encourage people to come together to experience their own and others culture (Adams, 2010; Museums Australia, 2003).

2. Practices of museum's sustainable development in Taiwan

Practices of four pillars' sustainable development in Taiwan's museums are briefly introduced as follows.

(1) Environment

Environmental sustainability is a predominant pillar among four pillars of sustainable development in relation to Taiwan's museums. Many museums adopted an environmentally friendly attitude when designing exhibitions. Waste management was highly advocated. For example, National Taiwan Museum adopted a '3R principle', reduce, reuse, and recycle, when designing exhibitions (Kuo,

2015). National Museum of Taiwan History also recycled and reused exhibition materials when making exhibitions to fulfill a sustainable exhibition design (Lin, 2012). In addition to practices of environment-friendly exhibit design, an exhibition sustainability survey along with a series of workshops were conducted to promote sustainable exhibition. National Palace Museum conducted the '2018 Exhibitions-Going Green Survey', collaborated with the Sustainable Exhibitions for Museums Group, UK (Cheng, 2018). It is an online survey for every museum in Taiwan to fill out[1].

(2) Economy

Traditionally, public museums in Taiwan are fully supported by governments. Some public museums have adopted the Operation Fund system and some public museum have transformed as public corporations in two decades, which means governments reduce their financial support for public museums. As a result, those public museums have to increase revenue through admissions, stores, restaurants, memberships, corporate sponsorship, etc. Public museums in Taiwan gradually increase self-earned revenue to cope with the shrink of government subsidy.

(3) Society

The Ministry of Culture of Taiwan encourages and subsidizes museums to implement projects regarding accessibility and social inclusion of minority groups, which includes female, disabled people, aboriginals, Hakka people, Taiwanese new immigrants, etc. Consequently, a variety of projects were implemented to serve minorities in Taiwan's museums. For example, public museums of New Taipei city held 'Seniors day' for elderly people and their families to experience museum in one day. Many museums held activities for disabled people such as patients of the Alzheimer's disease, visually impaired students, hearing-impaired students, etc. These include the National Taiwan Museum of Fine Arts, National Museum of Taiwan History, National Museum of Natural Science, etc. (Yeh, 2016).

(4) Culture

There are various kinds of museums in Taiwan, including fine arts museum, history museum, natural history museum, science and technology museum, etc. These museums preserve many kinds of natural and cultural heritage of Taiwan and the world. Exhibiting and communicating preserved heritage with people presents cultural sustainability of museums.

3. The NSTM's "Green Museum Initiative"

The NSTM implemented a "Green Museum Initiative", which incorporates the four pillars of sustainable development into its operations. The Green Museum Initiative comprises more than 10 projects in four pillars of sustainable development (Table 2). The NSTM also established a team

[1] The National Palace Museum has not yet announced the results of the survey.

Table 2 The Green Museum Initiative and its projects in the NSTM

Pillar	Projects
Environmentally sustainable development	energy saving, renewable energy adopting, green building improvement, green materials adopting, green purchase, etc.
Economic sustainable development	tapping resources and reducing expenses, reuse and recycle, etc.
Social sustainable development	developing audience, serving community, exchange and cooperation, etc.
Cultural sustainable development	enhancing collections and research, green education, green exhibition, etc.

comprising key persons in each department to implement the Initiative in each department.

The NSTM implemented the Green Museum Initiative from 2011, the outcomes can be found in its annual reports (National Science and Technology Museum, 2013; 2014; 2015; 2016; 2017; 2018; 2019). Significant outcomes and reviews are introduced briefly in terms of four pillars of sustainable development as follows.

(1) Environment

After implementing the Green Museum Initiative, energy saving was significantly improved. On electricity usage, the NSTM saved 343,543 kWh in 2012, decreased by 2.6% than 2011. The amount of energy saving raised to 1,820,000 kWh in 2013, decreased by 13.4% than 2012. The NSTM saved electricity use through air conditioning equipment replacement, replacing traditional light bulbs with energy saving light bulbs and LEDs, setting best temperature (26-28 degree centigrade) for air conditioner, etc. By fixing tap water leaking, low-flush toilet and low-flow faucet replacement, catching and using rainwater, etc., tap water was saved up to 6,836 Cubic Meter in 2013, decreased by 8.9% than 2012. Annual renewable energy power generation was 90 thousand kWh and annual green procurement reached 100% in 2018. In addition, The North Complex of the NSTM was qualified the bronze grade in Green Building Labeling System in Taiwan. In spite of the success, we have to note that improvement for Green Building costs substantial amounts of money, which needs an additional budget.

(2) Economy

Outcomes of 'Tapping resources and reducing expenses project' is significant. The NSTM's self-earned revenue (excluding subsidy from governments) increased to 206,306,631 New Taiwan Dollar (NTD) in 2018, while reduced expenses ranged from 11,469,000 to 71,469,000 NTD from 2011 to 2018. Self-earned revenue was mostly from cooperation projects, admissions, educational programs, exhibition area and classroom rental, etc. For instance, the largest portion of revenue in 2016 was cooperation projects (58%), followed by admissions (24%), exhibition royalty as well as educational programs (4.5% & 4.4% respectively) in 2016. The item of most reduced expanses was personnel expenses (81.1%), followed by procurement expenses (14.8%). Although NSTM's tapping resources and reducing expenses seems successful, there is a limit for revenue increasing and cost reducing, especially for the latter. Besides, utilities fee may rise in the future. These need to be

taken into consideration in relation to museum's economic sustainability.

(3) Society

Through 'developing audience project', the NSTM served 2,518,651 people in 2012. Since then, the NSTM served more than 2 million people each year. For the minority groups, the NSTM launched a 'Hand-in-Hand, Side-by-Side' welfare project for the disadvantaged, allowing 5,530 teachers and students from 222 schools to visit NSTM free of charge in 2018. Although social sustainable development seems successful, there is room to improve. The 'Hand-in-Hand, Side-by-Side' welfare project mainly served schools in remote areas, other minority groups such as low-income, minority ethnic groups, etc. could be included. Furthermore, NSTM could partnership with more institutions to implement social sustainable projects to serve more people.

(4) Culture

The aim of cultural sustainability is to improve the transmission and innovation of culture via NSTM's collections in terms of research, exhibitions, and educational programs. The NSTM acquires and digitalizes collections and conducts educational programs for promoting green education. In addition, NSTM conducted green exhibition assessments on four exhibitions, with all of them attaining "Gold" status in 2018. Cultural sustainability may be the most special pillar for museums. Preserving heritage is the heart of museums. However, cultural sustainability may contradict with other pillars of sustainability. For instance, preserving collections may consume much energy and cost a great deal of money. As a result, it is important for museums to strike a balance between cultural sustainability and others.

4. Conclusion

Museums in Taiwan dedicated to sustainable development in response to environmental, economic, and social change. They have made progress in the practice of sustainability in terms of environment, economy, society and culture. One of those museums, the NSTM, incorporated four pillars of sustainability, comprising more than ten projects, into a holistic "Green Museum Initiative", thus integrating sustainable development into its operations. According to outcomes of the Initiative stated above, we found that the NSTM's Green Museum Initiative has met with great success. However, worries happen while museums implement sustainable development practices, which remain to be overcome. Factors that hinder the implementation of sustainable development can be found in Taiwan's experience. These include: the lack of budget, the scarcity and poor training of human resources, the need for more social participation, some managers and staff members' resistance to change, etc. From Taiwan's experience, the author suggests that museums could develop a mechanism, incorporating museums' sustainable development policy and projects, to integrate sustainable development actions into museums' daily operations.

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Sustainable 'Hardware and Software' of Museums —Challenges and Opportunities for the Technical Museum of Slovenia (TMS)

Natalija Polenec

Technical Museum of Slovenia, Borovnica, Slovenia

Abstract Sustainability in museums is usually considered an investment in modern buildings that provides the ideal environments for museum objects and exhibits. However, sustainability is much more than that. It is a general philosophy of the museum's management, employees, and visitors. As a study case, I analysed the sustainability of the Technical Museum of Slovenia through two categories–'hardware', which depends on large investment and state funding, and 'software', which is more manageable. In this presentation, I will analyse the 'hardware' of the TMS, our efforts to protect historical buildings and nature in coexistence with the museum, as well as good practice in 'software' projects and management. The example will be the process of the museum's reorganisation and participation in the EU projects that promote sustainability.

Introduction

To aid in understanding, I will give a brief description of the main exhibition premises of the Technical Museum of Slovenia. Like many European museums, we are settled in a medieval monastery, called Bistra. The Carthusian order built a cloister (13th century) on the remains of a Roman settlement. Numerous natural disasters, earthquakes, and fires afflicted Bistra over time. In the 18th century, the cloister was closed. In 1826, the estate was purchased by a rich merchant and industrialist. He and his successors endowed it with the image of a fine manor, characteristics of which remain to this day. At the end of the Second World War, the estate was nationalised, and in 1951, Bistra became the headquarters and first permanent home to the TMS.

The first TMS forestry and hunting collections at Bistra were opened to the public in 1953. Today, we have more than 6,000 m^2 of exhibition area in the Bistra manor for the display of our permanent collections and exhibitions: forestry, woodworking, hunting, fishing, agriculture, textiles, transport, printing, electricity, electrical engineering, water-driven machinery, post, telecommunications, aircraft models, and metalworking.

The Technical Museum of Slovenia keeps 18,000 museum artefacts, of which 3911 are on display (21%). Thirty-one employees in the museum are funded by the Ministry of Culture, while an additional two full-time and six part-time are financed by museum income. Our annual budget is between 1,500,000 and 1,800,000 euros; 10% is generated by the sale of tickets, programmes, workshops and the museum store, 2–4% is funded through EU projects, and the rest is money

Photo: Historical buildings of TMS in Bistra
TMS Photo archive

obtained from the Ministry of Culture as a national institution. TMS' off-site unit is the Museum of Post and Telecommunications, which is also housed in a medieval manor. We have three collections in different parts of the country and two open-storage depots.

Sustainability of the Technical Museum of Slovenia

At first glance, the Technical Museum of Slovenia does not seem very sustainable. In analysing its sustainability, I formed two categories: 'HARDWARE', which depends on large investments in the buildings (state budget) and 'SOFTWARE', which depends on management. Both have their advantages and disadvantages, and it is obvious that it is not only the budget for investments that supports sustainability but—maybe even more importantly—the museum's philosophy and its management.

HARDWARE

According to this division, HARDWARE includes collections, historical buildings, energy consumption, and protected natural environment.

Preserving movable heritage and **collections** for the future generations is the principal mission of the museum, which is in itself a sustainable act. However, it requires an updated collection policy to be sustainable. TMS is in the process of redefining its collection policy.

Although **managing the historical buildings** for museum exhibitions does not seem very sustainable, there is a positive aspect to it. As a responsible institution, we have an obligation and privilege to manage the Bistra complex according to the guidelines of the Institute for the Protection of Cultural Heritage of Slovenia (IPCHS). As the complex was declared a national heritage monument and is still functional, there are significantly better possibilities to preserve it for the future. TMS

provides necessary investments and maintenance work, which allow the complex to remain in a rather 'good shape'. This way, it is open to the public and gives an additional value to the museum exhibitions. In addition, the area is protected by the national law Natura 2000 (Ljubljana Marshes), and it requires special care, which can be provided by the museum as a professional institution. The mansion is built from local materials, and most maintenance work requires the use of materials and crafts that are known to the local population. Keeping collections in a museum without providing a proper environment can be a significant challenge but, in our case, the collections displayed in the mansion are historically relevant and, fortunately, the environment is not very destructive for all of them (forestry, woodworking, hunting, agriculture, water-driven wheels). TMS has a private hydropower plant that provides additional electricity for the needs of the museum. In contrast, the power plant is a technical monument, as it was built in the first half of the 19th century. Small windows in the medieval part of the buildings create environment without UV rays, and thick walls enable a stable indoor climate.

Of course, there are many disadvantages. The museum is located 25 km from Ljubljana, and no public transport is available. The buildings have not been renovated (mansion, barns, granary, storage sheds), and they are spread out on the location. It is very difficult to control the gates and exhibition premises, which causes high security service costs. Poor infrastructure (no heating, old electrical systems, fire alarms, security systems, etc.) and high humidity due to water resources cause additional costs. Energy consumption is enormous, as we need numerous dehumidifiers for exhibits made of delicate materials, such as textile, paper, etc. Heating systems run on electrical power, and the light bulbs have not yet been completely replaced with low energy bulbs (LED). The area for exhibitions is limited, small, of irregular shape and with low ceilings. The property is surrounded by a preserved natural area (river, swamp, forest), therefore new constructions are not allowed, and special treatments are required to protect the landscape.

TMS is aware of the challenges in coping with historical buildings. We take actions that diminish disadvantages to the extent possible without a major intervention, such as a complete renovation of the manor. We constantly appeal to the authorities that the buildings need a complete renovation, including all installations and security systems. Over the years, we gradually renovate small parts of the buildings as we obtain funds. We have prepared a priority list, which is a guideline for the Ministry of Culture. We close the museum for two months in the winter, using this time for conservation, cleaning of exhibits and premises, and preparing for new exhibitions. We take advantage of natural environment and stream for presentation of water-driven objects (mills, saw, blacksmiths shop, etc.) and outdoor exhibitions. Every year, we replace a certain amount of old light bulbs with LED bulbs to reduce energy consumption.

In addition to 'hardware' related measures, we are active in raising awareness of the situation ('software'). TMS organised the Conference on Fire Safety in Historical, Cultural Heritage Buildings in 2018 and, as a result, the Ministry of Culture invited us to make a study case of emergency

evacuation plan for museum buildings and exhibits. We prepared presentation for all cultural institutions in Slovenia. As public transport is not available directly to the museum, we found a way to support sustainable transport, such as cycling and connecting with Slovene Railway Company to implement a system for transport between railway station and the museum (5 km). TMS integrated into the museum's presentation the importance of protecting the natural environment and uses the opportunities it has as a teaching environment for employees and visitors. The beautiful cultural landscape is a unique tourist attraction, which is accompanied by exhibition about the history of the monastery and the mansion.

According to the starting theory, 'SOFTWARE' can be an essential part of museum management and creates significant influence, image, and impact on the museum's audience.

The museum's management and its employees make the museum alive, and with a clear message they influence public opinion, educate and raise awareness of the importance of objective interpretation and the role of museum in the society.

The advantage of the TMS as a national museum is that the government provides the majority of money for the salaries (90%). Employees are aware of the necessity of changes in the museum's organisation and the management of its collections. However, the problems we are dealing with, such as inadequate space for exhibitions (shape, climate) and lack of money, encourage innovative approaches in the preparation of exhibitions.

TMS must deal with several issues. One is the lack of employees, such as curators, technicians, support, and some areas are not even covered (IT, librarian, photographer, archivist, etc.). In fact, the museum cannot hire more employees without permission of the government unless we do so with our funds. The organisation of the museum has not changed since its foundation, and it needs to be modernised, to be implemented gradually to allow adjustments.

Some collections do not have curators that would be responsible for them. We constantly face a lack of money to prepare new exhibitions or modernise the old ones.

As we are aware of these challenges, the TMS has started to implement necessary measures. We are in the process of reorganising the museum's structure, preparing internal documents, and expanding areas from collections to broader disciplines. We have defined employment needs. We provide education for all employees in order to improve their career goals. Museum exhibitions are prepared in house, using the internal resources of our workshops.

The social impact and the role of museums are critical topics.

As a national technical museum with 70 years of continuous work and tradition, we are one of the most visited museums in Slovenia. Almost 50% of the visitors are less than 18 years old. Some of the exhibitions are coordinated with school curricula. We conduct informal education for all generations on an ongoing basis. TMS performs the highest level of programmes following exhibitions among Slovenian museums (educational programmes, workshops, lectures, etc.).

Disadvantages include the fact that we cope with are an outdated collection policy, as it has not been changed since the museum's establishment in 1951. Some exhibitions are outdated, and the interpretation does not follow modern approaches in museology. TMS is a museum, not a science centre and as such not very 'fashionable'. Image/branding of the museum is based on its first collections (hunting, forestry, and vehicles) and not advanced technologies and industry. The lack of collaboration between ministries (education, economy, tourism, culture, environment, infrastructure) affects the development of the museum.

To engage with all these challenges, the TMS' policy is to raise awareness among the employees, providing a more stimulating environment for creativity, and proactively reacting to situations in society. TMS is raising sustainability awareness among both employees and visitors, for example waste separation, no touching of exhibits, etc. We recycle exhibitions, using frames, billboards, etc. to reduce costs. We use sustainable materials on workshops; children learn new skills, traditional crafts (baking bread, knife sharpening, making fabrics, etc). We also host workshops to approach more remote parts of the public. New exhibitions are designed with contemporary approaches – they not only present historical and technical data but guide visitors through multidisciplinary interpretation and engagement. We do our best to meet visitors' needs and improve their experience of the museum. Exhibitions raise awareness of current societal issues, e.g. the 'Science without Frontiers' exhibition on successful Slovenian scientists who were migrants was granted the national award for the best museum exhibition in 2018. Much effort is invested in obtaining EU funding to improve the museum's financial situation and prepare new exhibitions. We choose projects that promote raising awareness.

Some examples of such projects:

Sounds of Changes (continuation of Work with Sounds) is a cooperation between six European museums. The project's objective is to record and preserve the sounds of industrial and civil society, spread knowledge about these sounds and their context, and encourage their use in contemporary projects, such as theatre, music and exhibitions. (http://www.soundsofchanges.eu/the-sounds-from-the-past-are-here-to-stay/)

ICYDK – In Case You Didn't Know. The aim of the project is to improve understanding of intellectual property and its value, and raise awareness of its significance, especially among young people (https://icydk.si/eng/).

European Night of Researchers. The core objective is to raise awareness about research and its benefits, overcome stereotypes, stimulate curiosity and excite youngsters to take up the research careers (the concept of 'citizen science'). (https://cordis.europa.eu/project/rcn/217854/factsheet/en)

Dormouse Adventure Park. TMS participated in a local project that encourages children and families to learn more about nature and local food production, visit the museum, etc.

Conclusion

Can a museum in a medieval mansion be sustainable? Can the Technical Museum of Slovenia act sustainably? If the museum and its management implement the philosophy of sustainability in all areas of work, then even historical buildings are not a disadvantage, but they can be accepted and integrated into policy to take the best advantage of them. TMS is trying very hard to act this way, although there is still a long way to go. As our basic mission requires us to keep heritage for the future, we collect artefacts and share knowledge and skills, educate and react to changes or special issues in the society. And above all, we must be responsible as individuals that follow the same philosophy as the institution does, and act as a role model for our audience, visitors or partners.

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How “Natural History Museums” Can Perform as “Science Centers”

Takashi Toda

Lake Biwa Museum, Shiga Prefecture, Japan

Introduction: Science Museums in Japan

In Japan, we can classify science museums into two groups according to the names: “Kagaku Kan” and “Kagaku Hakubutsu Kan”. “Kagaku” (科学), “Hakubutsu” (博物) and “Kan” (館) stand for “science”, “various materials” and “building” respectively, and “Hakubutsu Kan” usually stands for “museum” (except that of fine arts). Therefore, “Kagaku Kan” and “Kagaku Hakubutsu Kan” roughly correspond to “science center” and “science museum” respectively. In general, “Kagaku Hakubutsu Kan” is either a science museum of the whole natural science including natural history, or a science center with a large amount of historical materials on science or industry. On the other hand, “Kagaku Kan” is usually specialized in activities to understand principles of science.

The main target of “Kagaku Kan” is usually children of elementary school or younger. The children experienced the principles are expected to learn techniques to apply them to actual problems in the education of high schools or universities. Some “Kagaku Kan” apparently declare that their mission is the smooth introduction to science education and the main part of the education is not included.

Exhibitions or other activities in such “Kagaku Kan” are usually designed to attract visitors with “easiness” or “enjoyability” and this should be in common with most science centers in other countries. In such case, the best design of the exhibitions (especially those with experimental devices) is assumed to be those with which people can notice the principles unconsciously without logical explanation. In order to optimize such design, it is important to select the condition of the experiment to feel the target principle best. Such optimized design has a risk to restrict the understanding to the selected condition and to make it difficult to apply the principle to other situation.

Mission of Local Museums

There are many local museums focusing on the natural and human environments in each area. In general, such museums are required to treat concrete phenomena in the target local area and traditional methods of natural history museums are effective for most of them. Typical methodology starts with events managed by museums, e.g., observation parties in the field. The participants are expected to be interested in the target phenomena and start to investigate them by themselves. Such activities may develop into the communication with other people who share the interest, exchange information with each other, result in the group studies, and their research results may enrich both

the participants and the museum.

However, some of target phenomena of local museums require the understanding of the principles of physics, which is out of the range of the traditional methods of natural history museums (Toda, 2016). In order to apply these methods, it is important that the participants can recognize target phenomena by themselves, i.e., only by observing materials as they are. On the other hand, in case when abstract and logical thinking relating to the principle is necessary to recognize the phenomenon itself, it is difficult to apply the methods. Traditional methods of science centers are of course effective at facilitating the understanding of the relating principle itself, but it is difficult to understand the relationship to the materials before the eyes.

Problem of Lake Biwa Museum as a Local Museum

Lake Biwa Museum is one of the local museums targeting to the natural and human environments in a concrete area "Lake Biwa and its watershed". Most of target natural phenomena are included in natural history and therefore traditional methods of natural history museums are effective. However, there are some exceptions. One of them is the fluid dynamics of the lake water.

Lake Biwa is the largest lake in Japan and the synoptic shape of the water flow is characterized with a gyre existing stably at the same location from April to December every year (Fig. 1). The flow of the gyre is geostrophic, i.e., the effect of the earth's rotation (Coriollis' effect) is important

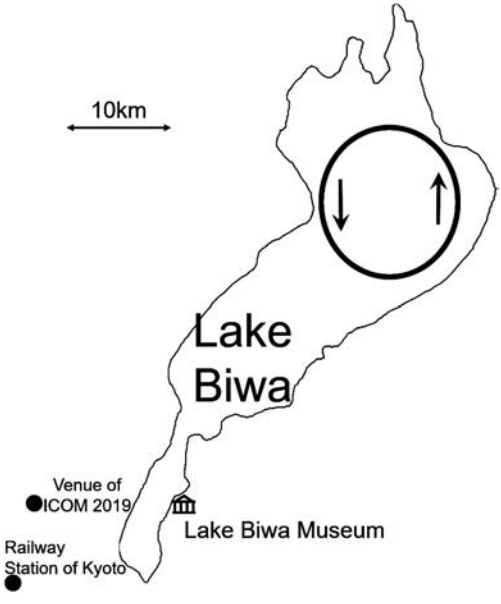

Figure 1. Location of the stable gyre in Lake Biwa.

Figure 2. Rotating laboratory of Lake Biwa Museum operated since 1996 until 2015.
(a) Front view of the laboratory from the exhibition room.
(b) Ball throw which was most frequently executed as a typical experiment in the laboratory.
(c) An experiment in the laboratory a using water tank performed once or twice in a year.

to its formation and maintenance. Therefore, it is very important to understand Coriollis' Effect to tell the gyre (Toda, 2014).

Lake Biwa Museum has been explained Coriollis' effect with a rotating laboratory since the opening of the museum in 1996 until the start of the construction for renewal in 2015 (Fig. 2). It is of course a typical method of science centers and was a simple counterpart to the typical method of natural history museums of the other parts of the museum.

We were very successful to explain Coriollis' effect itself with the rotating laboratory enjoyably, but failed to explain the relationship to the geostrophic gyre effectively. The experiment performed most frequently in the laboratory is to throw or roll balls and to walk or jump. Participants can feel everything tends to go to right-hand side (because the laboratory rotates counterclockwise) and experience Coriollis' effect instinctively. Experiment using a water tank was sometimes performed to explain the effect on the water flow, but it was far from the reappearance of the real lake water flow. The operators of the laboratory have been trying to explain the relationship of the phenomenon observed in the laboratory to the lake water flow, but they are not successful. This is one of the

reasons we did not continue to run the laboratory after the renewal (Toda, 2016).

Possibility to Connect Understanding of Principle to that of Local Problem

The reason why it is difficult to explain the relationship of the geostrophic gyre to its principle should be the lack of intuition in the relationship. The gyre in Lake Biwa is first reported by Suda *et al.* (1926) and they presented a hypothetical explanation of its formation, in which it is explained as a direct response to the wind over the lake. This explanation is very intuitive and easy to understand, and explanatory models based on it operated in some science centers. However, later investigation appeared that this explanation do not suitable for the duration and the energy budget of the gyre (Toda 2014).

Now it is known that the energy source of the gyre is both the wind and the heating over the lake. The shapes of both sources are not kept in the gyre at all, and only their amount of energy, vorticity, and other physical quantities are taken over. This process is possible because the gyre can store such quantities. In general, geostrophic flow (stable flow under the strong influence of Coriollis' effect) can store potential and kinetic energies (Fig. 3). Therefore, the geostrophic gyre in Lake Biwa can act as a large energy reservoir.

In order to understand this mechanism, it is necessary to accept that the gyre itself is an invisible "energy reservoir". Because the relationship to the energy source and the result gyre is indirect, stepwise understanding of each energy process is also necessary. There are some confusions based on these problems not only in the process of education, but also in the process of research. Toda (2014) pointed out that there are two different results on the energy budget of the gyre. At a glance, the two results seem to be incompatible, but there is only a difference in perspective: one result assumed the gyre to be just a flow with kinetic energy, and another assumed to be a system with both kinetic and potential energies.

The perspective to assume the gyre to be a "system" or an "energy reservoir" is expected to be an

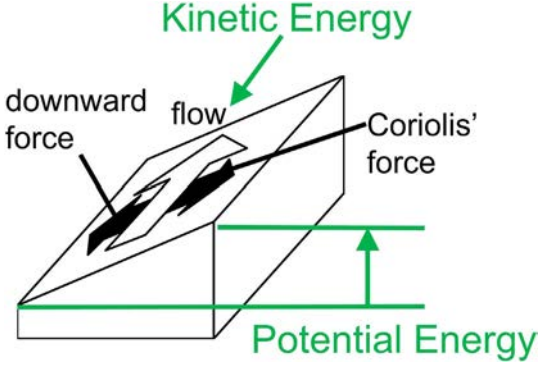

Figure 3. Balance of forces and existence of energies in a geostrophic flow.

effective solution to understand the energy process of the gyre. By settling the “energy reservoir” as a “role player” even with the inputs (wind and heating) and output (flow), it is expected that people can easily assume it to be the waypoint of stepwise thinking. We planned to build a new exhibition based on this idea, but failed to ensure budgets and not realized yet.

Possibility to Apply the Methodology of Natural History Museums

Another possible solution is to modify the traditional method of natural history museums and apply to the field without materials. As is mentioned, typical methodology starts with events managed by museums and results in group studies. Many natural history based museums establish systems to facilitate this methodology effectively.

The system established by Lake Biwa Museum is called “Hashikake”. The original meaning of “Hashikake” is a “Bridge Builder”, and in the dialect of the northern part of Lake Biwa, the word means people connecting boys and girls searching marriage partner. We changed the meaning into the connection between people surrounding the museum. It is a supporting system to people having an interest in some target of the museum. The participants make group of each interested field and museum offers a place and information. There are 26 groups now.

At first, we had been assumed that it is difficult to manage “Hashikake” group on the lake flow. However, in the process of the renewal of the museum, we reconsider the way to develop the activity on the lake flow and decided to try “Hashikake” methodology. Thus, we established a group for physics in the lake and ran for about one year. Then, a member is interested in the physical background of catch quantity of fish and starts to investigate it.

A possible problem to apply the method of natural history museums is to avoid the misleading caused by the distance of the target phenomenon and the principle. However, the result of the “Hashikake” group implies that the methodology to handle physical data relating to the target phenomenon seems to be a good guide to the principle. We are now trying to develop this idea.

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A Museum as a School?— Old Techniques Brought to Life in the UNESCO Town of Banská Štiavnica, Slovakia

Jozef Labuda

Slovak Mining Museum Banská Štiavnica, Slovakia

Introduction

The Slovak Mining Museum in Banská Štiavnica ranks among specialized museums, which are under the Ministry for the Environment of the Slovak Republic in Bratislava. The structure of the museum's expositions reflects the characteristic features of the town and its surroundings, i.e. very rich deposits of precious and non-ferrous metals such as gold, silver, lead and iron. Their existence stimulated the interest of first miners, or prospectors- Celts in the 3rd century B.C., who minted coins and made jewellery. Minerals can be seen at a mineralogy exposition at St. Trinity Square.

Long-term mining activity, both on the surface and underground is illustrated by two expositions- the most visited open-air mining museum (Skansen) and the exposition entitled Mining in Slovakia in the historic building of Kammerhof. In 2002, the exposition called shaft Glanzenberg, running under the historic centre, was open to public. The history of Banská Štiavnica is well-documented and presented in two outstanding structures- the fortifications called the Old and the New Castle. As for professional mining art, visitors can see examples of craftsmanship in three burgher's houses, or waldbürger's houses located at St. Trinity Square, in the museum's gallery. In 2015, the

Slovak Mining Museum opened its branch in Handlová, where coal has been extracted since 1906.

20 years ago, the museum launched a project called "A School in the Museum", which has been running since then. The museum has turned into an educational institution with specialized staff acting as educators. Also, a number of artisans and external instructors have been invited to cooperate, particularly those who specialise in traditional crafts such as working on a potter's wheel...

The use of museum's collection is and will be of special importance when educating young people. For example, the museum owns a unique collection of clay pipes, which are on display in three rooms at the Old Castle. The pipes called "štiavničky" enjoyed popularity and were exported in the 19th–20th century to Europe and overseas. In order to create an immersive learning environment, visitors can make their own pipes by forming a clay body and pressing it into a pipe shape and heating it to high temperature in a kiln.

In the shaft Glanzenberg, school children can try working with mining tools such as a hammer and pick, which were used from prehistoric times until the 18th century. Therefore, they have become symbols of mining and mining institutions throughout the world. As for the museum's gallery, which is rich in paintings, it is used as an out-of-school studio for two lessons where pupils are exposed to the works of masters from the 18th–20th century.

There's a specialized workplace at the Kammerhof museum- so called "little workshop", which serves as a place where children are taught to appreciate the environment and understand the need for its protection.... We apply the features of the environmental education when we demonstrate how a waste textile material can be used to make toys, or to weave rugs on a loom. Similarly, paper or plastic are employed to produce useful objects.

In addition, schoolchildren enjoy making seasonal pastry or other homemade delicacies. For example, shortly before Christmas, children are instructed how to make favourite Christmas wafers, while employing museum historical objects from the 19th–20th century. Also, they are invited to form and fire clay figures of Infant Jesus, Mary and Joseph of Bethlehem for the Nativity display. Before Easter, boys like to make popular wicker whips and girls decorate Easter eggs. These activities bring back traditions of our ancestors and their way of preparing for annual holiday seasons.

The period of school holidays from July to August is particularly suitable for working with young people. The museum educators prepare a programme which acquaints the youth with the history of the region and its mining traditions. Specialists in history, archaeology and mineralogy are involved in working with pupils who can visit various locations, either to see archeological digs, to recognize various minerals on mine dumps or to join a mining party called "shakhtag", whose origins date back to the 19th century and are linked to the existence of the Mining Academy.

We particularly enjoy the events where generations meet, for example when the pupils put up their works on display and where awards and certificates are given. We believe this is the way not only to stimulate young people's creativity but also to boost their self-confidence and a sense of belonging across generations. Also, we hope it is the way to bring up prospective visitors.

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Connecting Humans to the Universe —The New Shanghai Astronomy Museum

Thomas J. Wong,[1] Ji Minqing[2] and Alexander Brandt[3]

[1] Ennead Architects, USA & China
[2] Shanghai Science & Technology Museum, China
[3] Xenario Exhibition Design, USA & China

Abstract How does a museum dedicated to the subject of astronomy connect future discoveries to the body of knowledge of the last few centuries to ancient cultural narratives of the past? How can a museum experience make an impact on the visitor to convey the power of all that the universe encompasses? How can this experience set the stage for a more sustainable understanding of humanity's place on our planet?

This paper explores these themes through a presentation of the new Shanghai Astronomy Museum, currently under construction. The contributors include representatives from the Shanghai Science and Technology Museum, as well as the design architect and exhibit designer who will explain how the project connects the subject of astronomy to the cultural context of China past, present and future. The presentation demonstrates how the design includes architectural features and exhibit experiences to craft a lasting, memorable visitor experience and to literally connect people to real astronomical phenomena. Finally, the paper ponders the questions of teaching visitors about the universe as one possible means of encouraging more sustainable behavior on our planet, a veritable life raft amidst the vastness of space.

Introduction

The Shanghai Science & Technology Museum is a 3 in 1 museum complex, consisting of Shanghai Science & Technology Museum (Figs. 1 & 2), Shanghai Natural History Museum and the future Shanghai Astronomy Museum. Over the past 18 years, the total number of visitors to Shanghai Science & Technology Museum (SSTM) has reached over 62 million people. In 2017, CNN reported that SSTM ranked 6th on the list of World's 20 Most Popular Museums.

As the newest branch of SSTM, Shanghai Astronomy Museum (Fig. 3) will be located in Lingang New City, Pudong New Area, Shanghai, not far from Pudong Airport. With a total area of 58,600 square meters and construction area of 38,000 square meters, Shanghai Astronomy Museum will be the biggest astronomy museum in the world. This facility will contain permanent and temporary exhibits focused on a broad spectrum of astronomy, as well as two planetarium theaters: one featuring an optical projector to simulate the night sky as seen from earth, and another with state-of-the-art digital projection in a 29-meter diameter dome. Thanks to the joint efforts of the museum team and many excellent partners, the museum building will be completed this month and it will open to the public in 2021.

Fig. 1

Fig. 2

Fig. 3

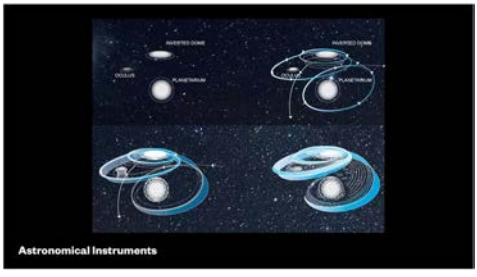

Fig. 4

Fig. 5

Fig. 6

SSTM's vision is to establish a full view of the universe, with the mission to inspire everyone's curiosity, encourage people to enjoy the starry sky, understand the universe and ponder the future.

Building Design

The new Shanghai Astronomy Museum was conceived with the following foundational context: in looking outward into the night sky and gathering knowledge about the universe, humans can and should examine the earth as a planet, an integral part of that universe, yet a unique and complex

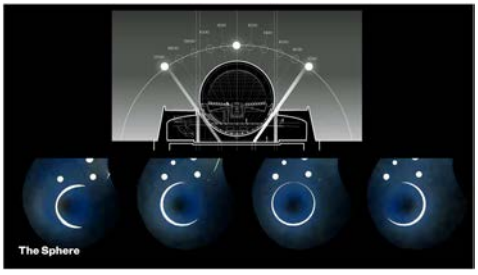

Fig. 7

Fig. 8

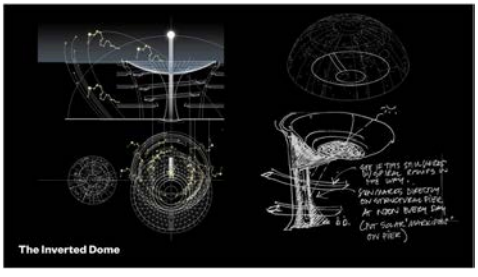

Fig. 9

Fig. 10

Fig. 11

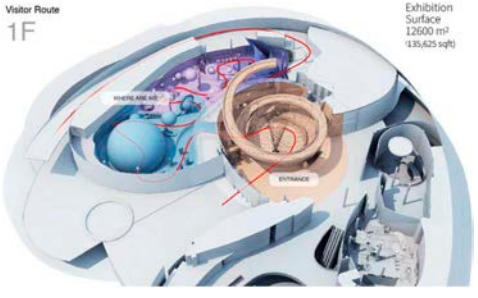

Fig. 12

state of planetary balance which makes possible the fact that this is the only place known to host life. This thesis is also fundamental to the architectural concepts for the building design, where an impactful and inspirational experience encourages visitors to reflect upon larger questions, including the special nature of life on earth, how humans fit into the cosmos and humanity's ability to shape the future of the planet through scientific understanding and space exploration. The new Shanghai Astronomy Museum is poised to become not only a groundbreaking museum experience, but a global instrument to disrupt people's submersion in human-centered constructs and reconnect

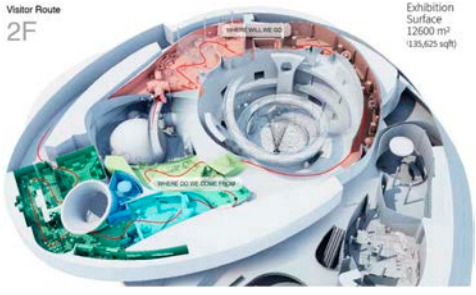

Fig. 13

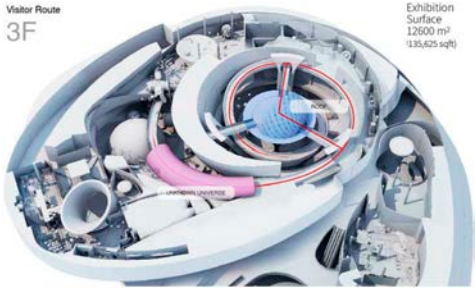

Fig. 14

Fig. 15

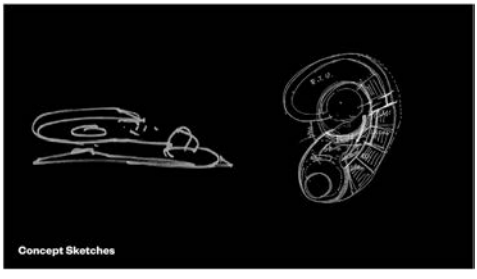

Fig. 16

them to the universe.

The genesis of the design concept evolves out of the fact that the universe is a place of incredible and dynamic motion, with celestial bodies travelling through space at millions of miles per hour, each exerting gravitational influence upon each other in an infinitely complex dance acted out through eons. This manifests itself in the design of the building through the formal abstraction of orbital motion which both influences the building shape and how visitors move through it. This orbital construct is affected not only by siting and movement, but also by three essential features within the building, astronomical instruments that we call the Oculus, the Sphere, and the Inverted Dome (Figs. 4 & 16). Each of these involve a visceral experience of astronomical phenomenon that are meant to heighten awareness of earth's orbital movement which shapes life on this planet: the movement of the sun across the sky, the earth's orbit around the sun, the direct confrontation between human and sky.

The first instrument appears at the museum's entry sequence, where a conical scope focuses sunlight at the entry to make visible its motion over the course of the day (Figs. 5 & 6). Clad in gold as if a noble absence, the Oculus provides civic engagement of the sun in the public realm. It is a reference to the temple of heaven, and other places that humans have found or created, to reach out to that which lies beyond our grasp.

Similarly, the Sphere which houses the planetarium theater is also designed to manipulate figures of light, in this case not only throughout the day, but also through the year (Figs. 7 & 8). A fundamental astronomical fact that has defined the very nature of our planet, the earth's angle of incline at 23 degrees from vertical changes the relationship of our equator to the sun. This is what creates seasons, what the cycle of agriculture is built around, and whose apex is marked in the solstices within the year. The continuous skylight around the perimeter of the Sphere shapes the light into an ecliptic condition within the interior. At the summer solstice when the sun sits highest in earth's sky, precisely at noon, the figure is completed such that a circle of light appears. This appearance celebrates the point within each year—like every year that has ever existed since the earth's orbit settled—where the northern hemisphere of our planet is most exposed to the sun's direct light and energy.

Finally, nestled at the heart of the museum is an atrium where visitors both arrive and return to several times throughout their journey through the exhibits. The atrium anchors the museum experience and provides a contrasting counterpoint to the dark, immersive environments of the galleries. As a culmination to the atrium and the visitor experience, one is invited into the instrument called the Inverted Dome (Figs. 9, 10 & 11). It is within this space that visitors (particularly those in urban environments) are given the rare opportunity to come into direct, uninterrupted contact with the sky. A concave shaped depression in the roof acts as a cutoff to the horizon and all the human interventions that have occurred upon it. What is left is a focused interaction with that element which is rarely acknowledge: the interminable sky, the life-giving atmosphere that envelopes our planet, and all that lies beyond it.

Exhibit Design

The dynamic, multi-layered architecture presents many opportunities to create highly theatrical interpretive moments, where the underlying story about Humans and the Universe can be told. The ultimate goal of the entire exhibit experience is to bring together the architectural space, physical and virtual media, hands-on interaction and a uniting story, to create a holistic experience that offers audiences excitement and personal growth. With over 600 exhibits, the experience dives deep into ideas and topics about astronomy and worthy of conveying in what can and should be a life-changing experience.

The exhibits are organized around three major and most fundamental of questions: "Where we are? Where do we come from? and Where we are going?" Each of these gallery experiences include a recurring encounter with a large spherical theater volume whose outer shell is rendered as the planet earth. This recurrence acts as a constant reference point throughout the exhibit journey and reminder of the need for self-reflection back to life-giving earth.

In a logical continuation of the architecture's theme, the exhibition layout in the first gallery follows the undulating movement of celestial objects (Fig. 12). Here visitors will make a ground level encounter of our beautiful earth as they grasp to understand where we are in the vastness of the cos-

mos. To emphasize the sensation of being in space, visitors find themselves interacting with exhibits above, below and all around them combining space, media, interaction, and story into a truly holistic experience.

The second gallery sets the stage for the birth of spacetime and visualizes how a pair of colliding black holes perturb the fabric of the universe (Fig. 13). Visitors will follow the rays of electromagnetic radiation, and finally, in this inorganic vastness, they will witness the miracle of life. It is at this moment, that visitors will see the earth a second time, with its marveling night lights-reminding them that this is the only place known to harbor life.

With the emergence of sentinel beings, the universe has been given a name. And in the enduring quest and struggle for knowledge, humanity has learned to overcome the gravitational pull of the earth to become a space-faring species, which is the theme for the third gallery (Figs. 13 & 14). Visitors will feel the lunar dust under their feet and get a close look at the crusty surface of Mars above. As they pass through zero-gravity, embarking on a daring spacewalk, visitors are presented with the big blue marble for the third time-again, yet not the same. The visitors' understanding has evolved, and with nostalgic eyes, they pass over and leave the earth to venture into the unknowns of the universe.

These and many other experiences are what visitors will encounter when the museum opens in 2021.

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Collaborating on Freshwater Conservation and Urban Sustainability

Song Ji

Wuhan Science and Technology Museum, Wuhan, P.R.China

Abstract Freshwater is at the core of sustainable development. In a sustainable world that is achievable in the near future, freshwater and related resources are managed in support of human well-being and ecosystem integrity in a robust economy. Wuhan is the largest freshwater center of China, as well as one of the megacities having the richest freshwater resources in the world. But in recent years, the aquatic ecosystems of Wuhan downtown appeared serious issues such as water pollution, lake shrinking and poor connectivity of urban water systems. Faced with these issues, many science museums in this city are actively seeking to cooperate with each other while vigorously promoting the freshwater resources protection education. The Water Exhibition Hall of Wuhan Science and Technology Museum follows clues of "Humanity, Ecology and Harmony", displays the water culture of Wuhan, water ecological systems and water ecological restoration and protection project. The Wuhan Natural Museum displays the geological background and the life history of the Yangtze river. Wuhan Water-saving Science and Technology Museum displays water-saving technologies closely related to daily life. There are many more besides those. At present, some cooperative projects between these science museums and research institutions are advancing rapidly.

Wuhan is located in the middle reaches of the Yangtze River, which is the third longest river on the earth. The largest tributary of the Yangtze river, the Han river, joins the Yangtze river in the center of the city (Fig. 1). Wuhan has been famous for its convenient transportation from of old.

Besides big rivers, Wuhan also has many lakes. According to the overall plan for lake protection approved by the end of 2018, Wuhan has 166 natural lakes (Fig. 2). The Tangxun Lake and the East Lake are the first and second largest city lakes in Asia respectively. Wuhan is the largest freshwater center of China, as well as one of the megacities having the richest freshwater resource in the world. The total fresh water area of Wuhan is 2217.6 square kilometers, coverage of 26.10%, per capita of 114000 square meters. Water gave birth to the city of Wuhan, which has a 3500 years' history.

But in the past decades, the development of industry and the expansion of urban scale have brought enormous environmental pressure, among which water is the first to be affected, the aquatic ecosystems of Wuhan downtown appears serious issues such as water pollution, lake shrinking and poor connectivity of urban water systems. For example, people filled lakes to build land in response to the increase of urban population, a large number of lakes have been buried, reducing their water capacity, satellite images have documented those "Disappearing lakes" (Fig. 3). So in the recent years, during the period of continuous heavy rainfall, water-logging in Wuhan is serious. Questions such as the urban water accumulation that caused by the urban waterlogging, have influenced the

Figure 1 The geographical location and city scape of Wuhan City

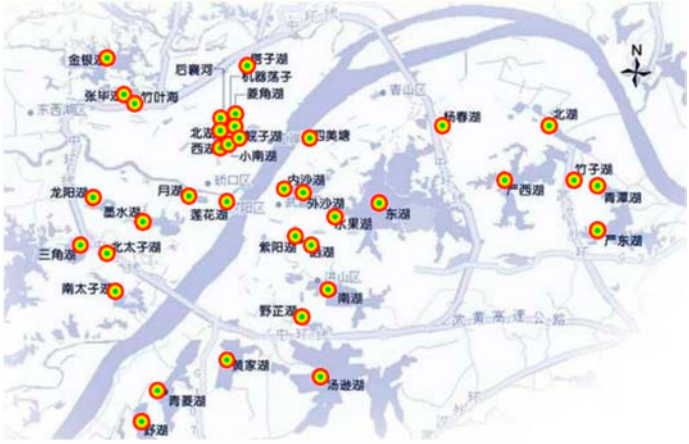

Figure 2 Location of major lakes in the central area of Wuhan

people's normal life.

On the other hand, the diversity of aquatic life is also under serious threat. For example, Baiji dolphin is a kind of small freshwater whale endemic to China, which only occurs in the middle and lower reaches of the Yangtze river system, but scientists say it may already be extinct. In 2006, scientists from the Baiji Foundation traveled up the Yangtze River for more than 2,000 miles equipped with optical instruments and underwater microphones, but were unable to detect any surviving dolphins. The foundation published a report on the expedition and declared the animal functionally

Figure 3 Shrinking lakes and stagnant water in the Wuhan downtown

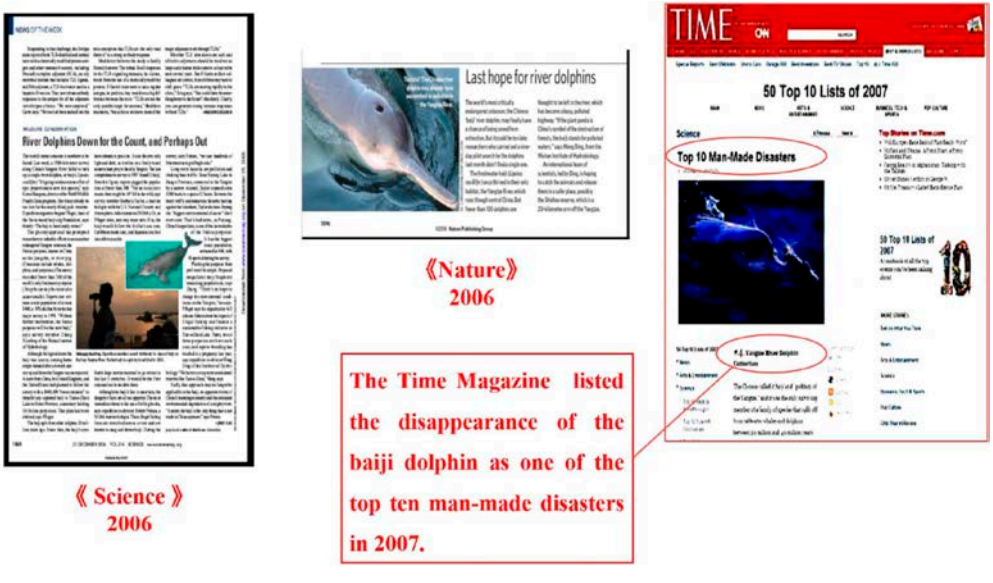

Figure 4 The Time Magazine listed the disappearance of the baiji dolphin as one of the top ten man-made disasters in 2007

Figure 5 Wuhan Science and Technology Museum and its Water Exhibition Hall

extinct. The Time Magazine listed the disappearance of the baiji dolphin as one of the top ten man-made disasters in 2007 (Fig. 4).

The good news is, in 2016, the Chinese government has made restoring the Yangtze river's ecological environment an overwhelming priority. So, what should museums do about it? How we participate?

Wuhan Science and Technology Museum is the largest comprehensive science popularization museum in Wuhan. The Water Exhibition Hall is a highlight of this museum. It follows clues of "Humanity, Ecology and Harmony", displays the water culture of Wuhan, water ecological systems and water ecological restoration and protection project (Fig. 5). For better communicating effect, we also carry out a variety of education activities (Fig. 6). But in this process, we are increasingly

Figure 6 Educational activities on water science and water conservation

Figure 7 Some unit members and educational activities of Wuhan Associationof Natural Science Museums (WHANSM)

aware of the limits of our power, especially the lack of professionals. So, last year, we started preparing to form an association, called Wuhan Association of Natural Science Museums, and the responsibility of environmental protection is written into the constitution. In fact, there are many science museums in this city are actively promoting the freshwater resources protection education. For example, the Wuhan Natural Museum displays the geological background and the life history of the Yangtze river. Wuhan Water-saving Science and Technology Museum displays water-saving technologies closely related to daily life. The Museum of Hydrobiological Sciences has 400,000 specimens, mainly freshwater fish. It displays the White sturgeon, the Baiji dolphin and other extinct species; and wildlife under special state protection like the Chinese sturgeon, Chinese alligator, Yangtze finless porpoise and mullet. But these museums also have shortcomings. Take the Museum of Hydrobiological Sciences for example, the staffs are the researchers of the Chinese

Academy of Sciences, they are very professional, but they don't have enough time for science communication. So, we could borrow their specimens, let them train our teachers, to realize advantageous complementarities and promote common development (Fig. 7).

In addition, some members jointly developed a mini program for collaboration. The Mini Program is a development capability within the WeChat platform that launched in January 2017. It is an application that does not need to be downloaded and installed. You can find the locations of these museums on the map and get information about them, If you want to go to one of them, you can jump straight to the navigation software, this is the driving route, and this is the bus or subway route. This Mini Program is still improving, we will add more museums into it.

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Sustainability through Co-operation and Co-creation —Managing Finnish Intangible Industrial Heritage

Hanna-Kaisa Melaranta[1] and Kirsi Ojala[2]

[1]Varkaus Museums, Varkaus, Finland
[2]Museum of Technology, Helsinki, Finland

Intangible Industrial Heritage?

Industrial heritage is most defined as the physical remains of the history of industry and technology. It focuses on buildings, industrial sites and environments, products and tools, labour history, and is seen as a study of merely material evidence of industrial history. Clearly, the definition is valid. However, it can be argued intangible industrial heritage must be a part of industrial heritage, in its broader sense and as an integral part of culture.

Arguably, industry is intergenerational. Industrial phenomena such as knowhow of technologies, practices and processes, both production related and social, professional identities, education and all the features of industrial work you cannot learn in theoretical studies but in practice, are part of intangible industrial culture and therefore, also a crucial part of daily life. This is why it deserves to be more widely recognized.

Museums have documented all these features for a long time. Daily life, work and company culture play an important role while documenting and preserving industrial heritage. And, besides of the past, museums also document the living, contemporary industrial companies and their culture and knowhow.

Cultural and Social Sustainability

When defining the complex concept of sustainability one starts with the Bruntland Report for the World Commission on Environment and Development (1992), stating sustainability as a "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs." Approaching 2020's we need to add to the definition the United Nations Agenda 2030 with its goals at global environmental, social and economic level (https://www.un.org/sustainabledevelopment/development-agenda/), and wanting to have a closer look in the museums' viewpoint of sustainability, Museums and the Sustainable Development Goals: a How-to Guide, is a useful tool. (McGhie, H.A. (2019). Museums and the Sustainable Development Goals: a

how-to guide for museums, galleries, the cultural sector and their partners. Curating Tomorrow, UK. See also, https://icom.museum/en/news/icom-establishes-new-working-group-on-sustainability)

However, we must take a closer look to study the definition of sustainability from the industrial heritage point of view. European research network investigating cultural sustainability between 2011 and 2015, focused interdisciplinary on the relationship between culture and sustainability. According to their approach culture can be seen *in*, *for* and *as* sustainability. Culture *in* sustainability implies culture is an equal part of sustainability with economic, environmental and social considerations. Culture *for* sustainable development is defined as a balancing role of the three considerations and to put into perspective especially the ecological challenges of sustainability. When culture creates sustainability, it can be seen *as* sustainability. (Culture in, for and as sustainable development: Conclusions from the COST Action IS1007 investigating cultural sustainability. Eds. Dessein, Joost; Soini, Katriina; Fairclough, Graham; Horlings, Lummina. (University of Jyväskylä, Finland 2015); Culture in sustainability: towards a transdisciplinary approach. Eds. Asikainen, Sari; Brites, Claudia; Plebańczyk, Katarzyna; Rogač Mijatović, Ljiljana; Soini, Katriina. (SoPhi 139. University of Jyväskylä, Finland 2017)).

The three meanings of culture and sustainable development are theoretical and thus rarely seen in the practical museum work within industrial (or other) heritage. Also, the meanings and roles often overlap each other's (https://www.nordiskkulturkontakt.org/wp-content/uploads/2017/09/Culture-and-sustainability_lores.pdf). However, the museums' stewardship of the cultural heritage obliges museums act sustainable. The International Council of Museums' (ICOM) Code of Ethics as well as the British Museums Association corresponding code and Finnish Museums Association's publication on sustainability emphasize sustainability as museums responsibility to the future generations (https://www.museumsassociation.org/ethics/code-of-ethics and http://www.museoliitto.fi/index.php?k=12278).

UNESCO Convention for Safeguarding of the Intangible Cultural Heritage

The UNESCO Convention for the Safeguarding of the Intangible Cultural Heritage was adopted in 2003 and ratified in Finland in 2013. The aim of the Convention is to promote the safeguarding of intangible cultural heritage, ensure respect for the intangible cultural heritage of communities, groups and individuals and raise awareness of the importance of intangible cultural heritage. In Finland, the national implementation of the Convention is the responsibility of The Finnish Heritage Agency. In 2015, The Heritage Agency published a plan for the national implementation of the Convention (http://www.aineetonkulttuuriperinto.fi/en/File/2959/ich-action-plan.pdf).

Since the plan of implementation, the Ministry of Education and Culture has nominated 52 elements for inclusion in the National Inventory of Living Heritage in Finland. All applications of the

elements were submitted by communities. There are themes of festivities, customs, music, dance, food culture, performing arts, oral tradition, handicrafts, games, children's plays, nature and universe (https://wiki.aineetonkulttuuriperinto.fi/wiki/El%C3%A4v%C3%A4n_perinn%C3%B6n_kansallinen_luettelo/valitut/en).

Obviously, our question is, why the intangible industrial heritage seems absent? Even internationally, it is difficult to find it (https://ich.unesco.org/en/lists). However, on the list, there are nominations for handicrafts and craftsmanship such as boat building skills and perfume making.

How to Recognize Intangible Industrial Heritage Sustainably?

According to UNESCO, an intangible cultural heritage is "a practice, representation, expression, knowledge, or skill, as well as the instruments, objects, artefacts, and cultural spaces"—"Depends on communities whose knowledge of traditions, skills and customs are passed on to the rest of the community, from generation to generation, or to other communities" (https://ich.unesco.org/doc/src/01851-EN.pdf). The definition applies to all cultural heritage including industrial heritage.

Nevertheless, collaboration of the museums and companies is needed in order to find the common understanding both the concept and what it means in practice.

The museum professionals need to have a shared knowledge of intangible industrial heritage. Luckily, the museums in Finland have a tradition of working together.

We established the Network for Collections Management and Contemporary Documentation (TAKO) in 2009. The network focuses on the contemporary documentation and a nationwide division of collecting tasks. The network consists of seven thematic pools and ca. 100 museums. The Industrial Heritage Pool includes 50 museums. These museums are responsible for preserving, researching and exhibiting a wide range of Finnish industrial heritage from metal industry to game industry and from forest industry to textile industry. In addition, Association for Industrial Heritage in Finland (TICCIH Finland) promotes preserving, conserving, investigating, documenting, researching, interpreting, and advancing education of the industrial heritage.

These two, TAKO and TICCIH Finland are naturally the partners to work on defining and recognizing intangible industrial heritage. Their project Recognize Intangible Industrial Heritage started in early 2019 and will continue until the end of 2020. In the project museum professionals had workshops to define the concept in theory and practice by using their knowledge deriving from their previous experiences working together with industrial and technological communities.

Secondly, the workshops were and will be taken in the communities, since it is *their* intangible heritage, not museum professionals' heritage. The role of museums is not only to preserve industrial heritage, but most importantly learn from individuals and communities about both tangible and

intangible heritage. Also, when the museums and companies collaborate, museums can inspire and encourage companies to utilize their tangible and intangible heritage. Starting from the project Recognize Intangible Industrial Heritage, the communities will also have a forum to define their own heritage.

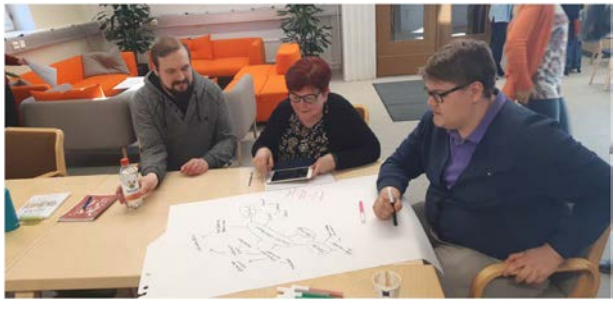
The Project Recognize Intangible Industrial Heritage in Finland

The project in recognizing intangible industrial heritage was granted by the Finnish Heritage Agency in 2019. The starting point of the project is to gain knowledge of and answers to the following questions:

- What is intangible industrial heritage? Is it possible to define industrial heritage through the terms of intangible heritage?
- Are the modern industry professionals and labourers aware of they are carriers of the industrial heritage in the chain of generations?
- What is the industrial communities' own industrial heritage (both intangible and tangible)?
- How do we carry out our responsibility as museum professionals for sustainable audience engagement and cultural inclusion?

The objectives of the workshops and a final seminar are to test how to map and recognize intangible industrial heritage and to gain knowledge how to strengthen inclusion in the industrial heritage museums in Finland. Increasing communal engagement and inclusion permanently in the museums is a primary goal.

Together with the Finnish Heritage Agency and the national implementation of intangible heri-



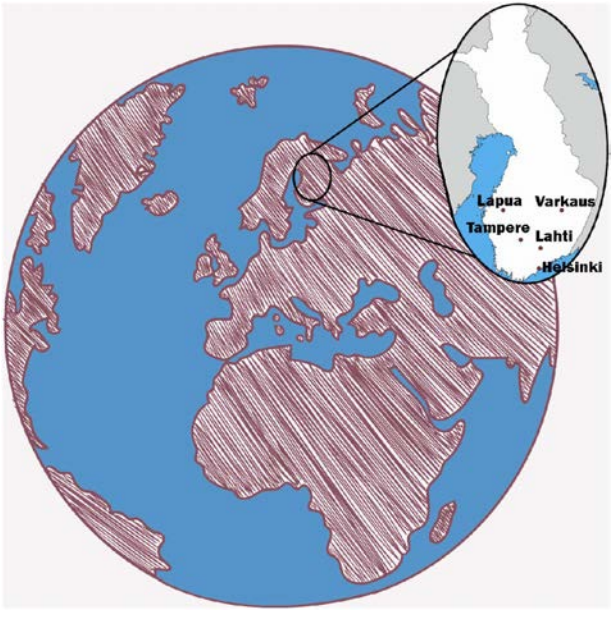
Picture 1 Brainstorming. How to define intangible industrial heritage? How do we carry out our responsibility as museum professionals for sustainable audience engagement and cultural inclusion? Photo: Hanna-Kaisa Melaranta.

tage we are also developing methods and instruments for industrial heritage operators to work with the concept of intangible industrial heritage.

The project does not aim to document or collect industrial heritage, yet networking with the communities and meeting with the locals or different groups recognising their intangible industrial heritage. At this point, UNESCO's Listing or the National Inventory of Living Heritage in Finland are secondary, hence the main goal is to recognize the concept of intangible industrial heritage.

Co-creation is needed both among the museum professionals for the peer to peer sharing and learning and between the museum and industrial professionals. Therefore, the project had two workshops for the museum professionals in the spring 2019. These workshops resulted with definitions of the concepts of intangible heritage from the industrial point of view and for the more ethically and culturally sustainable approach, plans for the further collaboration and co-creation with industrial professionals and local communities. According to the definition intangible industrial heritage is described as

- intergenerational, professional and local knowhow, knowledge, practices transmitted from generation to generation or from one professional to other
- learning from the past experiences, developing and transforming through time



Picuture 2 The workshops will take place in five towns in Finland. Map: Hanna-Kaisa Melaranta.

- professional and/or local communal identities

Additionally, a concept of "the Factory", defined as a glue of the local community, something that joins the community together, provides livelihood, housing and services was drawn into the discussions. The workshops' participants concluded, "The Factory" has a great significance in people's daily life-even if they do not work there. There are families working for the same factory is intergenerational. In fact, the owners of companies may change, yet the families will stay. For many, it is a question of their identity.

During 2019–2020, workshops "Your Intangible Industrial Heritage" will be organized in five towns; Varkaus, Lahti, Tampere, Lapua and Helsinki. These workshops are held together with local industrial companies and factories. Locally, these workshops may work as part of the identity building of the companies, or well-being activities for the members of industrial communities.

Varkaus Case

Varkaus museums have been following the theme of Agencies in the Industry since 2015, which was the 200th anniversary of industrial Varkaus. We opened the theme exhibition, Ten Stories from the Factory, in 2015. It is still open to public until October 2020. In this exhibition we represent the history of several operations and manufactures of Varkaus industry through people behind the factories.

Following the exhibition, project *Documenting the stories of the agencies of the industry communally*, was started in 2018. In this project the volunteers and friend's association were engaged to document and interview the former and present-day workers. During the project year there were collected almost 40 hours of recorded interview material, 90 pages of written material with over

Picture 3 A school class guided in Ten Stories from the Factory in Varkaus Museum. Photo: Varkaus Museums.

one hundred hours of volunteer work.

In Varkaus we are starting a four-year research project together with the Department of Ethnology and History in University of Jyväskylä. The subject of the research is the industrial heritage of Varkaus focusing on the history of industrial know-how and expertise. The Department of History and Ethnology and the Varkaus Museums are starting in 2020 a large multidisciplinary research project combining the subjects of Finnish history, economic history, ethnology, cultural anthropology, folkloristics and museology. In addition, the project will also include the scriptwriting of the museum's forthcoming main exhibition. The research project continues until 2023.

Your Intangible Industrial Heritage workshop, to be held in the early 2020 with Stora Enso Varkaus is going to focus the identity of the local employees of the factory facing major changes. It is linked with the research project, but also with the workplace well-being-events of the industrial community. There is an evident need for identity-based workshops and gatherings.

Museum of Technology Case

Museum of Technology in Helsinki is focused on industry, technology, inventors, professionals and hobbyists and will organize a workshop with the National Association for Amateur Radio in Finland. The radio amateurs' community consists of heterogeneous group of people with different backgrounds, education, age and gender. Some of them are professionals in science, technology or in other academic fields of study, some are engineers and inventors, or just enthusiasts, and enjoying the global network and ability to communicate in a way which can be described as historical in many sense.

Picture 4 Radio amateurs in Helsinki in 1928. Their individual call signs are written on the original photo. Photo: Museum of Technology.

Radio amateurs have a significant role in the Finnish technology. For instance, NOKIA corporation had many of them as employees and many of the ex-nokians are still working in technology. The Association has a long history and they are proudly sharing their knowledge and skills to the members and passing on them to the younger generation and new members. They actively hold meetings and organize events. The aim of the workshop is to encourage them to discuss their intangible heritage they presumably are aware of, find out how they see it and what are the prospects of future collaboration.

Conclusions

In Finland, we are at the beginning of recognizing intangible industrial heritage in 2019 and 2020. We are expecting to gain new knowledge and fruitful collaboration. It is crucial to focus on working life and company culture in preservation and safeguarding of industrial heritage. In many cases, museums in Finland already document the living, contemporary industrial companies and the culture of knowhow alongside of the past ways of workmanship. However, engagement of industrial communities is needed, hence the complexity of the modern industry with digital processes and fast global changes.

Cultural and social sustainability plays an important role in the project of recognizing intangible industrial heritage. Audience engagement methods such as co-creation is a vital tool to improve inclusion of the communities, groups and individuals carrying industrial heritage and passing in on to the next generations. We as museum professionals must step aside in our roles of as experts and let the communities have agency over their own intangible industrial heritage.

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Traditional Knowledge for Sustainable Future: Indian Indigenous Museums' Initiatives

Indrani Bhattacharya

University of Calcutta, India

Abstract Numbers of India's Indigenous Knowledge System practiced for centuries need to be explored for sustainable development. Traditional Indian rainwater harvesting methods include *tankas*, *madakas*, *talaab*, *johads* and many more. For example, *paar*, practiced in Rajasthan collects rainwater from the catchment areas to let it percolate into the soil. In Bundelkhand *talaabs* are natural reservoirs used to meet irrigation and drinking water requirements. After monsoon the beds are used for paddy cultivation. *Saza kuvas* are primarily used for irrigation by communities of farmers. *Water—the Elixir of Life* exhibition in the National Science Centre, New Delhi, shows the causes for ground water level depletion and helps to initiate basic idea of scientific use of water. Museobuses run by the science museums in India has units on *Water*, *Water—the Fountain of Life*, *Water Harvesting*, *Transformation of Energy*, *Non-Conventional Sources of Energy*, etc. that bring related traditional know-hows to the rural audiences particularly the young ones. The paper projects the initiatives by the Indian museums to portray the social relevance of ITK through exhibition, program, extension service, etc., in partnership with the communities aiming at inclusiveness for sustainable future.

The potential contribution of indigenous knowledge to sustainable development is becoming more and more relevant in present day world. Numbers of India's Indigenous Knowledge System practiced for centuries in different parts of India. Years-old methods for conservation of energy, use of alternative energy and museums initiatives in this context is highly topical in today's India. The Sustainable Development Goals (SDGs) are a collection of 17 global goals designed to be a "blueprint to achieve a better and more sustainable future for all. Alternative or renewable energy sources like hydroelectric, solar and wind energy produce less pollution. Solar energy may be used for street lights and in the buildings. Sustainable development in the field of energy is also deemed to contribute to economic sustainability. Clean water for all by 2030 is a serious challenge before India; India is serving 17% of the world population with 4% of the world's freshwater resources. Till date India stores less than one-tenth of annual rainfall. In May, 2019, Chennai—the southern city of India—started to run dry, people eagerly waiting for hours for a small pot of usable water. Many hotels and restaurants were shut down temporarily. The Chennai metro had turned off air conditioning in the stations, while offices have asked their staff to work from home in a bid to conserve water. Indiscriminate use of ground water for agricultural and industrial needs, excessive drawing of ground water for supplying water to high rise buildings by deep bore-wells and submersible pumps, deficient monsoon in the last few years in some areas make the demand-supply balance in metro cities more critical. Water is a scarce commodity in some arid regions in India.

Kund

From the Indus valley civilization, there are many examples of water conservation in India. The great bath is the earliest known water bath for community uses in ancient world. Several types of water harvesting systems are practiced by people in different parts of India. Mainly people of western drier parts of the country and people of the hilly regions practice different harvesting systems to conserve water. Some of these are ancient places of worship and of great architectural and got due recognition by international agencies. Water bodies and forms of worship have become part of national identity also. Mention may be made of Puskar Lake in Ajmer district of Rajasthan.

Numbers of India's Indigenous Knowledge System practiced for centuries Natural source is literally worshipped in many parts of Rajasthan or Gujarat or north-east hilly regions. *Baoli*, *tankas*, *khadin*, *kul*, *paar*, stepwells are very common throughout Indian subcontinent from time immemorial.

Baolis usually have a religious significance and were constructed as a philanthropic deed for

Talaab

punya or holy work. A large tank Gadisar was the chief source of water supply in Jaisalmir until 1965. This tank was built by Gharsi Rawal in 1367 AD. There are several other tanks like Govind-sagar, Gulabsagar, Malka, Sudharar, etc., but water lasted for few months in these tanks; ironically Gadisar had water throughout the year.

Paar

Paar is a common water harvesting practice in the western Rajasthan. It is a common place where the rainwater flows from the *agar* (catchment) and in the process percolates into the sandy soil. In order to access the *rajani pani* (percolated water) *kuis* or *beris* are dug in the agor (storage area). *Kuis* or *beris* are normally 5 metres (m) to 12 m deep. The structure was constructed through traditional masonry technology. Normally six to ten of them are constructed in a *paar*. However, depending on the size of the paar the numbers of *kuis* or *beris* are decided.

Jhalaras are rectangular water storage which has steps on three or four sides. It was meant for

Kuhls of Himachal Pradesh

community use. The water of it was not used for drinking purpose. The oldest *Jhalara* is the *Mahamandir Jhalara* which dates back to 1660 AD.

Johad

Bawaris are unique stepwells that were once a part of the ancient networks of water storage in the cities of Rajasthan *Chand Baori* is a stepwell situated in the village of Abhaneri near Jaipur in India. It is the deepest step well in world. The well is located opposite to a temple known as Harshat Mata temple.

Chand Baoli

Pushkar Lake in Ajmer district of the Rajasthan is a sacred lake of Hindus. The Pushkar Lake drains a catchment of the Aravalli hills covering an area of 22 square kilometres. The lake has a water surface area of 22 hectares (54 acres). It is a perennial lake sourced by the monsoon rainfall over the catchment—as the lake periphery is encircled by 52 *ghats* of various sizes.

Pushkar Lake

Hampi *Puskarini*'s architecture attracts tourists. The ruins of Hampi are listed in the UNESCO world's heritage sites in southern India. One attraction of the Hampi's architecture wonder is the Hampi *Pushkarani*. It is the example of Chalukya architecture of 15th century. *Pushkaranis* were the sacred tanks attached to the temples. The unique feature of this stepwell is that water is filled by aqueduct similar to the Roman architecture. The beauty of Hampi *Pushkarani* lies in its symmetrical architecture, which is beautifully adorned with the 15th century-styled carvings and sculptures.

Foundations of the *Khari Baoli* step-well were laid by Khwaja Abdullah Laazar Qureshi during the reign of Islam Shah (Salim Shah), the son of Sher Shah Suri. The work on this building was completed in the year 1551. Nothing remains of this *baoli* now, save copies of inscriptions that were preserved in works like *Aasar Us Sanadeed* (Sir Syed Ahmad Khan) and Miftah Al Tawarikh. Now it is a spice market.

In North East India, the hill tribes and indigenous people of Assam practice traditional water harvesting. The Apatanis of Ziro valley traps stream water and divert this to the field. Apathies use the stream water for wet rice cum fish cultivation system. In Meghalaya a century old system named 'Bamboo drip irrigation' is used by Khasis and Jayantias to irrigate the betel nut and black pepper cultivation. *Kuhls* are found in mountainous regions of Himachal Pradesh.

Water—the Elixir of Life exhibition in the National Science Centre, New Delhi, shows the causes for ground water level depletion and helps to initiate basic idea of scientific use of water. Mobile Science Exhibition is an attempt of National Council of Science Museums (NCSM) to communicate science in rural areas. These buses target the population which is unable to visit any of the science centres of NCSM. First MSE was launched by Birla Industrial and Technological Museum (BITM), Kolkata which is a centre under NCSM in the year 1965. Since then MSE have been proved as an important tool in communicating science in rural areas. At present 23 MSE buses of different centres of NCSM spread across India, go around the nearby rural areas and communicate to the people.

Some NGOs are working with the local people in these areas to combat water crisis. Jal Saheli is such a name. The Jal Sahelis have emerged as a group of empowered women about six years ago. The cost of one check dam is about Rs. 200,000–300,000 and labour is provided by the villagers themselves. Covered the heads with sarees, the women water warriors articulate the importance of water harvesting and rights of women as well in Bundelkhandi Hindi. A check dam, built by a women's group becomes full of water collected during monsoon. The water is being used for domestic and irrigation purpose during dry season in the village. Some farmers grow vegetables in small patches of land also.

Jal Swaraj: The Centre for Science and Environment, a New Delhi based non-governmental organisation (NGO) has been promoting the revival of traditional systems of water harvesting as a practical solution for drought proofing the affected areas. The organisation has developed a comprehensive strategy to further the impact of its campaign for participatory, equitable and decentralised paradigm for water management.

Rajasthan's Immersive Water Museum, Jal, in *Chowkaria* near Udaipur is an ongoing project

Jal Sahelis

which portrays this serious issue to the masses. It is expected to launch later this year. This will explore the relationship between water and technology, as well as crafts and water conservation. It will provide expert advice in water auditing, harvesting and conserving. It has being set up by an NGO called MA: My Anchor Foundation, spreading over 23000 sq. ft. It will portray the models of traditional conservation systems, stepwell, tankas, and functioning model of bamboo water conservation systems. The interesting craft shall showcase the relationship between crafts and water, like block printing, dyeing, potteries, metal works, etc. In the learning centres experts will teach students, farmers and cultivators on water auditing, harvesting and conserving. There will be an amphitheatre for storytelling and music sessions, particularly for the children.

Recently Government of India initiated a novel project under The Ministry of Cultures 100 day agenda to fabricate and run 25 mobile vans through the science museums for water harvesting at different monuments in India.

Not only water, other sources of energy like wind mill, solar power, etc., are also important topics in museum programmes. Muppandal windfarm, Tamilnadu is the largest wind power plant in

Jal—the Immersive Museum

India with 1500 MW installed capacity. Others are Jaisalmer Wind Park in Rajasthan. Wind power project at Brahmanvel in Dhule district of Maharashtra has 32 wind turbines; Damanjodi Wind Farm is one of the largest in the state of Orissa. Tuppadahalli Wind Park is located in the state of Karnataka.

The "Man and Environment" museum of the Narendrapur Ramakrishna Mission throws light on uses of alternative power like solar and wind. The Indira Gandhi Rashtriya Manav Sangrahalaya, Bhopal, promotes aspects of ITK, including the rich heritage of traditional medicine, and its relevance through interactive programs. Several Indian museums, particularly the science museums, portray the rich scientific and technical heritage in their expositions. The initiatives by the Indian museums aim to portray the social relevance of ITK through exhibition, program, extension service, etc., in partnership with the communities aiming at inclusiveness for sustainable future.

Museums in India have the potential to bring a change in creating positive thinking for 'sustainable future' among the visitors and also a source of experimental learning of India's indigenous traditional know-hows.

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Indigenous Traditional Knowledge for Sustainable Future: Indian Museums' Initiatives

Dr. Indrani Bhattacharya
Associate Professor of Museology
University of Calcutta, India

Third World War would possibly fought for "**Water.**"

Indian Scenario

- **Serves 17% of the world population with 4% of the world's freshwater resources.**
- **Till date India stores less than one-tenth of annual rainfall.**
- **Disproportionate use of water for agricultural , excessive ground water pumping and deficient monsoon in the last few years make the demand-supply balance more critical.**

India's Traditional Knowledge

Numbers of Indigenous Traditional Knowledge systems practiced for centuries in India need to be explored for sustainable development. In different regions of India , numerous traditional systems were used for years after years. Now ground water level in most of the metropolitan cities are decreasing. This year , Chennai- the southern Indian city faces severe water crisis due to absence of rainfall in summer.

India's RWH Systems

- Pisar
- Baolis or bawaris
- Jhalaras
- Sara kuwas
- Khadin
- Kul
- Talaab
- Madukas
- Johad etc.




Rajasthan's Immersive Water Museum-Jal in Chowkaria near Udaipur

BAOLIS

Were constructed as a philanthropic deed for punya or holy work .

A large tank Gadisar was in Jaisalmer and was built in 1367AD.

Other tanks like- Govindsagar, Gulabsagar, Malka, Sudharar etc. also exist.

Talaabs

In Bundelkhand it isnatural reservoirs for drinking and drinking water. After monsoon the beds are used for paddy cultivation

PAAR

In the western Rajasthan , paar is a common place where the rainwater flows from the agar (catchment) and in the process percolates into the sandy soil.

JHALARAS

Jhalaras were rectangular storage which have steps on three or four sides. It was meant for community use . The water of it was not used for drinking purpose. The oldest Jhalara is the Mahamandir Jhalara which dates back to 1660 AD.

Chand Baori is a stepwell situated in the village of Abhaneri near Jaipur in India. It is the deepest step well in the world. The well is located opposite to a temple known as Harshat Mata temple

HAMPI - PUSHKARANI

The Hampi's architecture wonder is the Hampi Pushkarani. It is the example of Chalukya architecture of15th century. Pushkaranis were the sacred tanks attached to the temples. The unique feature of this stepwell is that water is filled by aqueduct similar to the Roman architecture. The beauty of Hampi Pushkarani lies in it's symmetrical architectural which is beautifully adorned with the 15th century- styled carvings and sculptures.

KHARI BAOLI

Foundations of the Khari Baoli step-well were laid by Khwaja Abdullah Lazzar Qureshi during the reign of Islam Shah (Salim Shah), the son of Sher Shah Suri. The work on this building was completed in the year 1551. Nothing remains of this baoli now, save copies of inscriptions that were preserved in works like Aasar Us Sanadeed (Sir Syed Ahmad Khan) and Miftah Al Tawarikh.

Bamboo Drip Irrigation

In Meghalaya a century old system named 'Bamboo drip irrigation' is used by Khasis and Jayantias to irrigate the betel nut and black pepper cultivation land.They trap natural stream water using bamboo pipes which have to repair yearly.

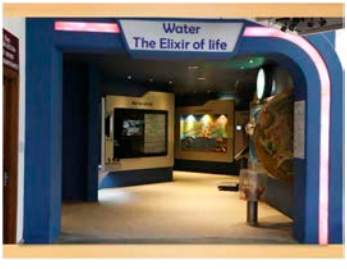
***'Kuhls'** are surface water channels found in the mountainous regions of Himachal Pradesh*

JAL-SAHELIS

WINDMILL- In the state of Tamil Nadu, Muppandal windfarm the largest wind power plant in India with 1500 MW installed capacity.

Museo-Bus

- *Mobile Science Exhibition is an attempt of National Council of Science Museums (NCSM) to communicate science in rural areas.*
- *First MSE was launched by Birla Industrial and Technological Museum (BITM), Kolkata which is a centre under NCSM in the year 1965. Since then MSE have been proved as an important tool in communicating ITK in rural areas.*
- *At present 23 MSE buses of different centres of NCSM spread across India.*
- *Many MSE shows exhibitions related to traditional energy, save water, alternative sources of energy etc.*
- *This year, Ministry of Culture announced to inaugurate 25 museums in their 100 days agenda.*



Water –the Elixir of Life

Water – the Elixir of Life exhibition in the National Science Centre, New Delhi, shows the causes for ground water level depletion and helps to initiate basic idea of scientific use of water, where visitors can find Floor-FX/Ground –FX with two projectors. When visitors step out , they can experience the movement of fish at the bottom of their feet in a virtual sea.

Museum programmes on water, energy etc.

- A popular talk on 'Conservation of Water, Energy & Soil for Human Welfare' was organized on the occasion of World Nature Conservation Day on 28th July by The Kurukshetra Panorama & Science Centre, Kurukshetra.
- Water-Our Life gallery was renovated in 2012, in The Science Center, Lucknow.
- Throughout the year, during different spells VITM and its satellite units organised several temporary exhibitions on Sustainable Energy
- Each and every year different museums organises this type of programmes on these topics.

Innovation Festival

Visvesvaraya Industrial &Technological Museum, organised Innovation Festival on 20 and 21st November, 2015.In this festival workshops on solar powered table lamp making along with clay modelling, paper engineering were introduced . Approximately 6200 students , teachers and general public participated in the festival.

Conclusion

Traditional knowledge plays an integral role in supporting sustainable development. Traditional lifestyle of depending on nature and natural resources can help to combat the present crisis of environmental disasters to a large extent. Museums are the right agencies to cater the traditional know - how's to the people through it's programmes.


THANK YOU

47th Conference of CIMUSET, pp. 109–115, 2020

Scientific Heritage—How to Understand and Study It?

Ewa Wyka[1]

Institute for the History of Science, Warsaw & Jagiellonian University Museum, Cracow, Poland

For historians of science and technology, the concept of technical heritage is intuitively clear. We think about historical industrial institutions, industrial buildings and machinery, but also about the legacies of engineers, inventors and scientists.

The heritage of science is, in a sense, a part of the broader technical heritage.

How do you understand science heritage as opposed to technology? What does this term fit into?

This includes widely understood historical scientific achievements, i.e. archives of scholars, their publications, photographic documentation, scientific correspondence, scientific and didactic instruments, materials related to the manufacture of instruments, history of companies selling scientific instruments and equipment, so called "migration" of scientific instruments, how they spread, who purchased them.

The interest of Polish science museum professionals is, in particular, in the heritage of scientific and didactic instruments preserved in Polish museums and scientific institutions.

The heritage of science, natural and exact sciences, experimental sciences, is closely related to the development of technology. Machines, devices, and above all technical thought, as well as, especially innovative design solutions, are necessary to make the instruments essential for scientific research.

They testify to the quality of the scientific instruments and their research potential. These factors, technological factors, we can say, will indirectly affect the development of science, and enable new discoveries that would not have been possible without a high-class apparatus. This statement is valid regardless of the era in the development of science.

One of the first research instruments of the Enlightenment period enabled to see phenomena inaccessible to the naked eye—the microscope allowed observation of small objects, another one from these period—the telescope made distant objects, also inaccessible to the naked eye, much closer. Today's research microscopes and telescopes are complex devices, we can say they are works of the highest class engineers and technicians.

Historians of science and science museum professionals are interested in instruments from the past and from today, collected as a documentation of the development of humanity, science, education but also technology.

The importance of collecting objects of science was first understood and started at the end of the

[1] ewawyka@gmail.com

18th century. The first such collections are preserved until today: the Paris collection of the Conservatoire des Art et Métiers, History of Science Museum in Oxford, Deutsches Museum in Munich, and others.

In many museums today, not only science and technology museums, there are instruments related to science, to doing science, to education, or as belongings of scholars.

The questions arise, whether we know, how many of these collections we have in our countries, for example, in Poland? What is their value ? Is there a need for national studies? We can ask, do we have this national scientific heritage examined, and if not—is it needed, if yes, how to study it?

I distinguish two areas of research:

1. the holistic view of the heritage of science
2. a particular object/instrument and analyses its value.

Let's start with a comprehensive look at science heritage. It could be understood as a study in a local context or a study of so-called scattered heritage. In the local context, i.e. what historical scientific instruments have been preserved in a given country, e.g. in Poland in my case, where are they located, what is their value?

Studying scattered heritage is looking for answers to slightly different questions. We should ask where outside of a given country are there preserved instruments originating from that given country, and made in that country. This raises more questions, like what was their journey to where they are now? Do they reflect scholarly relations? If so, with what scholars? A question arises about cooperation, or maybe competition between scientists. It seems that scattered heritage is still an open field for research.

These studies would require cooperation between institutions which kept scientific collections, typically between museums in different countries. Such common project would involve museum professionals from different countries. From my point of view, it would be interesting to know if the scientific instruments of Polish manufacturers could be found in European museums—globally in the world museums. Maybe it is worth rethinking the concept of a jointly implemented project, the goal of which would be to study the scattered heritage of individual countries outside their borders.

The second aspect of historical research on scientific instruments is the individual approach to the object—the instrument, i.e. analysis of the value of a chosen instrument. Such an estimation is needed to know the value of collections, it is also useful when deciding about the selection of objects for a collection.

How to rate a given object/an instrument? It is proposed to use three criteria to evaluate the given instrument.

The first criterion is that of a scientific value. To study a scientific value of the object we should find answers for the following questions.

Is the function of the object known?

Is the person using the object for research known?

Is the instrument one of its kind?
Does the object have additional equipment?
Does the object have original manual?
Is there any research or results linked with the object?

The next criterion is the assessment of the historical value of the examined object.

The questions we should answer are:

Is the object dated?
Is the maker of the object known?
Does the object have a maker's signature?
Is the owner of the object known?
Is the provenance of the object known?
Is the object unique to the collection?

The third, last, criterion is that of aesthetic value. This criterion seems to be more subjective than previous, but we can put questions like following.

Is the object complete, does it have all parts?
Is it damaged (corrosion, mechanical damage)?
Does it look like it is from its epoch?
Does it work?
Is it pretty?

By answering the above questions YES or NO we can relatively objectively assess the museological value of a given instrument.

By adopting the above assessment method, we can look at the scientific heritage preserved in museums.

Science heritage in Poland—research project

Research on the local scientific heritage in Poland was undertaken in 2018 as part of a research project entitled 'National inventory of historical scientific instruments'. The aim of the project is to create a database of the most valuable science objects in Polish museum collections. The results obtained until now allow an initial evaluation of Polish scientific collections. The main collections of scientific instruments are associated with scientific research institutions, universities with long traditions in Poland.

The most numerous and oldest scientific collections in Poland is located in Krakow, preserved in the several museums of the Jagiellonian University.

In the Museum of Pharmacy of the Jagiellonian University mainly 19th-century items, including chemical and pharmacy glass are kept.

There were two significant scientific collections at the Jagiellonian University Museum. The oldest is a set of astronomical instruments dated late 14th century. There are: torquetum, planispheric astrolabe and celestial globe. The last one is signed by maker Hans Dorn from Vienna, and two oth-

Photo 1 Exhibition of the instruments for liquefaction of gases, Jagiellonian University Museum,Cracow, photo G. Zygier

ers, although not signed have the same attribution.

The second scientific collection, dated turn 19/20th century, represents the experiments on liquefaction of gases, that were run in that time by two Polish scientist Zygmunt Wróblewski (1845–1888) and Karol Olszewski (1846–1915). In April 1883 they liquefied oxygen in a static state as a first time. The apparatus used by them has been preserved. Phot. 1.

A valuable collection is presented at the Museum of Wrocław University. The University continues tradition of the eighteenth century German Jesuits college called Leopoldina. Wrocław was a German city for centuries. After the second world war it was included to Poland. At the university museum, astronomical instruments from the 16th to the 20th century are the most valuable. Phot. 2

The National Museum of Technology in Warsaw owns a classic museum collection of instruments gathered by museum professionals. This is the first and oldest Polish technical museum, dating back to 1875. The instruments—a collection of purchased or donated items—are mainly 19th century surveying and metrological instruments, calculating machines, and devices on the border of practical science and technology. Phot. 3

Also in Warsaw there is a valuable collection of items related to the achievements of Madame and Pierre Curie. Maria Curie, *de domo* Skłodowska, was born in Warsaw. When in France, she maintained family contacts, also helping Polish scholars. Not only the donated instruments, but also the scholar's documents and her correspondence survived in Warsaw Museum. Phot. 4

Individual objects are found in other museums, mainly in university museums. The best example is the Museum of History of Medicine and Pharmacy of the Medical University Museum in Bialystok. The Museum is building its scientific collection by gathering mostly museological objects of medicine. Phot. 5

Photo 2 Museum of Wrocław University exhibition of scientific instruments https://uni.wroc.pl/popularyzacja-nauki/muzea-uniwersyteckie/

Collection of astronomical instruments is preserved also at Nicolaus Copernicus Museum in Frombork, where the astronomer lived about 33 years and where he died in 1543. Phot. 6

Summing up the value of the entire Polish collection, we can say that the preserved instruments illustrate the periods of splendor of the schools to which they belonged. Astronomical instruments from the 15th century reflect the flourishing of this science at the Krakow Academy in the 15th cen tury, and the Wroclaw collections—the teaching at the school in 18th and 19th centuries.

Most of the preserved instruments are not unique. Only individual scientific objects in Polish collections are of the highest class—they are unique, like the aforementioned set of astronomical instruments from the 15th century, or a set of instruments for liquefying gases. There are very few instruments from the 17th century when enlightenment science was already developing in Western Europe. In the seventeenth century and practically until the mid-eighteenth-century Polish education and science were in the hands of the Jesuits and represented a low level. Few instruments from the 18th century come from the resources of former schools. Others are contemporary and planned acquisitions of museum collections.

Photo 3 The National Museum of Technology exhibtion, Warsaw https://travel.sygic.com/pl/poi/muzeum-techniki-i-przemyslu-poi:8821234

Photo 4 Crown Prince Akishino and Crown Princess Kiko visit the Museum, June 2019, https://www.newmyroyals.com/2019/07/crown-prince-akishino-and-crown.html

Photo 5 X-ray apparatus, the Museum of History of Medicine and Pharmacy of the Medical University Museum in Bialystok http://muzeauczelniane.pl/muzeum-historii-medycyny-i-farmacji-uniwersytetu-medycznego-w-bialymstoku/

There are practically no historical scientific instruments made in Poland before the 19th century. The oldest instruments we have they are of European origin, mainly French, English, German, less

Photo 6 Nicolaus Copernicus Museum exhibition, Frombork, http://frombork.art.pl/pl/wystawy/

often Italian. The making of scientific instruments in Poland practically did not exist until 19th century.

Nowadays there are no science museums in Poland, like in Western Europe, in which scientific culture of visitors is shaped. There are no special regulations how to protect scientific heritage from 20th–21st century. I hope that the increasing activity of our science historians, museum professionals will result in the protection of the heritage of contemporary science. The article was prepared as part of the National Science Center project No. 2017/25 / B / HS3 / 01829.

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Research and Conservation of Bio-cultural Heritage and Traditional Technologies

Lilian García-Alonso [1] and José Luis Ruvalcaba[2]

[1] National School of Conservation, Restoration and Museography, Mexico City, Mexico

[2] National Autonomous University of Mexico, Mexico City, Mexico

Abstract This work includes the rescue of orchids, producers of the pre-Columbian adhesive known as *tzauhtli*. The identification of the products derived from orchids is a necessity for specialists in different areas. One problem is that there are not enough spectra to compare, the existent ones are hard to get and because of the necessity to access the living material in some cases, they are difficult to repeat. Thanks to actions like fieldwork, collection, and nurture of specimens of orchids now is possible to find a solution.

Key words: Orchids, Characterization, Conservation, Bio-cultural heritage

Introduction

Tzautli was the term that the Nahuatl culture used for the mucilage obtained from the reserve organs of some orchids. Throughout historic documentation and communication with biologist and orchid experts, it has been possible to appreciate that its use as a binding agent and adhesive was common in Mesoamerica thanks to its properties, hence its appreciation as a natural resource, as a legacy from traditional Mesoamerican technologies, and, therefore, as bio-cultural heritage (Boege, 2008, Toledo, 2009). Every day, the conservation of traditions, language, and the protection of material and immaterial dimensions in nowadays cultures gains more importance. For this reason, it is necessary to take an inventory of bio-cultural heritage that is documented, understood, and invigorated by science; not only for its intrinsic value of universal character, but because of its worth in the look for alternative models in the management of natural resources (Boege 2008, 2017).

In this research, we consider the analysis of the adhesive and binding properties of orchids, as mentioned in historic sources as producers of *tzauhtlis*, from orchids as an alternative restoration material and as a material of reference for its identification in objects of cultural heritage. This work would not have been possible if it was not for the living material that is being sheltered, propagated, and studied since 2011 at the ENCRyM's greenhouse.

It is important to consider that, even when orchids make the second most numerous families in the vegetal realm, most species cannot reproduce in different ecosystems from which they are originally. The species studied in this research are endemic from the Mexican territory and develop only in zones with a template climate; both are susceptible to changes in its environment, since its

growth in general depends in the symbiosis with other species. Due these characteristics, the orchids belong among categories of special treatment (SEMARNAT, 2017). Its indiscriminate use represents a problem, considering the environmental repercussions generated due the harvest of pseudo-bulbs, but it is undeniable that these plants have a strong cultural use. It is not ethic to make an indiscriminate use of this product without considering beforehand the environmental consequences. Due this reason, we approach the study of the *tzauhtlis* from a scientific standpoint and from its technical use in restoration, but from a perspective that proposes and promotes the sustainable management of productive orchids.

Precedents

Historic references are a valuable document to address the complexity of the materials that constitute cultural heritage, fundamental to approach the materials under the perspective of researchers from other times, and therefore carry out a research with a theoretical foundation. While making the historic research, we addressed the importance of the use and commerce of the *tzauhtli*, whether used as a powdered glue or as a fresh extract out of the bulb; the material was a binder of pigments and an adhesive in feather art.

Carolusa González (1996) characterized the mucilage of the orchid *Bletia campanulata* in a feather mosaic on a metal surface through chromatography (HT-CGC). She identified the orchid by comparison, because a chromatogram from this species and from other mucilages were already available: a few cactaceae and agavaceae specimens. In 2002, at the National School of Conservation Restoration and Museography, conservators and technicians studied a feather mosaic known as *Christ Savior of the World*. While developing the verdict of its state of conservation they noted that, in spite of the damage, the feathers where still firmly glued and the manufacture technique of the feather mosaic consisted in a superposition of layers from different species and colors, which were added to the cotton surface with *tzauhtli*. Damage was due to the natural aging of the feather, not because of the adhesive (Román, 2014). After the restoration of the mosaic, we performed tests with the mucilage in deteriorated silk and cotton pieces of cloth in order to extend its use to textile restoration.

Lilia Felix (once a professor in the plastic arts workshop at the ENCRyM) did many tests following different methods of extraction for which she used the mucilage mixed with adhesive METHOCEL™ (a polymer derived from pine pulp). The mixture of this two substances was utilized in different works of restoration: for the consolidation of a palm box from an archaeological context and for the silk threads of the embroidered figure or the flags from the Barradas "Loyal Legion" and "The King to Fidelity, as well as to glue a silk fan from the XVIII century.

In the beginning, mucilage from species *Prosthechea citrine* was the most utilized (Corona, 2009; Lara, 2012; Núñez, 2013). Thereafter, after making contact with Irene Ávila in 2013, a few specimens of *Laelia speciosa* where acquired, and it was confirmed that this orchid is mentioned in documentary sources as the producer of *tzauhtli* and that its use continues nowadays.

The identification of *Laelia speciosa* from documentary sources (Hernández, 1825; Sahagún, 2006) gave tools to follow the characterization of this species, which also carries a tradition of use in Michoacán. In the case of the *Cytopodium macrobulbon*, there were no historical records of its use, but there were in oral tradition, memory and usage, found in some regions of Guerrero and Oaxaca (Salazar, 2009; SEMARNAT; 2017).

In 2014, we began the official sample, collection, and protection of the orchid specimens. From then on, students from this and other institutions regularly visit the ENCRyM collection. This alive collection has allowed the realization of several tests, two mayor's thesis about different possibilities in its use and allows professors from the seminary-workshops to engage with the material.

It is important to consider that, even when orchids constitute the second most numerous family in the vegetal realm, most species can hardly reproduce in different ecosystems from those that they are predestined. The species studied in this work are endemic of the Mexican territory and develop exclusively in zone with a template climate. Both are susceptible to changes in its environment, since its growth in general depends on its symbiosis with other species. These characteristics consider the orchids among categories of special treatment (SEMARNAT, 2017). Its indiscriminate use represents a problem, considering the environmental repercussions that are created with the harvest of pseudo-bulbs but is neither possible to deny that these plants have a strong cultural use. It is not ethic to make an indiscriminate use of this product without considering beforehand the environmental consequences. For this reason, we approach the study of the *tzauhtlis* from a scientific standpoint, from its technical use in restoration, and from a perspective that proposes and promotes the sustainable management of productive orchids.

Objective

The study of orchids, their domestication and usage as part of the tradition and knowledge of the native cultures is a contribution to the research of the Mesoamerican bio-cultural heritage. If the mucilage is proved to be useful for this activity, the biological recovery and sustainability of orchids is promoted and, along whit it, the conservation of the Mesoamerican usage tradition of the mucilage as a fundamental part of a specific cultural heritage.

We aim to continue with the harvesting and domestication of the total of orchid specimens mentioned in historic sources for its research, use and assessment, as Mexican bio-cultural heritage. We already established orchid gardens in the Physics Institute at the National Autonomous University of Mexico (UNAM) and the ENCRyM of the National Institute of Anthropology and Archaeology (INAH). This will allow access to students and researchers to alive material and will facilitate the strengthening of professions related to its use: the creation of sculptures made out of corn fiber, musical instruments, and feather mosaics and as a binding agent for paint.

Methodology

The characterization of materials means the identification of its components, from the study of its physical and chemical properties. We developed a research that contemplated the historical and practical analysis of *tzauhtli*'s utilization, complemented with fieldtrips and interviews to gather first-hand references of its use. A collection, nurturing and sheltering of productive orchid specimens and the botanic study of them took place. We also developed of a basis for a scientific methodology that involved physical and chemical tests made under controlled and repeatable conditions.

As to the making of test tubes or extraction of the mucilage, it is important to keep in mind the climate conditions when collecting the bulbs, as in raining season these produce less material than in dry time. Before making the extraction, it needs to be clear the purpose of it and to make sure that the necessary material for its apply or study is available and at hand, taking in count that the mucilage can remain in storage inside a glass or plastic jar with a lid and in refrigeration for about 15 or 20 days.

In the case of *tzauhtli*, we found previous studies, but the lack of alive material and the difficult access to the techniques for organic materials (such as molecular spectrometry and gas chromatography) complicated its characterization. The study methodology contemplated the analysis of the mucilage with tests on the materials on which it is commonly used: textile and wood.

To confirm the resistance of *tzauhtli* employed as an adhesive it was crucial to make tests with the basis of a standard parameter of qualitative measurement. The physical tests: Fourier-transform infrared spectroscopy (FTIR) using an Alpha Bruker ATR system to the mucilage alone, traction test over the textile and wood test tubes, simulation of accelerated aging and colorimetry. We tested the chemical properties with High Temperature Gas Chromatography with Flame Ionization Detec-

Figure 1 Responsible collect of *Laelia Speciosa.*

tion using an Agilent CG-DIF Agilent 7980 B equipment.

No plant was harmed while extracting the mucilage. There is still enough material to allow this and other tests (Fig. 1).

Results

Results prove that the fresh extract of the *Cyrtopodium macrobulbon*'s bulb has good resistance before an extreme force while employed as an adhesive between two pieces of wood and this property remains even when the material has aged. The analysis included resistance tests in tests tubes exposed to controlled weathering simulation conditions and analysis of changes of color with colorimetry.

We did the characterization of the material with weathering, colorimetric, and tensile tests, plus Fourier-transform infrared spectroscopy, and High Temperature Gas Chromatography with Flame Ionization Detection. While studying the mucilage, the ecologic and sustainable recovering of the orchids got promoted, which allows to keep making analysis and, at the same time, to transmit the knowledge behind the use of *tzauhtli*, as well as its importance as cultural heritage. The use of different techniques allowed us to have more precision in the result's interpretation and to confirm if *tzauhtlis* are a viable alternative for adhesives. We identified the heteropolysaccharides contained in bulbs from orchids recollected in eight states of Mexico: Michoacán, Jalisco, Hidalgo, Guerrero, Morelos, Oaxaca, the State of Mexico and the border between Jalisco and Nayarit. One of the contributions of it is the library of FTIR spectrums from all the orchids considered as producers of *tzauhtli*.

We did the chemical characterization by Gas Chromatography with Flame Ionization Detection, a revision of the methodology with Gas Chromatography of high temperature, followed by González and Peña (1996). This variation permitted the characterization of *Bletia campanulata*'s, *Laelia speciosa*'s *and Cyrtopodium macrobulbon*'s mucilage by obtaining carbohydrate percentages. These chromatograms and FTIR spectrums constitute a sort of fingerprints of materials, it is possible to compare them with those of the organic materials, known or unknown, to read the constitutive materials presents in cultural heritage. In addition, we proved that it is just enough to have a little sample to make it. We confirmed that the characteristics of the orchid's growth environment does affect the quality of the mucilage, no matter if it is from the same species. Whereas with the *tzauhtli* from the *Laelia speciosa*, the plant coming from Hualula, Hidalgo has, better properties even after been acclimatized under the same conditions as other same species plants from different states. This represents an important contribution because it was showed that, in fact, the ambient characteristics associated to the growth of the plant have an influence in its properties, the single orchid species taken from mount "del Olvido", which is also the most genetically distant from those collected from Bolaños and Hualula, was the least resistant to detachment. To utilize the mucilage successfully, we will have to reproduce the species brought from Hualula, Hidalgo. This result was possible thanks to keeping the plants alive and sheltered under proper environmental conditions.

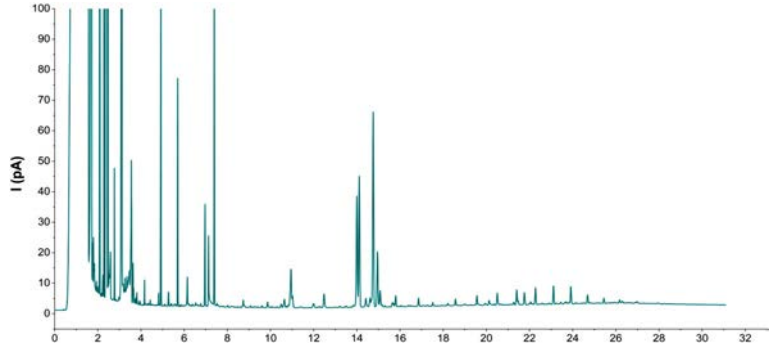

Figure 2 Chromatogram of *Bletia campanulata*.

The limiting factor in these techniques is that, with the FTIR the original support bands over which generally the adhesive is found are very similar to the object of cultural heritage being studied and it can difficult the results interpretation. With chromatography, the problem of the technique is the time taken and the fact that the equipment requires a column and specific reactive agents that are quite expensive. Fortunately, now we have chromatograms from three of the species producers of *tzauhtli* that sum to those obtained by González and Peña (1996). These contribute to compare the compounds found in the orchids bulbs and to count with alive material, besides the fact that it permitted to make the chromatograms, it assures the continuity of the analysis. Chromatography rehearsals of *Bletia campanulata* (Fig. 2) and *Laelia speciosa* mucilagues proved the efficacy and repeatability of the method implemented by Fiesco, and such action would not have been possible if we did not count with the alive material (Fig. 3). Three essays of chromatograms correspondent to the species *Bletia campanulata*, evidence of the repeatability of the method. Additionally we now have access to the saccharide contained in each specimen.

Tzauhtli from *Laelia speciosa* showed optimal qualities as an adhesive in silk, keeping an ade-

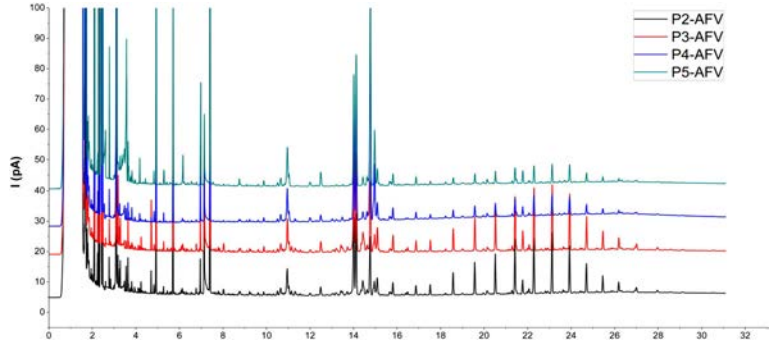

Figure 3 Three essays of chromatograms correspondent to the species *Bletia campanulata*, evidence of the repeatability of the method.

quate resistance to traction, so is not as aggressive to turn it rigid, it keeps flexibility and the change in color that generates after the ageing process is not perceptible by the human eye. *Tzauhtli* from the *Cyrtopodium macrobulbon* has great features for it is use as an adhesive for wood and, by its growth and reproduction characteristics, it is possible to get it out of the plant without making any damage. This is important because this species carries a tradition that is in danger of falling into oblivion and now this can be reverted as it has a practical use that adds to a special connotation as bio cultural heritage.

Discussion

The alternative use of *tzauhtli* as a restoration material is a way to push the acknowledgement and recovery of traditional and pre-Hispanic Mexican technologies. Furthermore, it is a 100% natural product that does not affect neither pollutes the environment and takes conscience on the ecologic importance of producer specimens, which justifies the necessity of introduce this kind of materials to the fields of restoration and conservation. We consider that orchid domestication can be a sustainable practice in regard of the production of organic materials for the restoration practice with a direct impact in the preservation of bio-cultural heritage.

Mucilages synthesis for its reproduction in the laboratory as a restoration material was not considered with the *L speciosa*, because it requires of a noteworthy amount of time to reach maturity and reproduce (Flores-Palacios, 2002; Ávila y Oyama, 2007), even though it could be necessary because of the effectiveness of its *tzauhtli*. However, there are alternatives to this so it is not necessary to risk the growth of the plant. *Cyrtopodium macrobulbon*'*s tzauhtli* has good properties for its use as an adhesive with wood and, for its growth and reproduction characteristics, it is possible to get it out of the plant with no harm to it. This is important because this species carries a tradition that is in danger of falling into oblivion and it can be reverted.

The ways in which humanity uses orchids has changed historically, and the availability of these determine the intensity of its collection, but also can contribute to its conservation. To give a specific use to the orchid allows to throw attention back at it and its production, as well as nurturing can protect it from being forgotten (Lara, 2016). For this reason, it is important to characterize orchid's natural adhesives and confirm the viability of it use in restoration procedures.

Conclusion

The alternative use of *tzauhtli* as a restoration material is a way to push the acknowledgement and recovery of traditional and pre-Hispanic Mexican technologies. Furthermore, it is a 100% natural product that does not affect nor pollute the environment and takes conscience on the ecologic importance of producer specimens, which justifies the necessity of introduce this kind of materials to the fields of restoration and conservation.

We consider that orchid domestication can be a sustainable practice in regard of the production

Figure 4 Orchid collection.

of organic materials for research and the restoration practice with a direct impact in the preservation of bio-cultural heritage, and the green house in which the plants are gathered functions as a space to teach interested students (Fig. 4).

In the beginning of 2017 the director of Templo Mayor, Leonardo López Luján required one of the same species to exhibit it in the exposition "Seeds of life". This specimen received the recommended cares by the museum personal and they displayed it during the length of the exposition. In 2018, the Chemistry Institute of UNAM developed a series of chromatography analysis with different species bulbs and, that same year, PhD students from the Physics Institute of UNAM used a bulb from *Laelia speciosa* to use the mucilage as a pigment binder. Consequently, the material is utilized, studied and deserves to be preserved.

Thanks to the fieldwork, collection, and conservation of the orchids, it was possible to generate a library of FTIR spectrums and chromatograms of mucilage that produce *tzauhtli*. The alive specimens are sheltered for its use by Scientifics, students and conservators they are available required to run more analysis or to repeat the chromatograms. This research finds its support scientific method-

ology. The interdisciplinary perspective that took place allows noticing the origins of a traditional technology that, throughout time and industrial development, has faded. The importance of bio-cultural heritage has historic roots, but prevails and gains sense from science, history, art and conservation.

It is important to continue testing *tzauhtlis* on other objects and supports, those being: tempera and oil paintings, polychromate sculpture and paper. This way, further references will permit to establish if the mucilage is useful to the restauration of other kinds of cultural objects.

From the accomplishments of this research, this work seeks to be part of a wider project that involves the study of other aspects of the biology of *tzauhtli* orchids as well as the work with academic and government communities to establish a program that offers alternatives of sustainable management. We consider a necessity to design a self-sustainable system that guarantees production and rescue. For example, to set out different cooperation possibilities with communities, included the academic, dedicated to the nurture and study of these plants. We also suggest the maintenance of a germplasm bank of the rescued species; this will allow its ecologic reinsertion to assure the conservation *ex situ* and its use in cultural materials (Izawa *et al.*, 2007).

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From the Portal for Science Archives in Italy to the New Collection Catalogue —Two Examples for an Accessible, Reusable and Interoperable Heritage Information using Linked Open Data

Giovanni Cella

National Museum of Science and Technology Leonardo da Vinci of Milan, Italy
cella@museoscienza.it

Abstract The National Museum of Science and Technology Leonardo da Vinci of Milan (hereafter referred to as "the Museum") is the largest science and technology museum in Italy. Founded in 1953 it preserves and valorises a unique scientific, technological and industrial heritage with: 19,000 artefacts, 50,000 books, 10 archives with 5,000 archival units, 250,000 photos.
One of the Museum's missions is to promote the dissemination of scientific culture, starting from its heritage, as an instrument of social growth and cultural enrichment. Among other instruments the museum decides to share its heritage information through open access tool to foster new opportunities and to make the cultural heritage data more accessible.
Working in that direction, the Museum recently delivered the project "Portal for the archives of science and technology in Italy" and is working on his NCC—New Collection Catalogue, both based on the same platform—XDams, an Italian open source software—able to work with Linked Open Data (LOD) and to manage different type of items according to standards—with the aim of:

- enrich the catalogue itself through the connection with the most common LOD resources;
- create a far more accessible catalogue with findable and reusable data for other institutions, scholars, and the public;
- gain a major interoperability among the museum heritage.

Key words: Linked Open Data (LOD), Museum collections, Scientific and technological heritage, Collections Management System (CMS)

1. Introduction

The National Museum of Science and Technology Leonardo da Vinci of Milan (hereafter referred to as "the Museum") is the largest science and technology museum in Italy. Founded in 1953 it preserves and valorises a unique scientific, technological and industrial heritage with: 19,000 artefacts, 50,000 books, 10 archives (5,000 archival units), 250,000 photos. Among its collection the Museum also holds about 500 artworks, and 150 interpretative models of drawings by Leonardo da Vinci, dating from the 1950s and representing the idea of an integrated interpretation

of culture [1].

When the Museum was founded, its entire heritage was created in a unitary vision, as a whole. With the development of new Museum's areas and exhibition sections and the renewal and implementation of its collections, today they are managed as separated groups.

Given the richness and breadth of its collections, the Museum is a reference point at national level for the recognition of the cultural value of the technical-scientific heritage in Italy. In fact, despite its richness and its long tradition, connected to important history of scientific research and industrial production, this kind of heritage struggles to be properly recognised, valued and protected.

Today the Museum aims to strengthen this role through a strategy based on two main elements, defined also by looking at international best practices and in general at common development strategies of cultural institutions in the world:

– Networking: defining the Museum as the main Italian hub for a scientific museums network, working together for the same goal, optimizing resources and increasing the impact of their projects
– Sharing: opening contents with findable and reusable data for other institutions, scholars, and the public

In collaboration with the National Academy of Sciences and the Sapienza University of Rome, in 2016 the Museum applied for and obtained a funding from the Italian Ministry of Education, University and Research, through which it was possible to launch an important work in this direction with the two projects:

– Portal for the Archives of Science and Technology in Italy (the Portal)
– NCC—New Catalogue of Collections

Given the important technological and web-oriented feature of the projects mentioned above, the choice was to adopt the XDmas platform [2], software developed by Regesta.exe, as it allows to work on key aspects for the realization of projects:

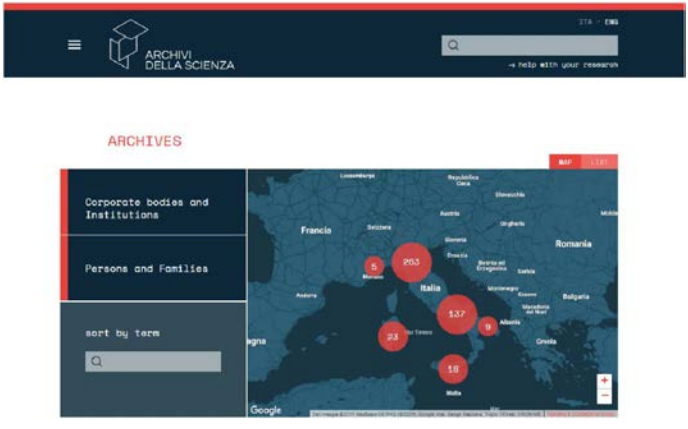
– Compatibility with national and international descriptive standards for archives and objects
– Flexibility in data and tools management
– Possibility of managing different types of collections in a unitary way
– Data output through LOD

The possibility of working with LODs was one of the fundamental aspects in this choice, not only from a technical point of view, but also from a strategic point of view. The use of LOD technologies for cultural heritage is important because it allows the Museum and project partners to improve, enrich and promote the dissemination of their information. The benefits are well known: usability, research, availability and interoperability of information, as well as the possibility of becoming an authoritative source of data that can be reused for other institutions, scholars, and the public.

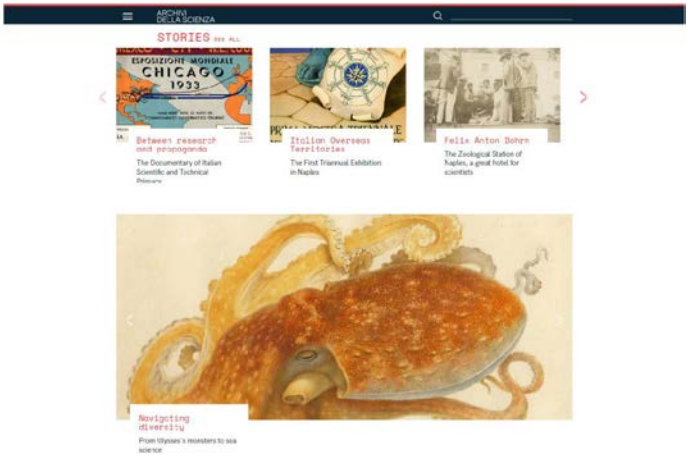
2. The Portal for the Archives of Science and Technology in Italy

Published in February 2019 [3], collects and gives access to over 1,500 archives of scientific research institutions, and personal papers of scientists, held in over 200 institutes throughout Italy, with information on content, chronological details, research tools, and accessibility.

It is an open web-based tool in which all interested institutions can participate. The archival information is entered directly by users, who can manage their own archives through the Portal. In this way data are immediately made available to the public and can be updated every time is needed. Each institution can guarantee the quality of the published information.



Picture 1 Archivi della Scienza Home Page—Archives Map



Picture 2 Archivi della Scienza Home Page—Stories

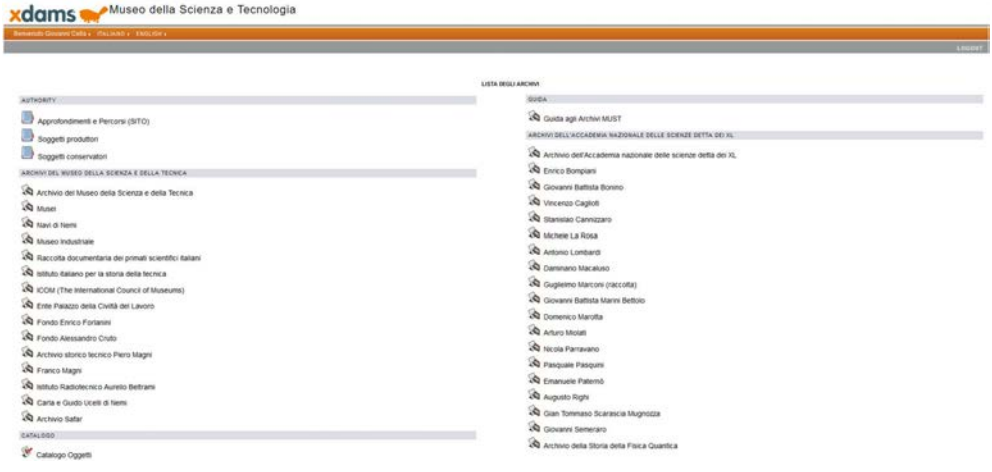
The Portal can also be enriched through the interconnection, via LOD, with: 1) the Italian National Archival System (SAN—Sistema Archivistico Nazionale) and its data about archival records, creators and institutions that own archives [4], and 2) the open data portal of Italian Ministry of Cultural Heritage and its data about cultural institutes or sites [5]. In this way the Portal represents the first national example of direct reuse of authoritative contents [6].

In the next few months, Portal's data—modelled using OAD ontology—will be available via a SPARQL endpoint [7–8]. When possible, for each creator and holder of archives triples alignment to VIAF and Wikidata are provided.

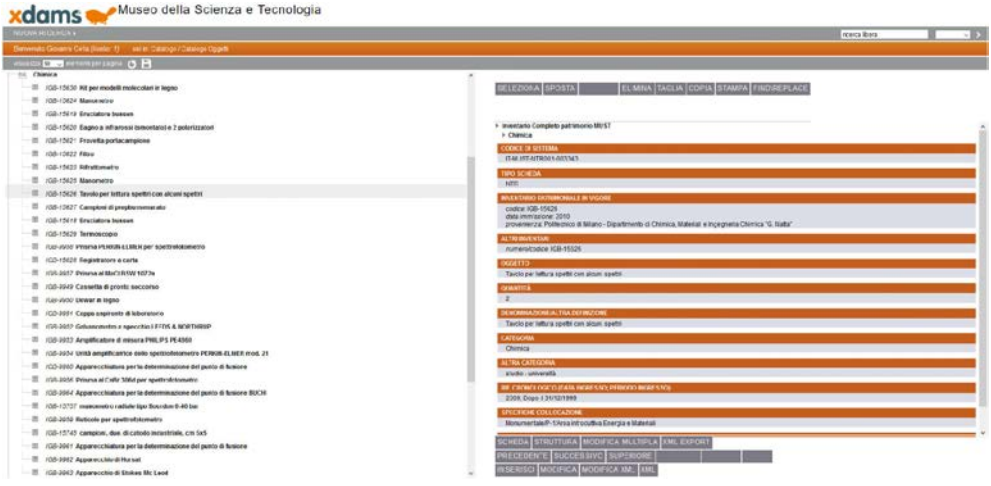
3. NCC—New Catalogue Collections

In September 2018 the Museum, along with the progress of the Portal project, started working at the NCC—New Catalogue Collections. NCC aims to create a unitary collection management system by providing a single point of access to its heritage. It combines the Museum's archival records already entered in the Portal, with the catalogue of objects, described following the national standards defined by the ICCD (Institute of Catalogue and Documentation), an institute belonging to the Italian Ministry of Cultural Heritage [9].

Until recently these standards were divided by type of object (works of art, musical instruments, technical-scientific assets, etc.), for each of which there were specific cataloguing data sets, without any correlation between each other. In November 2015, with an update in May 2017, the ICCD released the NTR—Normativa Trasversale [10] which, while leaving some data fields dedicated to the specific features of the different objects, groups together most of the cataloguing information in a unique data set.



Picture 3 Back-office of the XDams software platform software | Archives information and catalogue data



Picture 4 Back-office of the XDams software platform software | Catalogue list of objects and object main data

NCC data will be available via a SPARQL endpoint, using ArCo (Architecture of Knowledge) v1.0 ontology network, developed in a collaborative project that involves the ICCD and the Institute of Cognitive Sciences and Technologies of CNR (Italian National Research Council) [11]. This ontology represents all the information contained in the NTR and also the information peculiar to all the typologies of cultural properties, apart from naturalistic heritage. ArCo aims at modelling the wide domain of Italian cultural heritage for two main purposes:

– building a network of ontologies, compatible and aligned whenever possible with existing ontologies, that can be used as a de facto standard for representing cultural heritage data;
– publishing ICCD data as LOD: about 800,000 publishable files stored in a database, i.e. the General Catalogue, each describing a specific cultural property from diverse perspectives.

4. Arco ontology

ArCo ontology network consists of seven ontology modules connected by owl: imports axioms [12]:

The ArCo module (arco:) is the root of the network: it imports all the other modules. Moreover, it formally represents top-level distinctions for the Cultural Heritage domain.

The Core module (core:) represents general concepts orthogonal to the whole network, which are imported by all other ontology modules.

Denotative Description module (a-dd:) encodes the characteristics of a cultural property, as detectable and/or detected during the cataloguing process and measurable according to a reference system.

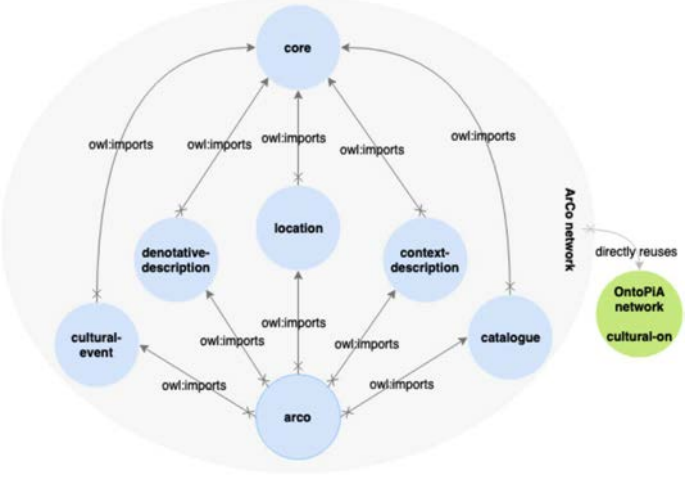
Context Description module (a-cd:) represents attributes that do not result from a measurement

of features in a cultural property but are associated with it.

Location module (a-loc:) addresses spatial and geometrical information. A cultural property may have multiple locations, motivated by different perspectives: history, storage, finding, etc. Sometimes they coincide, sometimes they do not.

Catalogue module (a-cat:) module provides means to represent catalogue records and link them to the cultural properties they are a record of. This module is based on the Italian General Catalogue of Cultural Heritage.

Picture 5 ArCo Ontology|Homepage of the documentation website



Picture 6 ArCo Ontology|ArCo v1.0 ontology network

5. Conclusions

Both projects (the Portal and NCC) therefore intend:

– To enrich the archival records and object catalogue itself through the connection with the most common LOD resources
– To create a far more accessible archives and catalogue with findable and reusable data for other institutions, scholars, and the public through LOD

The Museum wishes to continue the work started with the projects described here in the following directions:

– Mapping of LOD ontologies used in the projects with existing ontologies, increasing data connection at an international level
– Working on data sets interoperability, in order to study and research new connections inside the collections of the Museum
– Developing and sharing Thesauri for describing scientific and technological heritage
– Creating opportunities for reusing Museum heritage data in other digital tools (e.g. mobile app, video games …) inside and outside the Museum

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