Critical Assessment of Media Stations in the Permanent Exhibition of the Natural History Museum Vienna: Prehistory and Palaeontology

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Digital media and technical equipment both in temporary (special) and permanent exhibitions media illustrate and enable deeper insights into the content on display. For exhibition designers, it is a small line between useful media inserts and use of media that dominate the display over the original objects. Here some case studies about targeted media design and factors for the use of specific media in a museum are presented, including the long term perspectives for maintenance.

In the permanent exhibitions on Palaeontology and Prehistory of the Natural History Museum Vienna media of different kind are in use: Non-interactive systems like monitors embedded into the display cases or large interactive stations. The focus of the present evaluation were the interactive systems with haptic and tactile interfaces, photo boxes, and virtual activities empowered by a Kinect® system.

We examine the interaction between museum visitors and media: How are the installations used? How are people interacting with the stations? How much time do they spend at individual stations? Do different age groups of users react differently? Is there a difference between originally intended use and real use by the visitors? The assessments of media stations have been carried out in collaboration with external specialists, using the sociological methodologies of observation research and survey research with questionnaires.

At the Natural History Museum Vienna, the typical life span of a permanent exhibition is 15 to 30 years, due to the large number of exhibition halls and departments and funding. In contrast, the technical equipment in most media station has a life span of only 5 to 10 years. Therefore, media in a museum need constant maintenance, funds, and human resources.

Key words:
Exhibition, Natural History Museum Vienna, Media, Tactile and Haptic Interfaces, Evaluation.

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INTRODUCTION

The conference on Cultural Heritage and New Technology included a session about challenges and benefits of archaeological reconstructions in exhibitions, focusing onto a controversial discussion on the advantages and disadvantages of digital media use.

This contribution discusses the view of the scientists involved and staff responsible for maintenance of the media installations of two permanent public galleries at the Natural History Museum Vienna: Palaeontology (opened in 2001–2011) and Prehistory (opened in 2015). The aim of this study is to review, how media stations are developed in collaboration between scientists, exhibition designers, and media companies. We also critically assess how they are used by the visitors. In line with the focus of the CHNT-conferences on the advantages of the latest types of modern media, the long term perspective of media stations in exhibitions is discussed here. This also includes costs for maintaining, ageing of media, problems with functionality in “over-use” (e.g., simultaneous use by large user groups, like school children or thousands of visitors during special events like the Long Night of Museums).

Context: The Natural History Museum Vienna and the exhibitions Palaeontology and Prehistory

The "Natural History Museum Vienna" (NHM Vienna) was built in the second half of the 19th century and houses the natural history collections of the Habsburg imperial family. Opened in 1889, the museum was deliberately designed as "palace of natural sciences". One of the unique selling points of the museum is its historical ensemble. All aspects of visual art in the building – architecture, sculpture, painting – reflect the original conception as a museum and give reference to the collections originally intended to be exhibited in each room [Jovanovic-Kruspel and Schumacher 2017, 14–15, 128–185].

The earliest collections of the NHM Vienna are more than 250 years old [Jovanovic-Kruspel 2015, 13-22]. The NHM Vienna is home to more than 30 million objects (from botany, zoology, physical anthropology, mineralogy, paleontology, and archaeology). The museum's exhibition rooms [Ott et al. 2016] cover 8,460 square meters and present more than 100,000 objects which are shown in 39 large galleries.

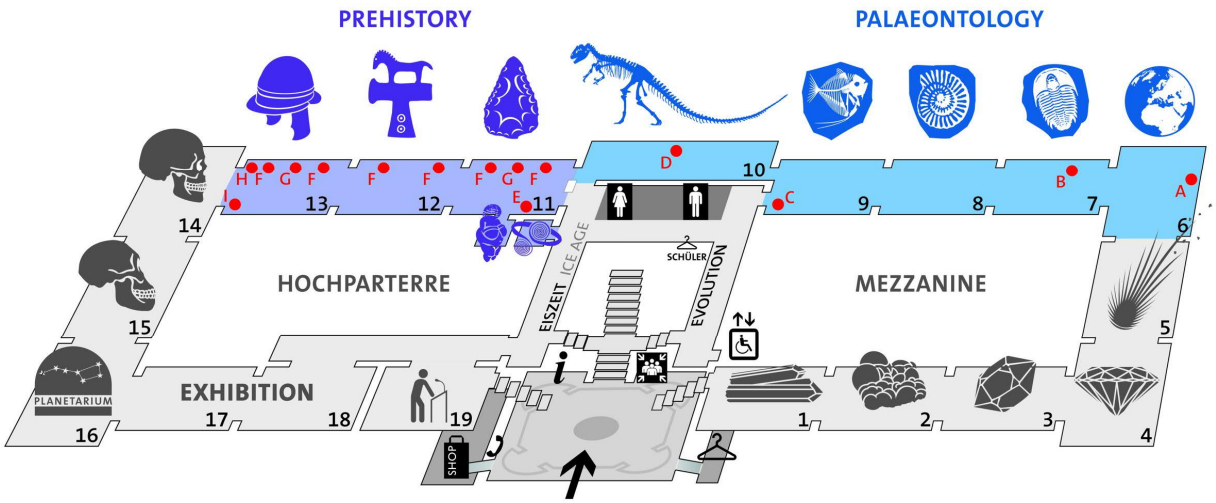

Fig. 1. Floor plan of the lower floor of the NHM Vienna, showing the location of the exhibitions on Prehistory and Palaeontology and the interactive media stations (red circles). A: Volcano Pump, B: Time Machine, C: Hippo Lab, D: Dinosaur Puzzle, E: Cave Monitor, F: Citation Show Case(s), G: Highlight Finder(s), H: Virtual Changing Room, I: Migration Station

The central theme of the exhibition **Geology and Palaeontology** (Halls 6–10) [Harzhauser et al. 2004] is the evolution of life and its interaction with Planet Earth (Fig. 1). Only a small portion of the ca. 3.5 million specimens housed in the scientific collection of the department [Harzhauser and Kroh 2018, 516] are shown in the exhibition. Starting with the birth of the solar system the exhibit shows 4 billion years of Earth's history and important steps in the evolution of life. Hall 6 [Harzhauser and Kroh 2009] is dedicated to the interaction between the lithosphere and the biosphere. The Volcano Pump allows visitors to explore effects of eruptions and the GaiaSphere allows a unique view on Earth from Space.

In Hall 7 early organisms from the Precambrian and Palaeozoic eras are shown, both as original fossils and in form of reconstructions and dioramas. An interactive station called "Time Machine" [Harzhauser and Kroh 2011, 92] visualizes the movement of continents through time and even allows a glimpse into the future of Earth. The Mesozoic Era, the age of the dinosaurs, is the topic of Hall 8, with the evolution of marine animals and terrestrial plants exemplified by exceptional fossils. Hall 9 presents Cenozoic fossil faunas and floras that visibly look more familiar to modern animals and plants than those shown in the previous halls. The "Hippo Lab" [Harzhauser and Kroh 2011, 92] illustrates the evolution of horses and the tight interconnection between changing environments and evolution.

In the Dinosaur Hall (Hall 10) original fossils, historical skeletal casts and live-sized reconstructions of dinosaurs and other Mesozoic reptile groups are displayed [Harzhauser et al. 2011, 2017]. An animated Allosaurus and the interactive Dinosaur Puzzle are magnets for the younger visitors.

The halls dedicated to Palaeontology and Geology were developed over the course of several years between 2001 and 2011 and opened successively. Exhibition and animation techniques have progressed considerably during that time. Most interactive stations and 3D animations in this part of NHM Vienna have been developed in collaboration with our external partners, checkpoint media and 7reasons.

The permanent exhibition of the **Department of Prehistory** (Halls 11–13, Venus and Gold Cabinet) [Grömer and Kern 2018] is the only one at the NHM Vienna with a main focus on human cultures.

Hall 11 traces the beginnings of human culture, starting with the Neanderthals and early modern humans who lived as hunters and gatherers. Further milestones in human development include the first farmers of the Neolithic, the earliest use of metal during the Copper Age as well as changes in society during the Bronze Age. Hall 12 is dedicated in its entirety to the UNESCO World Heritage Site Hallstatt in Upper Austria with its 7000 years of mining history and name-giving for the Early Iron Age in Central Europe with its famous salt mine and cemetery. Hall 13 is home to objects dating from the Late Bronze Age, the Early and Late Iron Age, as well as the first millennium AD – the two millennia of technological, cultural, and social changes during which the foundations of today's Europe were laid. The Gold Cabinet contains several highlights including the gold discs from the Stollhof Hoard, which are amongst the oldest gold objects in the world, while the Venus Cabinet offers a home for two world-famous Stone Age exhibits: the Venus of Willendorf and "Fanny" the dancing figurine from Stratzing.

This permanent exhibition was opened in September 2015 and its media stations have been developed between 2013 and 2015 in cooperation with the media company 7reasons in Vienna.

Who is the audience?

The different disciplines present at the NHM Vienna – botany, physical anthropology, zoology, geology, palaeontology, mineralogy, and archaeology – enable to reach a wide audience of up to 750,000 visitors each year [Köberl and Kritscher 2017, 75-77]. Visitors come from various age groups and education levels, ranging from children to adults and from non-experts to scientists and academic groups.

Nevertheless, the museum is a classical "family museum" – more than half of the visitors are under the age of 19. The young visitors are on the one hand coming with their families – but more often in kindergarten and school groups, the latter mostly within the framework of school education.

CHALLENGES FOR MEDIA DEVELOPMENT

The exhibitions at the Natural History Museum are housed in a historic building and as consequence of heritage law and the policy of the museum, the historic ensemble is to be preserved (as it is part of the unique feature of the NHM). This creates unique chances, but also challenges. Where preserved, the historical show cases are re-used when renewing exhibition rooms (e.g. Halls 11 and 13). Dating back to the 19th century, these show cases were not designed to include electric light or ventilation necessary for dissipating the heat radiating from light bulbs or screens built into the show cases. Likewise, these show cases were designed for Victorian-area style of exhibitions that focused on presentation of large numbers of objects but did not necessarily provide space for explanatory texts or graphical information. This is in contrast to modern exhibition design which typically involves a reduction to a much lower count of representative objects that are accompanied by ancillary information, enabling story-telling in order to help the visitors understand the relevance of the exhibited objects. Preservation of the historical ensemble also dictates how and where modern media can be included in the exhibition, since we do not want them to dominate the design and thereby destroy the historical atmosphere of the galleries.

Here we are discussing the use of media in the galleries, which display Palaeontology and Prehistory: the evolution of the life and early cultures. Decisions about the display of objects and contents in those rooms are driven by various factors. The choice for certain types of media is an important factor in exhibition design (Fig. 2). The main factor revolves around objects and storytelling, followed by the needs of the users and the choice of external partners.

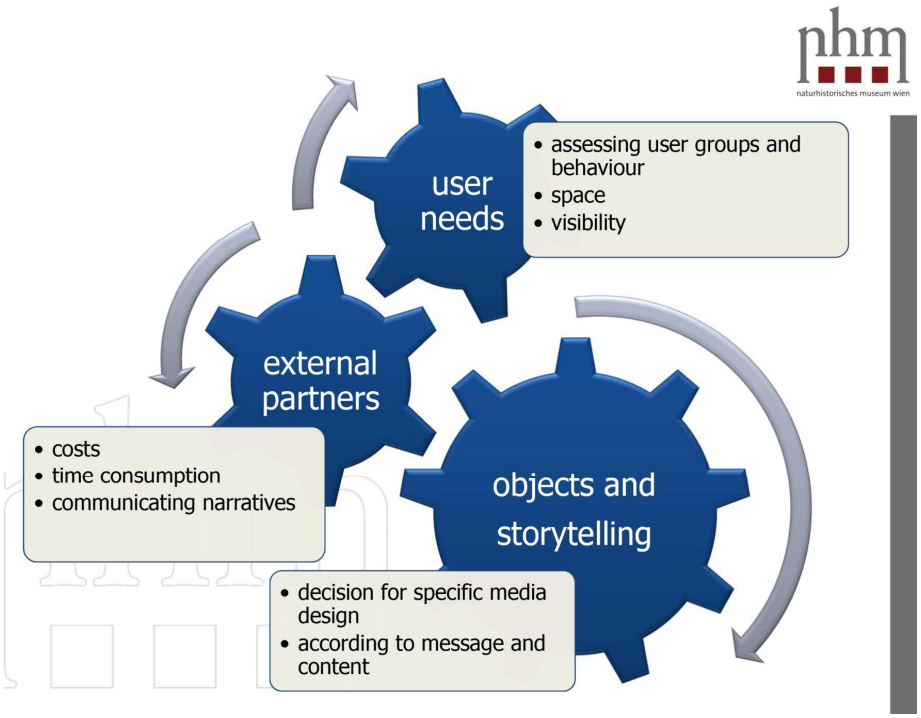

Fig. 2. Factors for display decisions

To exemplify this with the display for Prehistory [Kern 2018, 20-23]: Which objects and narratives should be presented to the public and what message should the exhibition convey? The aim was to show highlight objects such as the Venus of Willendorf, one master-piece of early art and 29500 years old and to inform about cultural and technological developments of mankind with facts that concern us till today like agriculture or bronze casting. There is also a need to address stories of contemporary significance such as identity, resource management, or migration. A key principle at the Natural History Museum of Vienna and one of its unique selling points is the "magic of the original". That is to let the original artefacts speak for themselves, as such, specific care needs to be taken that the media stations do not "cover" or "override" the original objects. The decision for specific media design must therefore be selected according to the content and the "message".

The assessment of user needs is vital for a successful museum. One consideration here is the issue of available space: how much space is necessary for a particular type of media station and the visitors using it? This has to be assessed in relation to the space available in the exhibition hall. Visibility is also an important factor: what are the needs of the visitors, the museum guides, or the scientists designing the exhibit? For targeted media design it is important to have a good assessment of user groups and user behaviour [see e.g. Sovis 2019].

When working with external partners, animation companies, software developers, and media designers, different aspects need to be communicated. Foremost, the external partners need to understand the narratives to be told. Consensus, furthermore, has to be reached on how to fill the "gaps" of knowledge for animations (e.g. the colour and structure of dinosaur skin; visual aspect of the prehistoric landscapes). It is also important to communicate the needs of both the scientists and the visitors to the external partners. Construction time and costs are further important factors that need to be taken into account.

Case studies: Media in permanent exhibitions at the NHMW (Palaeontology and Prehistory)

Combining real objects with state-of-the-art multimedia stations is an important focus for the permanent exhibitions at the Natural History Museum Vienna. Such an approach is expected to both give visitors new insights into the topic addressed and to bring objects to live. Depending on the message to be told in the exhibition, different media types are used [see Kern 2018, 23; Harzhauser and Kroh 2009, 44–48].

Types of media used (Palaeontology and Prehistory)

Non-interactive systems:

- Monitors embedded into the display cases
- Large projection on a 3D terrain model (model of the Hallstatt High Valley; Hall 12)
- Dome projection on a curved screen (GaiaSphere – simulating a view of Earth from Space; Hall 6)

Interactive systems:

- Tactile interfaces (touchscreens): Dinosaur Puzzle (Hall 10), Citation Show Cases (Halls 11–13), Migration Station (Hall 13)
- Photo box: Virtual Changing Room (Hall 13)
- KINECT system: Cave Monitor (Hall 11)
- Haptic interfaces: Volcano Pump (Hall 6), Time Machine (Hall 7), Hippo Lab (Hall 9), Highlight Finder (Halls 11 & 13)

Non-interactive systems like screens or projections have been among the first digital media types to be established in the NHM Vienna almost two decades ago, like also in other museums such as the Louvre, the Museum of London or the Museum of Scotland [Economou 1999, 2003; Copley 2010]. The clips shown at the NHM Vienna typically run in a permanent loop. The videos and animations are intended to show aspects no readily visible in the preserved and displayed object, and to support storytelling.

Fig. 3. Dinosaur Puzzle Station in Hall 10 (image: K. Grömer)

More recently, interactive systems were added when new exhibitions were created, which will be the focus of further discussion in this contribution. The interactive stations at the NHMW range from classical haptic interfaces where the visitors can push a button or turn a wheel to influence the display, to touchscreen interfaces. Both types of interfaces have advantages and disadvantages: the former are more expensive in development, but very sturdy in the long run, while the latter allow for more flexible interaction and are less expensive, but prone to malfunction from a variety of reasons.

Tactile interfaces with touchscreens are among the media widely found in numerous museums. In terms of handling they are more or less timeless, only the content (and presentation design) needs to be updated. In the exhibitions on Palaeontology an example can be found in Hall 10 (Dinosaur Hall). There a game called “Dinosaur Puzzle” (Fig. 3) allows visitors to test their skill in comparative morphology and assign bone to two different types of dinosaurs (a herbivorous Triceratops and a carnivorous Allosaurus). Completion of the game is rewarded by a virtual walking dinosaur model that can be turned and manipulated (switched from a life-like animation to a skeleton reconstruction) to further explore dinosaur morphology. More educative than playful are the tactile interfaces used in the exhibition on Prehistory. The so-called “Citation Displays” in Halls 11 and 13 use a classical touchscreen to inform about general outlines of important steps in mankind and provide an introduction into achievements of certain time periods. The Migration Station in Hall 13 shows the waning and waxing of cultures and peoples very clearly through animations, as well as the transience of empires and changes of borders over the millennia.

Fig. 4. Virtual Changing Room in Hall 13 (image: K. Grömer)

A special interface is used for the Virtual Changing Room in Hall 13 (Prehistory), a photo box station (Fig. 4). The design is intended to resemble an actual changing room. It includes a big screen, which enables visitors to virtually dress up (in one of 20 prehistoric costumes). They are able to select between costumes that have been reconstructed after original artefacts on display. Available are costumes for women, men, girls and boys from Bronze and Iron

Ages, Roman period and Early Medieval, covering a time-span from 2000 BC to AD 800 [Grömer and Kern 2018, 32–33]. A photo can be made of one's own face and manipulated to replace the face of the virtual person presenting the costume. Once finished, the picture can be sent home via E-mail. It is accompanied by archaeological background information explaining details about the costume chosen.

A different type of interface was chosen for the Cave Monitor in Hall 11 (Prehistory) (Fig. 5). There a KINECT system enables visitors to explore Ice Age cave paintings from UNESCO world heritage sites like Lascaux, Altamira, and Grotte Chauvet [Antl 2018, 68–69] with a virtual torch. KINECT(R) systems are typically used for gaming consoles and allow interaction by gestures without actually touching the screen.

Fig. 5. Cave Monitor in Hall 11 (image: A. Schumacher)

Fig. 6. Highlight Finder in Hall 11 (image: A. Schumacher)

In contrast to the touchscreen and KINECT® system interfaces, haptic interfaces require sturdy design to survive thousands of interactions in real world usage. Such interfaces are employed to provide a direct tactile feedback to the visitors supporting the reception of the message to be conveyed by the respective interactive station and to provide for variety in the type of interactive station used. The haptic interfaces used in the Highlight Finders in Halls 11 and 13 (Fig. 6) represent an interactive navigation system allowing visitors to discover outstanding objects. Small accompanying video clips provide additional detailed information about the artefacts and the respective historical contexts. A major challenge for the development of these stations concerned the selection of the information (pictures, texts) included according to the level of the audience (small children, families, adults with some background knowledge).

In the exhibition Palaeontology, three different haptic interfaces are employed in the media stations on display. The Volcano Pump in Hall 6 (Palaeontology) visualizes local effects of volcanic events in a model of prehistoric Vesuvius and shows the global effect of volcanic ash injected into the atmosphere by such an event. The haptic interface used is a stainless steel pump where visitors can interactively increase the pressure in the magma chamber and experience the pressure drop as the volcano erupts (Fig. 9). The Time Machine in Hall 7 (Fig. 7) shows the continental movement and the changes of the appearance of the planet earth through time [Harzhauser and Kroh 2011, 92]. Visitors control the timeline of events by turning a large steering wheel designed to resemble an abstracted steering wheel of a ship. This design enables also the usage of the machine during guided tours, allowing the tour guide to turn the wheel while facing the group and explaining the events happening during the animation. The Hippo Lab (Hall 9) illustrates the evolution of horses and tries to convey the message that evolutionary changes are linked to external factors such as the environment or nutrition. Users can experience this by turning one of the cogwheels controlling e.g. vegetation, which causes the other cogwheels representing among else body size to change as well.

Fig. 7. Time Machine in Hall 7, overview and space needed (images: K. Grömer and A. Kroh)

Fig. 8. Migration Station in Hall 13, overview and space needed (images: K. Grömer and A. Kroh)

When planning interactive stations, the positioning (visibility) and available space are crucial (Fig. 7-8). If a station is hidden from view behind other showcases, few visitors will notice and use it. Stations that are intended to be used during guided tours need special attention during planning. An example is the Time Machine in Hall 7 (Palaeontology). Despite its age (dating from 2004), it is one of the most popular media stations and is also extensively used during guided tours. This usage was anticipated during planning and room for 20 to 25 people (size of a school class) was left free in front of the station (Fig. 7). The haptic interface, a steering wheel, was designed in such a way that it can be controlled blindly by the guide while explaining.

Usage by large numbers of visitors, often simultaneously constrains the type of interface used. It needs to be sturdy and able to cope with multiple input. Stations designed for the use by single visitors or small groups (families) need less space such as the Migration Station in Hall 13 (Fig. 8). Here the planners have more choices in terms of interfaces. Most touchscreen interfaces are limited to these types of stations because they usually cannot cope with conflicting input from dozens of users.

The Highlight Finders in Halls 11 and 13 (Prehistory) act a bit like first person shooters, allowing visitors to trace a cross-hair across the room that lights up when it passes a particularly interesting object hidden in the museum displays, such as an elaborated belt hook from the Celtic sanctuary Roseldorf. When the cross-hair remains focused on these objects, the Highlight Finder displays additional information for that object, including short video clips (Fig. 6). Usage of these stations is intuitive for the majority of the visitors, but many expect an added touchscreen functionality that does not exist.

The Volcano Pump in Hall 6 (Palaeontology) is an unusual haptic interface (Fig. 9). Built like a tire inflator, it allows to build up pressure in the magma chamber of a volcano to make it erupt. The construction was a challenge, because we wanted the visitors to feel the increase of pressure. This was achieved by using industrial pneumatic components like they are used in assembly lines. How strong this effect can be was dictated by the "law of the lever" (*Hebelgesetz*). A compromise was needed between an effect that still can be felt by adults and force that children can still handle. Strong wear necessitate a complete re-design of the mechanics after only two years.

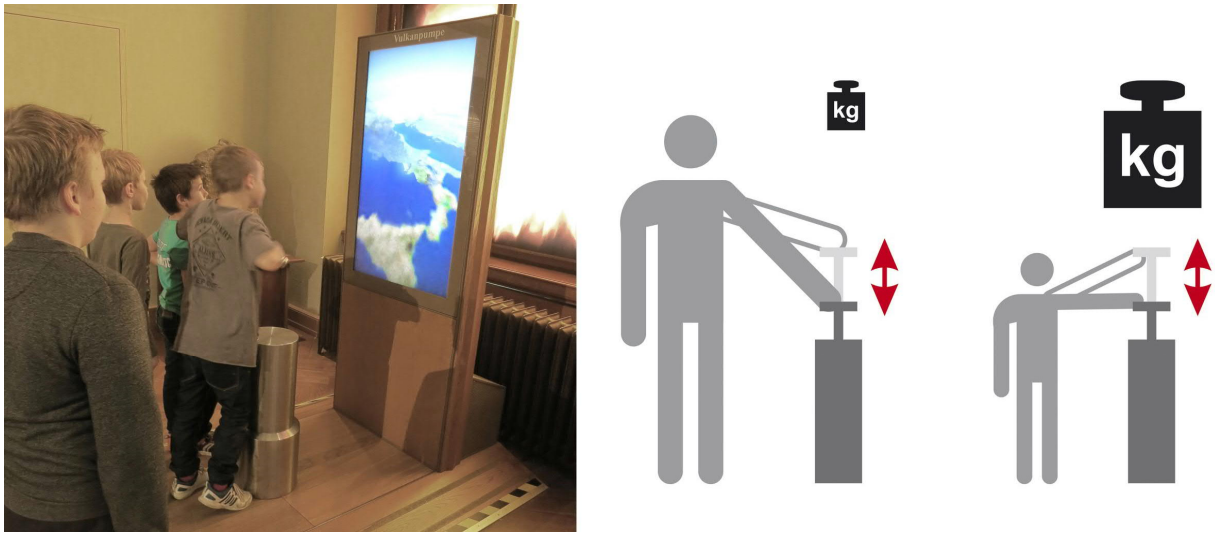

Fig. 9. Volcano Pump in Hall 6, overview and force needed to use it (images: K. Grömer and A. Kroh).

Assessments of media stations

Often visitors use media stations in a different way than planned by the exhibition designers. An interesting example for such a situation could be observed in the Moesgård Museum during a visit in 2018. The Moesgård Museum was recently re-built and features an excellent exhibition with numerous media stations. One of these is intended to

explain usage of different arrow head shapes, which depending on the prey and its use were differently shaped[1]. Visitors can select one of three different arrow types, pull and release it. After the arrow hits the animal there is a short animation, explaining, for example, that club shaped arrow heads were used for furry animals in order to not damage the hide. During our visit, however, few visitors seemed to pay attention to the information text displayed after the animation, eagerly pressing the Home button in order to shoot again.

In order to gain deeper insights into the usage of the interactive stations by the visitors of the Natural History Museum Vienna, assessments have been run. In these, we study the interaction between museum visitors and media, and assessed user group composition and user behaviour. The results support the planning of future media stations and decisions regarding refurbishment or replacement.

In the year 2018, two studies about media stations in the permanent exhibitions Palaeontology and Prehistory have been carried out [Plaß 2018; Sovis 2019]. Both have different research-settings, employing both qualitative and quantitative techniques of sociology research [Ashley and Orensten 2005; Macionis and Gerber 2010, 40–42]. The first [Plaß 2018] has been an assessment by students of a specialized college of Elementary Pedagogy, who did observation research on museum visitors (assessment by observing visitor behaviour without getting into direct contact with them). The second study [Sovis 2019] was run as a seminar for students of the Vienna University for Economics and Business. In the course of the seminar a questionnaire was developed and a study was carried out as survey directly contacting the museum visitors. Those two kinds of visitor assessment – observation and survey research – are common among sociological studies of museums [e.g. Baumann 2000].

Observation research of museum visitors

The assessment about visitor behaviour in observation research technique [Macionis and Gerber 2010, 40–42] by Sophie Plaß from Elementary Pedagogy and four students in August 2018 resulted in statistical data (300 data sets) about visitors use of modern media in the permanent exhibitions Prehistory and Palaeontology [Plaß 2018]. In a first step, for 2 weeks the museum visitors were observed by the researchers to study their behaviour with different media stations. User behaviour was documented using standardized data sheets and care was take to collect equally distributed data for the different media stations selected (Dinosaur Puzzle, Time Machine and Volcano Pump in Palaeontology; Citation Display, Migration Station, Highlight Finder and Changing Room in Prehistory). Data collected included:

- Who is using the station (age, gender, groups, single persons)
- How it is used; what people are doing?
- Is there a difference between originally intended use and real use by the visitors?
- Duration of stay: How much time visitors spend at the stations?

In a second step, the same group of researchers also assessed the frequency of use of certain media stations within a defined time-span. For this, the proportion of visitors using the station surveyed was counted in relation to the number of visitors in the exhibition hall.

Statistical analysis of this assessments highlighted that the user groups differ depending to the type of the media station surveyed (Fig. 10 left). Specifically, the Dinosaur Puzzle in Hall 10 and the Virtual Changing Room in Hall 13 turned out to be “fun stations” used by whole families. The Citation Displays and the Migration Station, in contrast, attracted more single users, probably due to the fact that they require a more intellectual approach and are rich in textual information. In case of these stations, the visitor behaviour observed at these stations match with the original intention by the scientists and exhibition designers during the design state. Occasionally, misuse of media stations could be observed: for example, the Highlight Finders in Hall 11 and 13, or the Time Wheel in Hall 7 sometimes are used as climbing device – to our surprise this behaviour was not restricted to the very young visitors only.

Results on the duration of stay show a distinct pattern (Fig. 10 right). Most visitors spend around 2 minutes at a station. This also applies to media stations that offer much more content than could be explored in this short period of time (e.g. the Citation Display).

[1] https://en.natmus.dk/historical-knowledge/denmark/prehistoric-period-until-1050-ad/the-mesolithic-period/the-stone-age-hunters-bow-and-arrow/

Considering usage of the stations, the survey showed very clear results. Some of the stations are very popular, particularly the Changing Room and the Volcano Pump. These are stations with a high fun-factor and very limited amount of textual information and are apparently well used because they offer a welcome respite from the usually text-rich information presented in the traditional show cases.

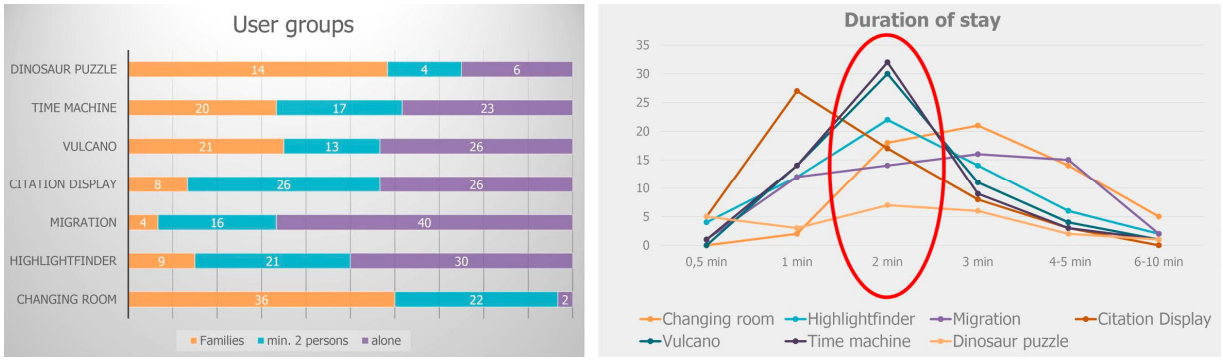

Fig. 10: Assessments of Media stations, observation research (2 weeks observation). Left: assessment of user groups (Question: "Who is using the station?"); right: duration of stay (Question: "How much time visitors spend at the stations?") (images: S. Plaß and K. Grömer)

Survey research with questionnaires

The survey research with questionnaires [Macionis and Gerber 2010, 40] by Wolfgang Sovis and his students from Vienna University for Economics and Business went in another direction [Sovis 2019]. The researchers gathered data using more than 300 interviews based on a questionnaire developed specifically for the survey of the usage and acceptance of the media stations in the NHM Vienna – exhibitions Palaeontology and Prehistory. To compare the results of the two different assessments, the same media stations have been in focus.

The questions included (next to basic demographic data) how often the particular visitor has been at the NHM Vienna and if a guided tour has been booked. According to the media stations it was asked about the visibility of the stations and their usability (is it understandable how to use it, is it interesting, entertaining, educative, visual appreciating and user-friendly?). The data sets have then be analysed statistically using cluster analysis methods as commonly used in sociology.

A clear result from the survey (Fig. 11) was that usage of some media stations are not well understood by the visitors. This is exemplified by the interaction with the Cave Monitor in Hall 11. Handling of this fascinating station turned out to be non-intuitive for many visitors and the station often remained unnoticed because people did not recognize it as an interactive station, but considered it simply as a backlight board with explanations. Another result is also that according to the comments by the visitors, some of the media stations would benefit from more extensive explanations on how to use them, e.g. the Highlight Finder.

Some of the questions also asked for the placing of media stations. The results show that both the Dinosaur Puzzle and the Migration Station have been missed by the visitors as they are placed on more or less hidden places in the room or not readily recognizable as interactive stations from afar. Media stations like the Volcano Pump, the Time Machine and the Changing Room have been voted by the visitors as the most popular ones – this is not only caused by their prominent placement in the rooms (good visibility), but also due to their content, their usability, and the "fun factor".

The questionnaire also was aimed to assess acceptance of future trends by the visitors. For example, people were asked on their opinion on a possible Virtual Reality Apps. Many visitors were in favour of such an app and indicated that they would make use of it. They, furthermore, indicated that such an app would be a good way to visualize more complex objects (e.g. from Prehistory) and to clarify their function.

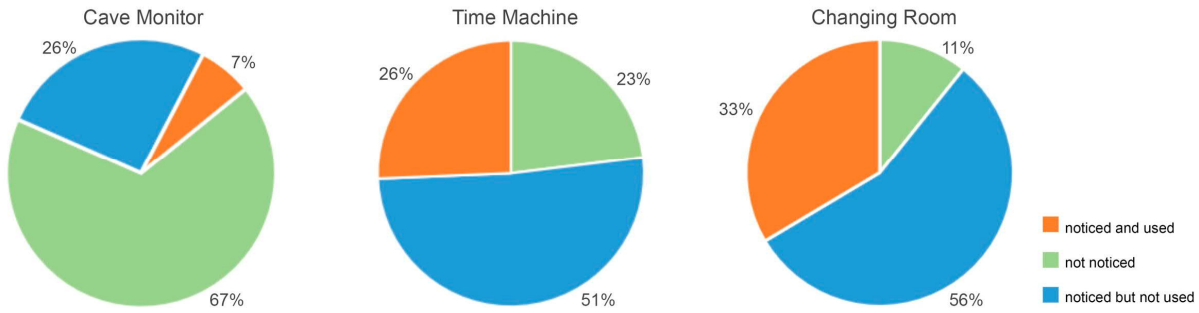

Fig. 11. Results of the questionnaires, visibility and use of three selected media stations [after Sovis 2019]

Long-term Perspectives

When planning exhibitions it is commonly forgotten that media stations do not represent a one-time investment only and need constant maintenance and resources, both human and monetary. Developing exhibition media is very time consuming and, therefore, expensive. The installations are developed using technology available at that specific point of time. Technical progress, however, is rapid. Specifically in the field of 3D animation, products age rapidly. Likewise, the media stations themselves are ageing and after a few years the software used may no longer be supported by the producers and replacement for hardware, as well as skilled technicians may be difficult to come by. Intended lifespan of permanent exhibitions at the NHM Vienna typically is 15 to 30 years. With few exceptions, media stations have a much shorter life cycle. In our experience, IT hardware of media stations typically needs to be replaced every five to ten years and 3D animations tend to appear old fashioned after at least ten years (even much earlier). This shorter life expectancy of media stations needs to be factored in when planning permanent exhibitions and both staff for maintenance as well as funds for replacement need to be set aside to guarantee long-term function.

Common problems that have been observed are:

- Wear and tear of mechanical components
- Ageing of electronic components
- Ageing of CGI effects (rapid progress in the field of 3D animation)
- Loss of manufacturer support (software and hardware)

Interactive stations in a big museum are typically employed in a highly stressful environment. Apart from normal ageing, long run times and increased levels of dust lead to heating up of electronic components and shorten the life spans than experienced in home or office use. Also misuse of mechanical components as observed in the assessments of media stations [Plaß 2018, 2–3] and over-use with touchscreens cause technical problems. Few touch interfaces can cope with the simultaneous input e.g. of a whole school class of ca. 25 children. At special occasions, e.g. Long Night of Museums in the beginning of October each year, 15.000 people visit the NHM between 6 pm and midnight [Köberl and Kritscher 2017, 32] [2]. Such events represent a challenge for the media stations (and the technicians responsible).

Furthermore, 3D animations in media stations created with limited museum budgets, cannot compete with Hollywood productions or modern video games. Such museum 3D animations typically show their age quickly – an animation that looks good today, may look dated in 5 years – due to permanent technical advances graphics, animation or surface rendering employed in commercial film production and advertisements.

For future exhibitions where media stations with scientific content have to be developed, the insights gained from the visitor assessments are of interest [Plaß 2018, Sovis 2019]. The user needs and preferences, especially their mean duration of stay have to be taken into account. On media stations with a high load of scientific input in form of texts, clearly, few visitors make use of the full content offered. Such great effort spent on the creation of additional content for a single media station might not return the intended attention. Instead, it seems best to place a higher

[2] https://langenacht.orf.at/

effort on the quality and ease of access than on the sheer amount of information incorporated in a single media station.

Three examples from the museum furthermore serve to illustrate unexpected challenges. As mentioned before, due to unexpected wear, the mechanical system of the Volcano Pump had to be completely replaced after only two years of use. A complete re-design of the system was needed in order to mitigate wear in future usage.

The Dinosaur Puzzle was prone to crash or freeze from sensory overload when a whole school class tried to play the game at the same time. Bread crumbs dropped by visitors created fake touch input. Both issues could only be solved when the touch screen had to be replaced due to its end-of-life. The chance to a more resilient touch technology, however, necessitated complete revision of the software because tactile input is registered differently by different systems (some register an interaction when a finger is places on the screen, others when it is lifted from the screen, for example).

The Citation Show Cases, in contrast, may freeze when ambient temperature is high in summer and heat expansion causes loss of contact between the overlying glass surface and the touchscreen.

Each time a major problem arises, some careful evaluation is needed if a station can be repaired or should be replaced. In this decision making process, the results of the visitor assessments are very useful. This applies, for example, to the Volcano Pump, that had to be replaced to better technical standards several times. Identification as one of the most popular stations in the visitor assessments [Plaß 2018, 2; Sovis 2019, 17] supports the decision for continued updating of the station.

The assessments by the Vienna University for Economics and Business [Sovis 2019, 99–100] also argued for using novel media like Virtual Reality (VR) Apps with additional information, 3D animations, and augmented reality. These media, however, often require extensive investments both during installation and for continued operation. Many impressive VR systems are not suitable for unattended usage and require permanent supervision of the stations by personnel. In addition, like most visual digital content such media are prone to rapid aging and need constant updating to stay attractive.

In a future perspective, the NHM Vienna aims to include novel media for science communication [Hantschk et al. 2016] within the exhibition rooms. Ideally, content developed for these media can also be presented in World Wide Web (e.g. Google 360° view, online visit of the museum rooms: [Ott et al. 2017]), and form part of online exhibitions.

CONCLUSIONS

This study deals with modern media for permanent exhibitions. It discusses the perspective of the scientists involved and the staff responsible for maintenance. It also provides insights into the collaboration with external partners, the assessments of user needs and long-term perspectives gained from two decades of usage of media stations at the NHM Vienna.

To conclude, in the permanent exhibitions on Palaeontology and Prehistory the media stations are intended to support storytelling. They are designed in such a way that they do not dominate over the original objects. A critical assessment of media stations in use at the NHM Vienna shows the importance of accounting for their shorter lifespan in contrast to traditional museum exhibitions when planning permanent exhibitions. The planning stage is crucial for the later success of a station, although it is hard to predict how visitors will interact with any given station. Both, the observation data and the answers to questionnaires indicate that the attention span of the visitors is very limited. The amount of textual content included in an interactive station needs to be adapted to the typical short usage time by most visitors. Additionally, long-term perspectives need to be carefully considered during planning stage – media stations need constant support and resources, a factor commonly underestimated, which can cause issues to keep them functional over the whole lifetime of an exhibition.

A key conclusion of years of museum experience is that long-term maintenance costs for multi-media stations can be substantial. It is important therefore to account for his costs in annual budgets in order to insure operability of the stations for the lifetime of the exhibition.

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Digital First? Saving Digital Worlds, Artefacts and Inhabitants

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This paper offers observations on the state of *"digital first"* preservation efforts in the *"digital ecosystem"* and sheds light on their place in the context of the digital Sciences and Humanities. It showcases approaches taken by different actors, identifies important but neglected challenges and offers some ideas for future "digital first" preservation approaches.

In the context of this paper *"digital ecosystem"* encompasses beings ("users"), material things and content related to "digital" aspects and is defined by the author as "all infrastructure (hard- and software), especially the critical components, used in the operation of the global systems of interconnected computer networks that users interact with and the signals that can be sent, stored and /or exchanged through it".

"Digital First" in the title refers to digital information and artefacts in the digital ecosystem that "originate in and have characteristics that can only fully exist in the context of a digital environment".

Key words:
Digital Archaeology, Digital Humanities, Computer Games, Digital as Primary Source, MMO.

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INTRODUCTION

While digital tools are widely used in the digital Sciences and Humanities (e.g. [Hausar 2016]), the "Digital" as an ecosystem where purely digital artefacts including the context and the "worlds" they exist in need to be experienced, recorded, reconstructed and reactivated for posterity is a minority view. With parts of the digital ecosystem not clearly defined but in some cases treated like state-territory, where purely digital artefacts can be created and also be stolen – with real-life criminal law repercussions – the question of preservation of those artefacts is paramount for digital archaeology and history. The sheer amount of data produced every year (1,7 MB of data every second [Domo 2017]), the different actors involved and the fast advances in digital technologies make it a daunting task.

Even using bridging technologies like (3D-)printing, a digital artefact can seldom be recreated in a physical form that closely resembles the digital, as sometimes it is a mere copy of the form without the (full) functionality. These "digital first" objects can best be recreated in a digital environment.

It only gets more complex if we think about whole digital spheres like web-portals, social networks or – even more complex – "Massive Multiplayer Online Games" (MMOs). The recreation process needs the emulation of the necessary hardware, the server-side software and (emulation of) the input devices. It further needs all the historical user interaction data with each other and the software. Only then can an artefact be adequately recreated and researched. Finally access to this recreated artefact is reliant on preserving or emulating the digital infrastructure. As preservation efforts often operate under constraints, emulations using modern technologies (e.g. emulating the DOS operating system in DOSbox, a software running on modern computers) offer an adequate compromise in some cases.

While there seems to be consensus on *what* is needed to preserve digital artefacts, the question of *who* should finance, coordinate and lead the preservation effort is still contested. While national libraries in principle would have the legal foundations to archive digital content (e.g. [Austrian National Library 2019]), they do lack financing and a clear political commitment. That leaves preservation efforts for now mostly in the hands of private enterprise (e.g.

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Google Books[1]), non-profit organizations (e.g. Internet Archive[2]; Project Runeberg[3]; Project Gutenberg[4]; eLibrary Projekt[5]), museums (e.g. Computerspielemuseum[6]), universities and educational institutions (e.g. alo – Austrian literature online[7]; phaidra[8]) and individual archivists. While there is some cooperation especially in the case of digitalization of corpora, there is still not enough done on preserving "digital first" artefacts.

DIGITAL FIRST ARCHIVES: WHY, WHAT AND HOW?

Former "Society of American Archivists" (SAA) president David B. Gracy II, when commenting on the use and necessity of archives in 1987, pointed out, that

> *"archives, like deposits that archaeologists dig up, are documentary remains of the past pulled together and preserved for use in the future. (…) The greatest service of archivists is contributing to the continuity of culture by stimulating connections between the useful information from the past and the challenging needs of the present. (…) Archivists serve not only contemporary (often transient) needs but also the possible needs of the researchers in the far-distant future"*
>
> [Gracy II 1987]

Judging by the intent that is documented in laws in countries around the globe (e.g. laws regulating national libraries or limiting copyright), this obligation of preserving for the public good is still a duty today.

While this idea is well established in digital scientific and cultural endeavors, digital industries and – to a certain extent – private users, too – do not always see preservation as an important goal. James Newman, in one of the few early works on digital game preservation, argues that this lack of focus is due to the fast-paced nature of the creative market and a medium that has strong characteristics of obsolescence and supersession [Newman 2012]. This adds an additional layer of complexity to preservation efforts.

All digital artefacts are part of the digital ecosystem. They need bits and pieces of the system to properly function. Using the digital ecosystem as a basis to define the scope of the effort therefore offers insights into the individual parts that have to be archived to preserve a "digital first" artefact:

First and foremost the *hard- and software* needs to be preserved and made long-term accessible in working order, including digital and analog *artefacts associated with it* (e.g. manuals, which are "infrastructure" needed for the operation of the software), the *information exchanged* over the digital lifespan (e.g. databases) and finally *meta-information* from users and their interactions with the preserved artefact (e.g. reviews, forums).

In principle these aspects of preservation of "digital first" ("born digital") objects are well established in the literature (e.g. [Webb 2003]) and work well for static information like a digital picture. Interactive digital objects like games – and especially MMOs – offer a glimpse of what is to come even for "simple" digital objects in a digital ecosystem that is dominated more and more by social platforms with dynamic content and less by individual webpages with static objects. These should be preserved using the initial environment or, if necessary, have to be migrated in a standardized way into new rendering environments (e.g. [Ioannides et al. 2010b]). While there were a variety of EU projects dealing with interactive virtual representations of non-digital objects, especially text (from reUSE 2003[9] up to READ 2016[10]; the author's own elib.at digitization repository profited from these initiatives), even recent EU projects focusing on the digital infrastructure, like e-Infrastructures [University of Vienna 2016]; the author was part of the Open Access focus in Austria), did not provide solutions for the preservation of large scale social web objects in Austria [University of Vienna 2016], like social media platforms or MMOs (perhaps this will change with the follow-up e-Infrastructures Austria Plus or other initiatives like the Designing Digital Heritage Network [Ioannides et al. 2010a]).

[1] https://books.google.at
[2] https://archive.org
[3] runeberg.org
[4] https://www.gutenberg.org
[5] Elib.at: https://www.univie.ac.at/elib
[6] https://www.computerspielemuseum.de
[7] http://www.literature.at
[8] https://phaidra.univie.ac.at/
[9] https://www.uibk.ac.at/reuse/
[10] https://read.transkribus.eu/

As complex archiving situations will become more common, MMOs are the ideal testing environment on how such repositories should be constituted and how the individual parts should be joined together. All of these parts involve a variety of challenges that can broadly be divided in four main categories (for an overview of the basic challenges see e.g. [Lessig 2006; Mazziotti 2008; Langley 2019]):

- *Legal Barriers e.g.*
    - laws prohibit digital archiving longer than the digital artefacts sometimes exist
    - so called “abandonware” without clear ownership
    - general trademark and copyright provisions in conflict with archiving efforts
- *Software Barriers e.g.*
    - “Digital Rights Management” (DRM) & other Copyright Protection Measures make archiving and emulation difficult
    - time-consuming reverse engineering, as source code no longer available
    - ports, patches or game modifications (“mods”) no longer available or only available for one version of the game
- *Hardware Barriers e.g.*
    - physical access to storage media is no longer possible
    - lack of parts for continuous repairs
    - problems with storage
- *Costs over Time e.g.*
    - initial costs
    - monthly costs and
    - costs of porting and emulating
    - personnel costs

The *preservation of the meta-information*, like video reviews or forum discussions is not included as those four categories have to be applied in full for each case individually (e.g. preserving a forum discussion makes it necessary to preserve the forum, too).

Preservation has to take into account the short lifecycle of digital information and measures guarding against the aforementioned obsolescence and supersession.

To get a better understanding of the challenges, the preservation of computer games is used as an example.

CASE STUDY: ARCHIVING COMPUTER GAMES (MMO)

Using computer games as an example is instructional, as they are at the forefront of the technical development cycle (e.g. VR-games), are on the one hand locked into a mostly commercial system with fast and short development cycles but also have a thriving open source modding and programming community. Computer games have no established and standardized archiving strategies and a lot of games have been lost due to the above mentioned challenges – especially the unclear legal situations. In some cases, games are simply abandoned and are either lost or curated by enthusiasts in abandonware archives.

There are generally 3 large groups of questions to answer, when preserving games, that deal with different aspects, games need in order to function (see fig. 1): Hardware, Software and Player Interaction.

Fig. 1: Ingredients for Game Revival and Examples. (Own work. Hausar 2018)

There are a variety of game types to compare but especially important for archiving and revival purposes is the difference between those that can be played without an active online connection to the internet (ecosystem 1) and those, that need this connection to work (ecosystem 2).

The first type of game-ecosystem, as diverse as the individual challenges in archiving games may be, have mainly challenges in the field of hardware, from early arcade games (e.g. preserving the arcade machines) to e.g. Commodore 64 and Amiga 500 games, which need the hardware and the input devices to be preserved alongside the code. The code also often has to be adapted, emulators created and old input devices reengineered in order to work. The game content is often scripted and the main differences are how players react to it. Here different out-of-game player content should be archived to offer insights into the range of reactions. While ludologists have tried to capture authentic player (e.g. with “Electroencephalography” (EEGs) [Balducci et al. 2017]) interaction in controlled environments for some time it remains a distraction and a daunting task. The technically and financially low threshold for making digital videos, the popularity of streaming and online sharing of everyday experiences offers a new option as the player does not see the observation as unnatural. Most of the observation data is captured and shared by the observed themselves (e.g. Twitch Gaming Channels) and can be downloaded for archiving under open licenses.

The second type of game-ecosystem offers its own unique challenges. Here the difference is mainly between scripted games, where content is mainly scripted and players cooperate and compete against the scripted content (e.g. “World of Warcraft” (WoW)) and sandbox games (e.g. EVE Online), where the content is mainly created through the interaction of players amongst each other’s on centralized servers. Another difference is scale, meaning the number of players that are able to play together over the net, ranging from one on one games up to Massive Multiplayer Online Games with thousands of players. These games generally have centralized hard- and software (main problems in archiving are legal in this case) but the interactions in gaming sessions with multiple players can differ widely even with scripted content and are therefore difficult to archive (WoW has around 9600000 subscribers).

Massive Multiplayer Online Games as server-based games are not reliant on a specific client infrastructure. This is an advantage from the perspective of the archivist. As mentioned above, depending on the type of MMO, content is either provided and scripted mainly by the game company (e.g. WoW) or in the case of a sandbox-type game through the interaction of players using in-game tools (e.g. EVE Online). Massive multiplayer online games focus less on a gripping storyline to motivate players than on player cooperation or adversity.

There are a lot of different game design approaches: Some games let players cooperate in scripted quests against the game’s “Artificial Intelligence” (AI), other games focus more on an open sandbox, where players are free to use the game mechanics to build their own stories. Some games divide their players into regional groups, others let all

players join one server. Games are played in a persistent online world hosted by the respective game company servers.

As the second type of game ecosystem is a much harder challenge, it will be used as an example for the complexities of digital archiving and reviving:

Disregarding the legal complexities of getting the rights to the server data and game source code, a server cluster has to be provided to run the game. For a test environment with only a few players the initial costs for hardware are around EUR 1500 and costs for keeping the cluster up is around EUR 250 per server per month, if you use commercial hardware. This setup allows a few players to replay an MMO from scratch but does not re-create player stories and out of game content.

Player experiences can only be archived as recreations based upon playthroughs, player podcasts, streams and videos as well as community sites like forums, websites and fan-art. This content is hosted on a variety of external platforms that have to be recreated as well. One example is the World of Warcraft Wiki, which is a fan run site collecting stories, personal accounts, video and chat interactions and game advice. The community content is provided under open licenses and can be archived in bulk over the API (e.g. [Littmann et al. 2018]).

But how can you get people besides scientists to engage with the archived content?

ACTORS AND APPROACHES

Then and now it is necessary to raise awareness for the value of archives and the content that can be found, both analog and digital, as it is not always immediately clear how each citizen benefits (concerning the continuity of the challenges see e.g. [Roe 2016]). Due to the overall hesitant way in which traditional archiving institutions have participated in the preservation efforts so far, a variety of different and complementary strategies have emerged to finance these efforts, some of which are listed below:

- *Legal framework for digital preservation* and financing of long-term archiving infrastructures: This approach is for example used in Germany, where designated institutions are granted powers to archive content (e.g. legal right to hack copy protection granted to the German National Library for archiving purposes). This approach balances the rights of the individual author against the rights of all citizens to knowledge, culture and information, a principle that is strongly rooted in the continental European law traditions and present in most constitutions. It is a difficult deliberation that has to be made on a case-by-case basis (e.g. article 2 of the UNESCO Guidelines [Webb 2003]), but it is rewarding: If the rights of all citizens would not have been deemed more important than one author's rights, Kafka's works would have been lost to us as they would have been burned according to the express wishes of the author.
- *Offering grants* aimed at preservation efforts: Mostly used in concert with scientific research, grants specifically for archiving are established e.g. in Austria through the "Austrian Research Promotion Agency" (FFG).
- Requirement for *open access and archiving strategy* when receiving public grants: Another way to promote archiving in the scientific context is to mandate that proposals have to contain an archiving strategy.
- *Rebuild and Open Source*: Enthusiasts and citizen-scientists sometimes reverse engineer games and open source the code, so others can build upon and expand on the original game (e.g. FreeCiv as an open source fan-project recreating the iconic original Civilisation game).
- *Emulate it online* so it is possible to preserve at least the emulation, if constraints do not allow for any other solution and make it easily accessible: Out-of-copyright games can legally be recreated online so a broad new user base can experience them online (e.g. Internet Archive).
- *Archive as physical objects* e.g. in a museum or in the form of retro-games: A good example are old arcade machines, that can be experienced best in a real-world environment (e.g. in the Computerspielemuseum).
- *Update and sell old games* as a business model: Preserving old games offers businesses the chance for a second commercial cycle as retro-games thus making it also in the interest of companies to preserve their old games (e.g. "Good Old Games"[11]). While this in itself is not a solution to long term archiving, companies might not

[11] https://www.gog.com

simply delete their old games during their copyright term, thus making any legal preservation effort extremely difficult and expensive.

- *Semi-legal or illegal preservation* through abandonware or piracy: Black market economies offer illegal alternatives if accompanying factors are excluding certain groups (e.g. prices or availability).

Most of these approaches are sadly driven by private actors and not by official institutions. This is a problem – both from a legal and a long-term preservationist perspective – that has to be addressed on a country and international level. Initiatives like the Internet Archive, with mirrors in Europe and Cairo, are de facto filling the void until official institutions can catch up. Even then, a comprehensive legal framework is a necessity to legalize preservation of "digital first" content.

CONCLUSIONS

The status quo of digital preservation is severely hampered by the general approach of lawmakers towards the digital ecosystem. Recent developments like the efforts for a European Copyright Directive are not encouraging. There are a lot of undecided questions concerning the nature of the digital domain that have to be clarified to allow institutions like the National Libraries to officially include "digital first" artefacts under their existing mission statements:

As National Libraries archive on a nation-based approach, clarification is needed, which online content is seen as being in that nation (e.g. game company headquarter; player base; domain-based like *.at* or *.ac.at*).

Clarification (and legal security) is needed on how the different national and international actors should work together in the preservation effort

Finally, further clarification is needed on the general trade-off between copyright-exceptions and the right of society to knowledge, culture and art to determine, for which society of the future the content will be archived.

Looking back to 2003 and with full knowledge of all the effort put into digital preservation since then, the warnings from article 3 of the UNESCO preservation guidelines remain still relevant:

> *"The world's digital heritage is at risk of being lost to posterity. Contributing factors include the rapid obsolescence of the hardware and software which brings it to life, uncertainties about resources, responsibility and methods for maintenance and preservation, and the lack of supportive legislation. Attitudinal change has fallen behind technological change. Digital evolution has been too rapid and costly for governments and institutions to develop timely and informed preservation strategies. The threat to the economic, social, intellectual and cultural potential of the heritage – the building blocks of the future – has not been fully grasped."*
>
> [Webb 2003]

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Industrial Heritage and Seka Paper Mill

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Industrial heritage today is being taken even more seriously in the academic field. It is due to the instituting of heritage studies across humanities, social sciences and natural sciences and developments in contemporary archaeology. Industrial heritage is broadly defined by many specialists after Nizhny Tagil Charter (2003) as consisting of “the remains of industrial culture which are of historical, technological, social, architectural or scientific value”. Industrial sites such as the early production units and factories in Turkey are generally abandoned and forgotten; only a few of them however were preserved and museumized. Meantime, industrial heritage comprises more than just material culture, but also valuable intangible forms of heritage. In the case of factories as the products of early industrial developments in Turkish Republic during 20s and 50s, they provide us important insights about the structural alteration in culture and social life in the region. Lives in factories and their campus areas were the representation of transforming identities of young republic. Therefore, preserving and conserving of such sites should consider not just the building itself but tangible and intangible heritages values together. Temporal layers including the time when the factory was still active, when it was abandoned and spatial layers including living and working quarters of industrial sites should be equally transmitted to various targets groups. Probably the best way to accomplish this is using augmented reality applications. This project considers how augmented reality contributes to perception of visitors with maintaining cultural mediation in SEKA Paper Museum situated former pulp and paper mill in Kocaeli district. It also suggests that cultural heritage specialist today should participate more in such studies in order to design accurate substructure, interface and content.

Key words:
Industrial Heritage, Seka Paper Museums, Augmented Reality, New Media Tools, Heritage Studies.

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INTRODUCTION

Industrial heritage is defined in Nizhny Tagil Charter as consisting of “the remains of industrial culture remains which are of historical, technological, social, architectural or scientific value.” [ICOMOS 2003]. Industrial archaeology meantime has been emerged as a new discipline in 1950’s. Since then it has been expanded from material studies to multi-layered studies of networks of production and distribution of industrial revolution [Casella 2005, 27]. Nowadays, it is generally accepted that industrial archaeology is both related to heritage preservation studies and industrialization [Palmer and Orange 2016, 73].

Archaeological studies provide important information on understanding and explicating industrial heritage areas. However, because of the nature of industrial heritage by its definition industrial archaeology is also concerned with social context and meaning of things. Therefore archaeological studies as heritage studies of industrial areas require interdisciplinary work in order to reveal not only the material meaning of sites, but also their role in social and cultural contexts. The heritage values and material remains related to the industrial areas could be summarized as:

- Architectural values and aesthetics of industrial buildings
- Technological values of machinery systems
- The relation of industrial area to its environment, etc. its surrounding campus area and the connection with city
- Both its social-cultural and economic-political context within the city and nation.

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Industrial heritage comprises more than just material culture, but also valuable intangible forms of heritage. These tangible and intangible heritage elements of wider social and cultural significance as part of the records of people lives provide an important sense of history and identity.

Industrial heritage areas are usually in conflict with contemporary living quarters and social dynamics of the city, therefore preserving such complex sites as a whole for longer terms is connected to the concept of sustainability. Although there has been a general agreement on the theoretical framework of sustainability, practices are still contradictive [Landorf 2009, 495]. Indeed, sustainability could be evaluated under "cultural-social sustainability, sustainable development and financial sustainability" sub-titles especially for the heritage sites examples of adaptive re-use in order to maintain sustainable heritage management [Landorf 2009; Pozo and Gonzalez 2012; Falconer 2006; Bergeron 2012; Özdemir 2009].

Regarding to the aim of sustainable management, preservation and conservation planning phase of industrial areas requires an interdisciplinary approach for including different layers of heritages values and could be consisted of following stages:

- The consideration of the location of heritage site: whether its current situation is within urban areas or it is in rural context.
- The examination of machines in the industrial complex
- Documentation of historical pictures, objects and records
- Architectural analysis for diagnosis of deterioration mechanics and decay situation
- Decision of re-use or re-habitation areas
- Suggestion for the theme of re-use.
- Designing display elements and tools.

As a distinctive example for industrial heritage sites in Turkey, Seka Paper Mill is presented in this article. The development of Seka Mill is analyzed in its historical process to realize its contribution to the memory and heritage of the city and identify the various layers of heritages values. Then conservation and transformation of Seka Paper Mill into Paper Museum are evaluated with regards to principles of industrial heritage and sustainability. "Augmented reality" (AG) technology is considered as an alternative way of representation of heritage values in accordance with the contemporary museology and exhibition techniques. Test results of Seka Paper Museum AG demo application and public survey of who have used the demo is presented in last part.

SEKA PAPER MILL

Seka Paper Mill was constructed in 1936 within the city of İzmit-Turkey [Dölen 2015]. The media of those days identified paper with civilization and there were celebrations in the city upon the first paper production (Fig. 1). Likewise in the case of other factories as the products of early industrial developments in Turkish Republic during 20s and 50s, Seka provides us important insights about not only the economic growth trends, but also the structural alteration in culture and social life in the region.

After the production has started, the activities in education, which have been initiated as transferring of experience and knowledge from German engineers to their Turkish colleagues continued as vocational courses in 1939. By 1941, in-service training activities have become more organized and students were encouraged to study abroad. Vestibule school in 1944 and elementary school in 1945 were founded in the complex in order to provide formal learning [Kocabaşoğlu et al. 1996, 168-171]. Social organization activities in the factory as has been developed rapidly between 1937 and 1943 when retail society, infirmary and canteen, dining hall, movie theater, social club and playground were put in the services for the factory workers and their families who lived in the campus area [Kocabaşoğlu et al. 1996, 171-175; Dölen 2015, 430]. Moreover, the in-house communication was established with "Seka Postası" and until 1984 this newspaper created a source for the city's social life. Sekaspor sports club was founded in 1937 and had many contributions to sportive live in İzmit in various branches such as wrestling, boxing, football, basketball, and athletics, coxless and sailing.

By 80s while investments of private sector to paper industry increased, Seka Paper Mill could not take the pace in technological developments and environmental requirements. Besides, because of inefficient organization, the

financial difficulties and increasing population in the city, the mill was privatized in 1997. The factory has an important role in the lives of workers and townspeople and people were emotionally connected to it. Therefore, when it was decided to close, there were after strong objections and strikes for almost a decade. Finally, however, production ceased in 2005 and the factory area was transferred to the Municipality on the condition that it would be use for public purposes.

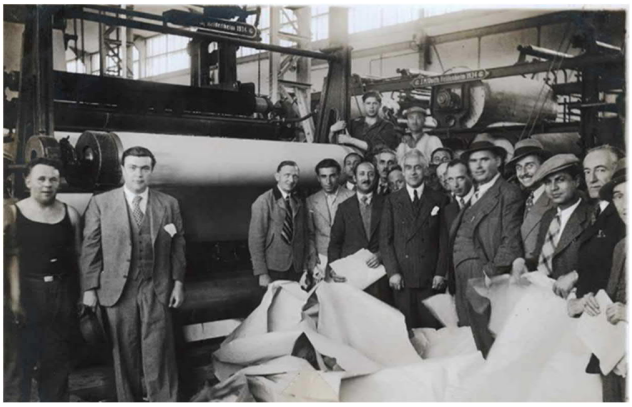
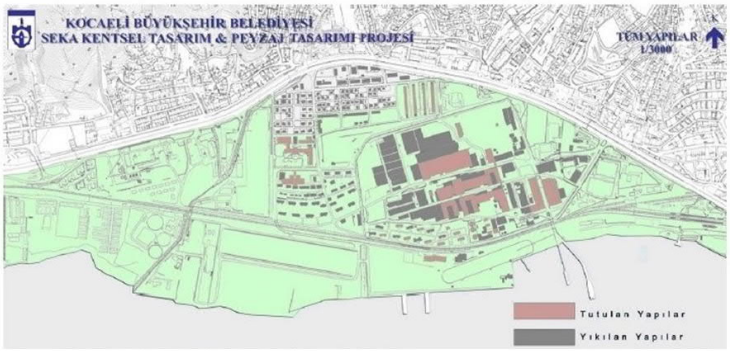


Figure 1. First paper production in Seka Paper Mill. Turkish and German engineers 1936 (Seka Archive)

Conservation and re-habitation project of Seka

Seka conservation and re-habitation project was consisted of 3 stages (Fig. 2). The first stage was completed in 2007 and was focused on the seaside. This part was transformed into a multi-purpose green space for maintaining sea line continuity [Oğuz et al. 2010, 161]. Second stage was on preserving and transformation on the area where the building complexes were located. The architectural analysis was applied to determine decay status of the buildings and conservation problems [Aydın and Kartal 2016]. According to this study, many architectural elements were applicable for re-use with little interventions. The project has initiated in 2009 for the conservation of First Paper Mill. The conservation planning was designed as transformation of First Paper Mill into Science Center and Paper Museum and aimed at preserving whole elements of building including the machines, which were still working, at their original places. However, some of the machines were sold after it was closed; therefore these areas were used as places for showcases. The project is considered to be Turkey's biggest industrial transformation project and the museum, which was opened in 2016, occupies 12345 m^2 of the old Seka Paper Mill. The themes presented in the museum include the manufacturing stages of paper, Kocaeli's history, the factory's history and social milieu.



Sekapark Projesi Kapsamında korunan ve yıkılan yapılar (Orijinal, 2006)

Figure 2. Re-habitation plan of Seka area is indicated in green. The buildings that are preserved are shown in red (Seka Archive)

Evaluation of museum exhibitions

Although, the project team was not participating in the planning progress, the museum administration referred to the Department of Conservation and Restoration of Cultural Properties for consultation on the efficacy of the exhibition and consistency of design with the industrial heritage principals and sustainable heritage management. After the examination of the Museum through surveys in the museum and analysis of the documents related to the restoration project, it has been decided that there are positive elements which are in accordance with contemporary industrial heritage preservation principals as including of different layers of heritage values.

However, different themes disrupt integrity and prevent visitors to realize the authenticity of the factory and its historical and social importance:

- Some old photographs belonging to factory workers are located at the entrance of the museum and there are others scattered around the museum and placed on the lockers, however they are disconnecting from context and meaning (Fig. 3).
- Showcases present too much information, which is not interconnected to each other such as the history of the factory, history of the city and history of paper production.
- Documentaries are installed at the projection screens at various places in the museum in which people are talking about the importance of the museum in their personal lives as well as in the city's identity. However, the projection screens were placed not in accordance to visitor's route or to the displays (Fig. 4).

Fig. 3. The entrance of the museum

Fig. 4. Video of oral history on the projection screen

The life style in the Seka Paper Mill and its campus area was the representation of transforming identities of the young republic. Therefore, preserving and conserving of such heritage site should consider not just the building itself but the meaning of tangible and intangible heritages values together. Temporal layers including the time when the factory was still active, when it was abandoned and spatial layers including living and working quarters of industrial sites should be equally transmitted to various targets groups in order to express the Seka's history and identity as a whole. This would help to not only visitors to understand the story of people and story of that time, but also would increase the participant of local organizations. Probably the best way to accomplish this is using new media applications.

Zollverein Coal Mine Industrial Complex in Germany could be among the best examples for the conservation projects of industrial areas in the world. The coal mine was constructed in 1932 as a part of industrialization progress and became the well-known symbol of German industrial revolution until 1993 when it was closed. The complex shares the similar heritage values of wider social and historic significance and the destiny with Seka Paper Mill. The adaptive re-use preservation formula was applied to Zollverein Complex as in Seka. However, unlike Seka Paper Museum, the function of buildings and their surrounds has been transformed to a huge area consisting of museums dedicated to industrial heritage and architectural design, social locations for numerous leisure activities including an open pool and monumental path where the guided tours are organized. When compared to Seka,

Zollverein complex appears to be reconstructed with a more integrated approach. The industrial heritage area was designed with its surroundings to be a focal point and a symbol of heritage values as it was in the past. People visit here not only to see the exhibitions and read the information, but also to experience the site, spend time and to be together.

New media tools and Augmented Reality for Cultural Heritage

New media is usually considered the same as digital media and technology-driven alternatives. In this respect, the relation of new media and cultural heritage could be categorized as:

- Increasing interaction between visitors and objects at display,
- Increasing the perception of archaeological sites by visitors,
- 2D or 3D reconstruction of architectural remains,
- Interactive learning in cultural heritage area,
- Using remote access to heritage sites

The common purpose of various applications is the active involvement of user who is the subject of the application. New media usage in cultural heritage field is associated with McLuhan's theory i.e. technology or new media is the extensions of man [McLuhan 1964]. However, authenticity of cultural heritage and its original texture are important factors regarding to the visitors' perception. When the application is designed to increase the sense and understanding of user, the essence of the matter, which is the story, and meaning of heritage components could be overlooked. Then the historical building for instance could be perceived as a stage for some historical games and the user of technological applications becomes a part of the design as its perception dims and the reality blurs.

Nevertheless, traditional methods of exhibition are re-shaped and the relation between the user/visitor and the object is transformed. Using digital techniques make it possible to build 3D models, reconstructions, and environments of virtual reality of archaeological sites or ancient structures and related cyber games. A better understanding of new media concept especially for cultural heritage studies with the help of interdisciplinary approaches could provide limitless possibilities for preserving, monitoring, representation and management of cultural assets.

For the case of Seka Paper Museum, to make information more easily available through visualizing the content of both temporal and spatial layers, we have concluded that probably the best and simple way to accomplish this in the real context is the application, which presents historical photographs in augmented reality (AR). However, the use of AG in industrial heritage areas is very limited as of today. One of the examples is from Newcastle Australia, which suggests AG application as a better and more holistic approach for preserving abounded industrial areas [Morrison et al. 2012]. The other one considers mixed reality consisting of virtual and augmented reality for reconstruction of power plant complex in Piestany Slovakia and the importance of interdisciplinary cooperation for industrial heritage studies [Hain et al. 2016].

SEKA PAPER MUSEUM AUGMENTED REALITY APPLICATION

Material and methods

The archive of Seka Museum was examined and selected photographs were grouped in four regarding to selected spaces and objects in the museum (Fig. 5). The selection of photographs related to spaces was performed considering they could be re-producible. From an archeological point of view, the objects at display should reflect the meaning and contain more information on the history of the factory and the people who used them. Therefore, for their own storytelling, some of the objects at display were chosen and matched with old photographs in which they were in use.

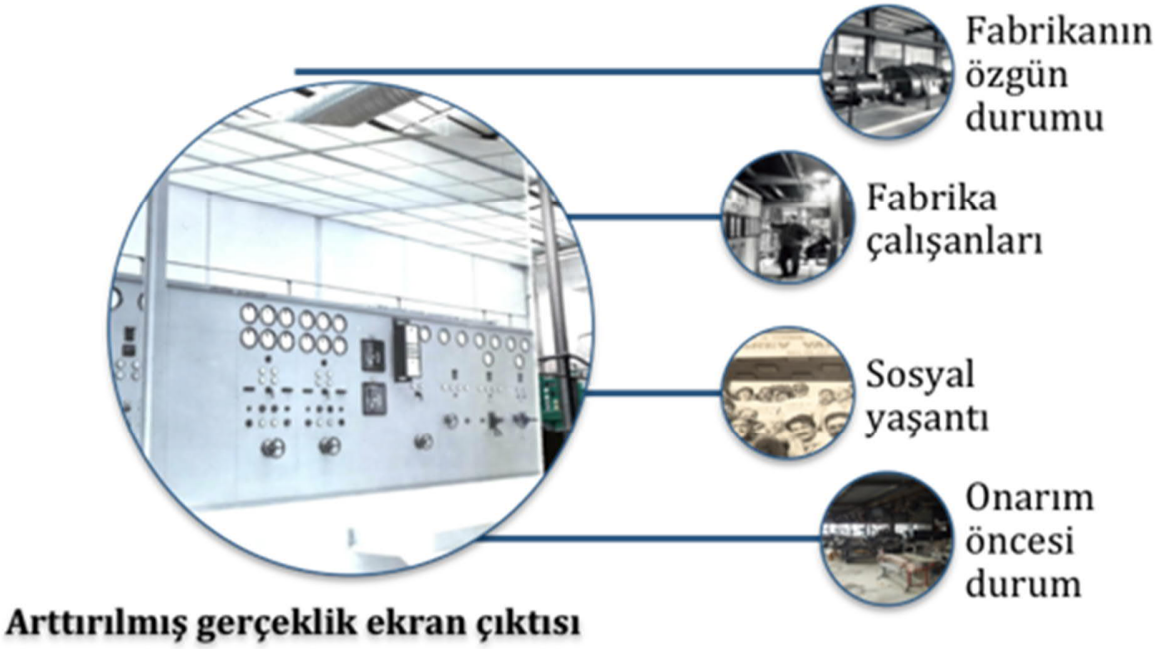


Fig. 5. Screen print of application including photographs of that when the factory still active, factory workers, social live in campus and the situation before restoration

In the application image-based tracking technique was applied. Image-based tracking uses real reference images for targets [Rainio et al. 2015]. The target images are matched with the corresponding historical photos when AR camera recognizes the scene by using real features from the images. The AR application contains a number of known target images. The images that would be used for tracking could be produced from the frontal view; however tracking could be difficult in situations where the tracking target is not planar, since in reality the recognition by AR camera works through 2D images. In order to handle this, there are several methods including point cloud image tracking, which is computationally more expensive. In this study, by using markers placed on the ground, the viewing direction of the users was limited more to the direction where the reproduced images were taken.

The aim of choosing image-based tracking is to ensure visitors/users could easily realize the differences in the spatial set up of the building due to both the abundance and restoration of the mill using old photographs as reference points.

Target images were re-produced by the students of the Photography Department of Kocaeli University from the same perspective. However, the viewing angle of visitors should match with the visual angle of AR camera. The visitor's route also should be considered, i.e. the viewing points should be within the route. For indoor places when artificial and natural lightening were both applied, determination of lighting values in the areas, where natural lightening was used, bears importance for AR application to work. Meanwhile for the objects at display the perspective is not significant.

Instead of developing an interface and designing a mobile application, when considered the purpose and ease of usage, AR application works simply with the camera of compatible devices. The Application was created using Unity game engine (version 2017.2.0f3)[1] and Vuforia[2] for Android platforms. For the ease of use, viewing points were marked with graphic images at the scene (Fig. 6-7).

Another important component of transferring the information and experience to the visitors is sound [Hain et al. 2016, 2034]. Some of the machines in the Museum are still working; however it is impossible to keep them working

[1] https://unity3d.com/get-unity/download/archive
[2] https://developer.vuforia.com/downloads/sdk

all the time. By recording the sound of the machine, we are able to synchronize the real time vision with the original situation through AR cameras.

Fig. 6. AR view of the factory environment in Galaxy Tab A

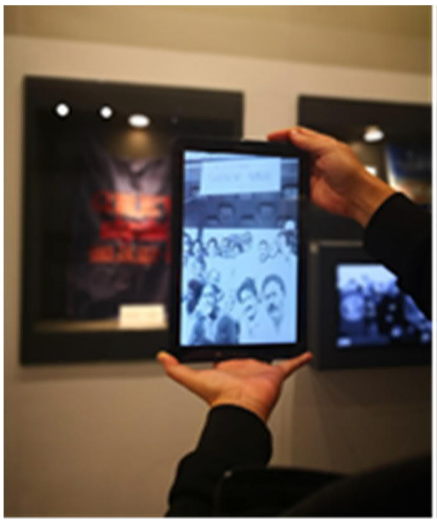


Fig. 7 AR view of the museum objects in Galaxy Tab A

RESULTS AND DISCUSSION

50 volunteers have tested the Seka Paper Museum AR application using Galaxy Tab A (2016) SM-P580 tablet at specific viewing points inside the museum. They have selected randomly among the visitors in order to evaluate the functionality and the potentiality of the demo application. Each person has been briefly trained individually in order to explain the application and was guided throughout the museum (Fig. 8-10). The age of visitors ranged from 8 to 70 years. At the end of the augmented tour, people were asked to fill a questionnaire. The questions are aimed to gather data about age, gender and the degree of confidence in using tablet, familiarity with AR applications and opinions on demo application. The scale was ranged from 1 (strongly disagree) to 5 (strongly agree) and average value according to gender and age groups is given in Table 1.

Table 1. The Results of Survey

	Degree of confidence in using tablet	**Familiarity with AR applications**	**Seka Paper Museum AR DEMO**	
Gender			Ease of use	Usefulness
Female (n=15)	5	2	5	4
Male (n=35)	5	3	5	4
Age				
8-18 (n=5)	5	4	5	3
19-29 (n= 25)	5	3	5	3
30-39 (n=17)	5	2	5	4
40-50 (n=3)	4	2	5	5

Fig. 8. Volunteers have been briefly trained individually

Fig. 9. Guided tour for AG application in the museum exhibition galleries

Fig. 10. Guided tour for AG application in the museum

The tests results indicate that target group is using tablets, however many of them are not familiar with AR applications. The all agreed that the application very easy to use and many of them thought that it was impressive to see the old photographs at their original places and hearing the sound of machines. Some described their experiences as “traveling in time” or “seeing past in 3D”. Surprisingly, especially participants, who are over 30, were trying to turn around with tablet and see whole area in old photographs.

It is also detected that image-based tracking system used in Seka Museum is affected by changing details. In larger galleries and in wider perspectives, it is not easy to control the environment. When the place of some features at the exhibition halls, such as the trolley seen in Fig 10, could be changed after photographing them, it would be difficult for the AR camera to recognize the target image. Besides that, industrial machines have a large number of distinctive features and reflective surfaces, which both introduce challenges for image-based tracking. Visitors experienced these technical difficulties, especially when targeting the tablets or getting the right position, which was marked regarding to target image.

CONCLUSION

Digital technologies are considered as an alternative for conventional methods for documentation and preservation of cultural heritage values and also for exhibitions in order to increase the interaction of visitors with museum objects as transmitting visually the story of the object. However the nature of the object and the nature of cultural heritage site define whether the application would be. Therefore planning and decision require collaboration with experts who specialize in the field of cultural heritage studies. For industrial heritage sites, minimum intervention has many advantageous such as easy handling and maintenance, limited costs. Besides the physical remains, industrial heritages sites include intangible heritage values of a specific place as reflecting the people’s lives and memories and days’ of glory of that area. AR application could provide a better understanding of complex industrial sites and enable sustainable management.

As one of the earliest examples of industrial revolution in young Turkish Republic, Seka Paper Mill has authentic values including its technological properties and historical value. The transformation of Seka Paper Mill into Paper Museum is a qualified example of such transformation project. Developing an AG application for Seka Paper Museum in order to provide contemporary industrial heritage preservation concept and a holistic approach for including all layers of heritage values is a new project. After evaluating the museum exhibitions and visitors’ route an AG application for the Paper Museum was offered, because the size of the area and intensity of intangible heritage values. When the feedbacks of volunteers who have tested the demo of AG application are evaluated, it is understood that the demo application has valuable potential of presenting the different spatial and temporal layers and increasing the perception of visitors. The project, however, should be developed according to the technical difficulties that were experienced depending on the spatial features of the Museum.

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A Proposal for the Virtual Documentation and Dissemination of Information from Archaeological Objects

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Nowadays, there are several virtual tools to document the archaeological objects for the general public. The use of knowledge network makes it possible to disseminate the content and provide access to the creation and the distribution of other types of image which were previously restricted to only a few people. In this way, the analogue image has been replaced with its digital version, assuming that it is the best approach to achieve a more comprehensive dissemination of information, without asking if the archaeological context has been marginalised. In general, virtual technology is being used to surprise, without really attempting to help explain the object, with all its historical memory. The purpose of this approach is to compare these working methods from both analogue and virtual points of view, considering problems such as the cost of modelling, the amount of time required, or the need for an expert user to manage the virtual tools. The virtual documentation will include all of the interactive information of the object, managed from a Wiki[1], including bibliography, links to archaeological database, high resolution photography[2] and 3D models of the archaeological objects obtained from both 3D scanner and digital photography using the Image-Based Modelling system[3]. In conclusion, it is considered that the traditional analogue information from these objects can and should be included in this virtual proposal.

Key words:
Virtual documentation, Archaeological context, Archaeological Database.

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INTRODUCTION

The graphic representation of archaeological heritage gives added value to textual information and facilitates the dissemination and conservation of these types of objects. Until recently, the graphic documentation of an archaeological object catalogued in a museum or collection was summarised in a drawing, a photograph, or in some cases a series of them, of varying quality and detail, according to the historical moment and the fashions of the time.

For investigators, the transition from drawing to photography represented a revolution, as in addition to the time saved in this mechanical process, the idea was to obtain an immediate approach to *reality*, 'to the historical truth'; a fact that in some cases, such as that of the Lady of Elche, proved not to be the case (Fig. 1). In his study, the photographer Peter Witte analysed photographic intentionality, especially applied to this sculpture [Witte 1997]. Using the interplay of shadows and different perspectives, images were created which, at times, helped to shape the interpretation of an Iberian divinity, evoking certain mysterious features, while on other occasions this presented a high-ranking woman from pre-Roman Iberian society, in its most advanced and positive stage.

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[1] http://www.wikidot.com/
[2] https://www.flickr.com/
[3] https://sketchfab.com/

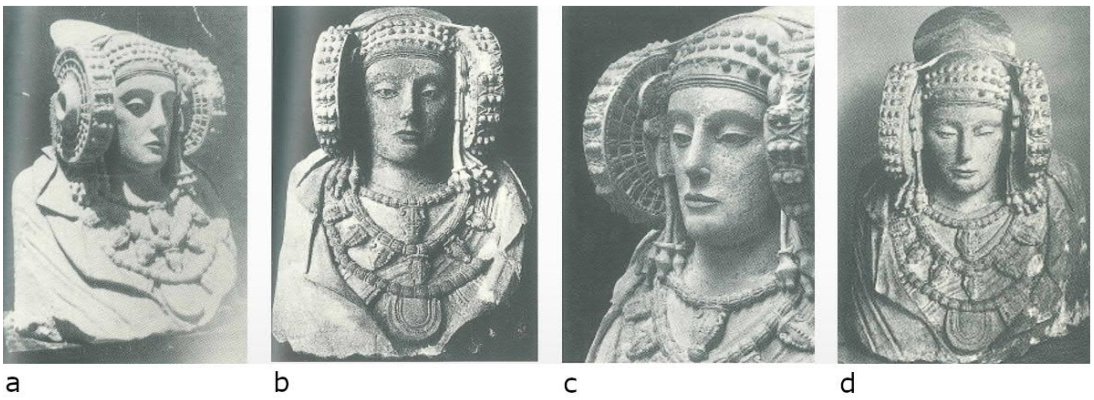


Fig. 1. The Lady of Elche photographed by: a) Pedro Ibarra (1987), b) H. Bulle (1912), c) Mas´s archive (about 1940) and d) Wagner (about 1950) [Witte 1997, 49, 53, 55, 57]

Today, the graphic representation of any archaeological object can be approached from two directions: on the one hand, approaching through the object – as a subject of study – and, on the other, exploring the global dimension that leads from a set of objects to the acquisition of catalogues of pieces; the basis of any fundamental research process.

But starting out from here how is the object approached?

In an image-based society, where more relevance is given to images than words, it is usual that in some public institutions in which "three dimensional" (3D) modelling work is carried out, these images often replace the historical background of the piece; something that should be amended, as the image without the textual past of the object lacks historical sense (Fig. 2). In addition to this is the fact that the culture of leisure generates benefits, and it is tempting to abuse technology in order to attract visitors, as also occurs in some exhibitions. This is the case of the 3D models associated with virtual realities produced by film companies that immediately attract the viewer. But is this the case for a researcher?

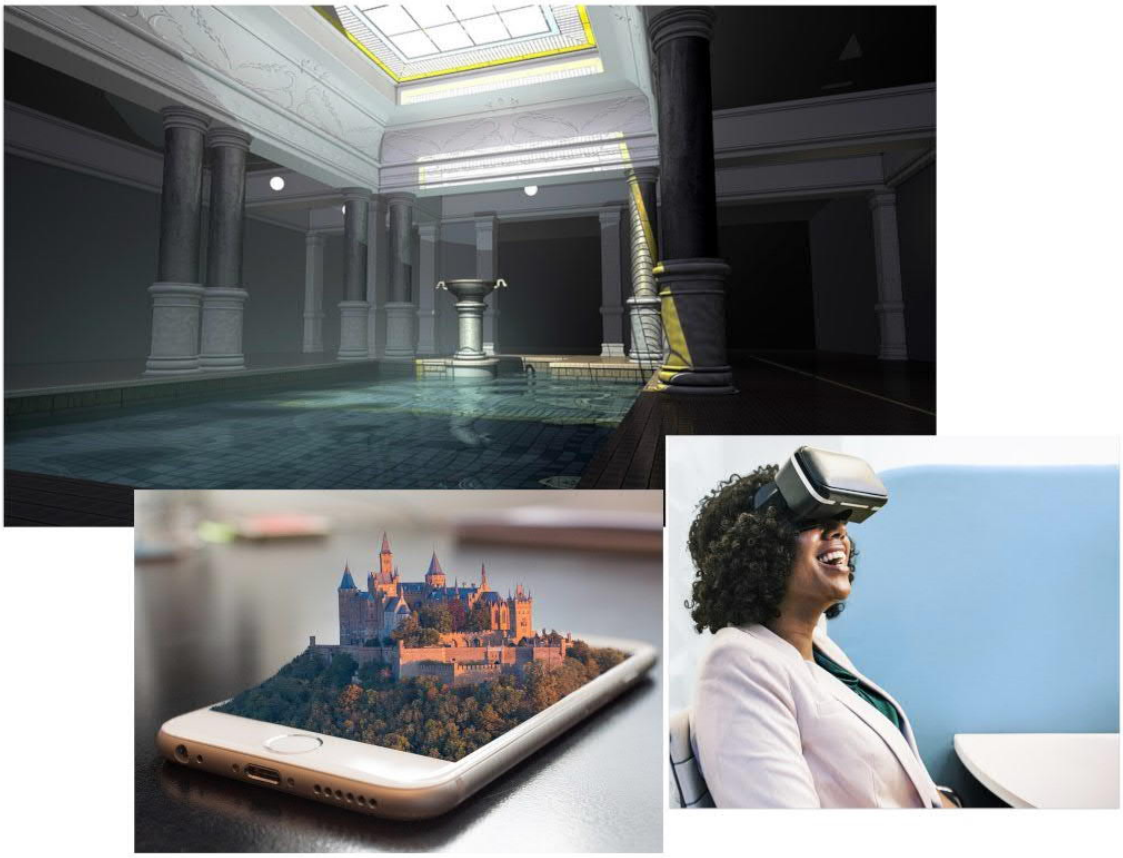


Fig. 2. Examples of the use of new technologies applied to the field of heritage (images from Pixabay)

THE USE OF 3D MODELS: SOME REFLEXIONS

The graphic documentation of the object can be studied from both a scientific and dissemination-based perspective. These 3D models are naturally useful for researchers and the general public, but it is important to say that both dimensions head in different directions, as they obviously have different objectives.

There is no doubt that the researcher obtains a formal knowledge of the piece immediately and visually, leaving to one side the other senses that give us direct contact with that object; in other words, the sensations of texture, the global volume of the object, and other connotations are lost. For example, in traditional archaeology, it has always been and continues to be essential to 'touch the pieces' in order to verify the details (Fig. 3). The continuous work provides a continuous experience that leads to a certain degree of academic 'prestige' when it comes to transmitting opinions about these objects, and about their interpretation, as G.M.A. Richter did in his study about art in antiquity [Richter 1970].

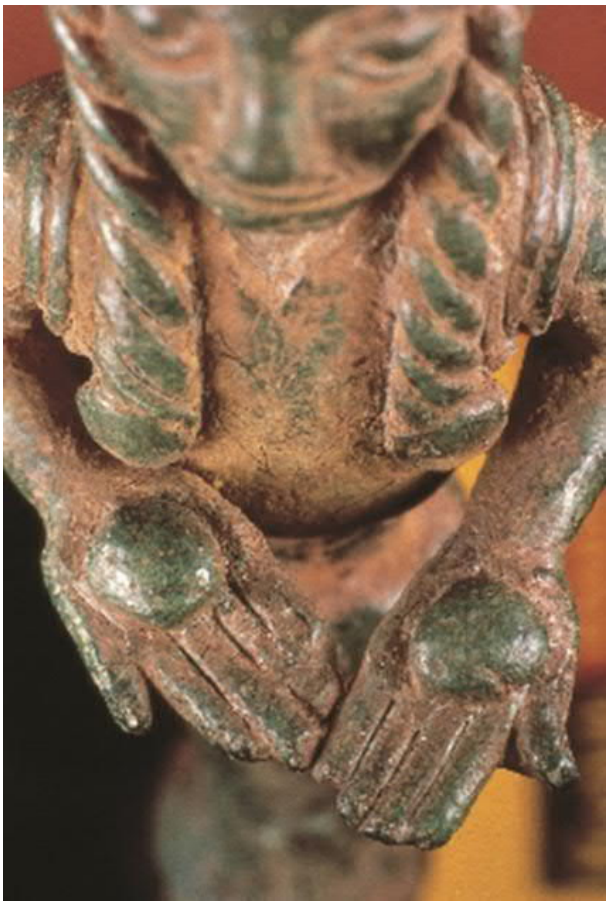


Fig. 3. Close-up of a woman offering bread in her hands (Photo: G. Nicolini)

Therefore, it seems evident that a part of this traditional sensuality will be lost in this way of approaching objects, and that for the time being, the type of consequences this will have in future works in 25 or 30 years' time cannot be gauged, if those objects are only approached through the virtual medium. This is one of the limits.

However, this capturing of objects through 3D models does have demonstrated advantages, such as immediacy when it comes to obtaining physical information about the piece (for example, obtaining dimensions and volumetric measurements) and the conservation of some of its elements, such as the irreversible process of degradation suffered by the painted decorations of some Iberian protohistoric vessels (see Fig. 4), which leads to the conclusion that within a few years, these wonders of Iberian art will have vanished [Tortosa and Ramallo 2015; Tortosa and Comino 2018]. Our own experience working with these paintings since the 1990s have proved the pictorial deterioration they suffer in their containers, in a way that from that time until today the lost details can be visually perceived. Therefore, these models would become primary sources of the past in the future and even more, the accurate virtual information would become a better source of information of the past than the object themselves.

Fig. 4. Iberian pottery (Museum of La Alcudia, Elche, Spain) (Archive of Iberian Iconography, IAM-CSIC)

TOOLS TO CREATE GRAPHIC DOCUMENTATION OF ARCHAEOLOGICAL OBJECTS

Today technological and instrumental advances allow any object to be graphically documented with different devices and with unprecedented metric and visual quality. The improvement of digital cameras, the use of 3D scanners, 3D printing and networks for the dissemination of information via the Internet allow for a transition from flat two-dimensional photography to the creation of a three-dimensional virtual model, as a faithful reflection of reality, which is globalised through the network. Aspects such as the quality and fidelity of the colour, texture, metrics or volume are important contributions in the definition of the piece, which help in studying it and creating accurate graphic documentation that complements the traditional historical documentation. In any case, the museum curation can always revise these criteria to adapt the documentation of the objects to the necessary circumstances.

Some methodologies can be highlighted for the creation of graphic documentation of historical objects:

Firstly, high resolution photography (using a 50-megapixel or more camera) with calibrated colour and using good lighting conditions: Archaeological photography is intended to provide accurate and reliable graphic documentation of archaeological objects, considering that the images must preserve the dimensional and chromatic properties of the objects with a reduced and controlled distortion. Digital photographic techniques have evolved with the development of cameras, lenses, and lighting, and it is possible to apply techniques and filters to enhance and improve different characteristics of the image [Felicísimo 2011].

In addition, current technology has allowed for the leap from two-dimensional photography to three-dimensional virtual models, using two consolidated techniques that make it possible to generate models of historical objects: 3D scanning, and the “Image-Based Modelling systems” (IBM systems).

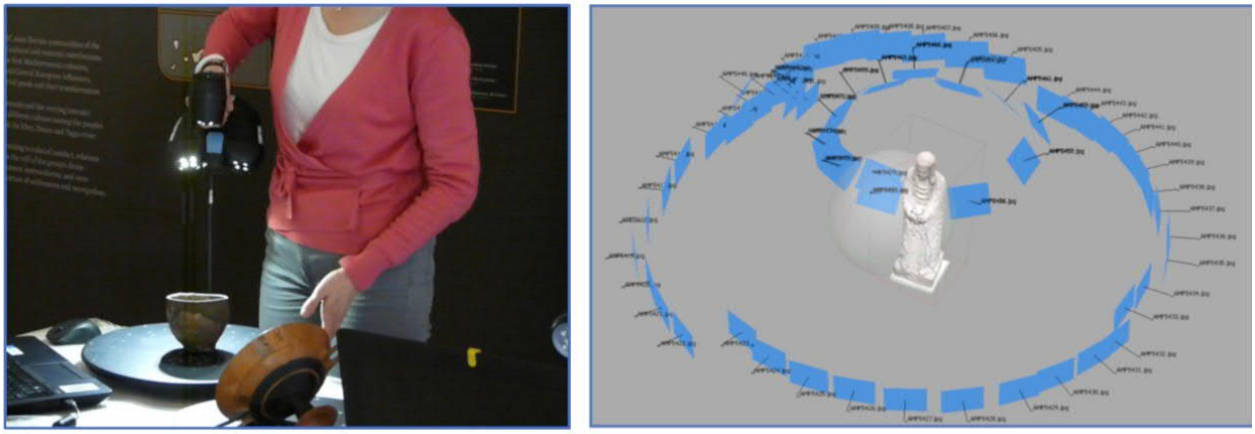
A scanner is a device that digitalises objects so that they are available in virtual format via point cloud model and image photographic texture recording. A wide range of scanners is available, and the applications in the field of cultural heritage are constantly growing, making it possible to create a faithful model of reality [Georgopoulos et al. 2016; Di Angelo et al. 2018]. For example, some structured light 3D scanners provide resolutions of between from 0.1 mm to 0.5 mm (Fig. 5 a). The structured-light scanner is a non-contact, optical system based on the projection of a calibrated light pattern onto the object to be scanned to capture the deformation of the pattern and generate a point cloud with the possibility of texture information [Mathys et al. 2013]. Generally speaking, when comparing a high resolution 3D scanner with IBM system, the first one provides a highly accurate solution, is more expensive and the learning curve is usually longer.

IBM systems recreate the virtual model from a series of overlapping digital images of the object being represented, and are based on the principles of automated photogrammetry and computer vision (Fig. 5 b). IBM systems are based on multi-view 3D reconstruction technology and use algorithms such as “Structure from Motion” (SfM) and “Scale Invariant Feature Transform” (SIFT) [Wu 2007]. There are several open-source and low-cost IBM applications that make it possible to create 3D models of objects or scenes in an easy workflow, as the process does not require advanced knowledge of 3D data processing. Conversely, IBM systems provide less metric resolution than the 3D scanner, especially in large objects or scenes. In the same way as 3D scanners, IBM systems have a

wide range of applications in the field of cultural heritage [Pierdicca 2018; Palomar-Vazquez et al. 2017; Polo et al. 2017].

Both techniques (3D scanner and IBM systems), with their advantages and disadvantages, can work alone or together [Dostal and Yamafune 2018; Carrero-Pazos et al. 2018] to the point where it can now be said that the techniques of creating 3D models for heritage purposes have reached a stage of maturity, taking into account the large number of publications and scientific journals dealing with this topic [Katz and Tokovinine 2017].

Of course, current technology offers other devices that can be used to create virtual models and obtain more comprehensive information from the archaeological object, such as spherical cameras, thermal cameras, or multispectral cameras [Šedina et al. 2019].



a b

Fig. 5. a) 3D scanning of the material from Medellín (National Archaeological Museum, Madrid, Spain), b) The image shows the photographs taken to create the 3D model: a total of 74 photos from different perspectives

DISSEMINATION OF THE INFORMATION

Once the graphic information of the object has been generated, the next step is to disseminate it through different channels. There are several networks and platforms for disseminating heritage information. It is not the aim of this paper to list them all, but the dissemination of historical information through the Internet is sufficiently developed, and there are public and private initiatives that support different formats.

This may be the place to emphasize an aspect that needs to be developed: standardization for metadata, not of the archaeological object, but of its representation or model. A review of the standards for the dissemination of 3D models shows that there is not yet a specific and complete proposal for the construction of metadata. There are only some technical fields related to the file format (for both images and 3D models [Harpring 2017]), dimensions in height and width, resolution, file size, and visualization software [Baca et al. 2006] but in general there are no standards that indicate the recommendation or obligation to include technical characteristics [Previtali and Valente 2019; NISO 2007]. Actually, some essential aspects of the 3D models construction are obviated; e.g. in the case of photogrammetric models: number of images used, distribution of the same, modelling software, correction of greys, use of colour profiles, illumination, “Colour Reproduction Index” (CRI) of the textures, uncertainty of the dimensions; in the case of scanned models: scanning technique, texture capture (yes or not, dimensions, colour space), nominal resolution…

On this subject, we want to comment that one of the projects we develop has a section of analysis and proposal of specific metadata structures for images and 3D models including essential technical aspects (proposed as mandatory) and developing optional extensions that cover from the specification of illumination to georeferencing.

Sketchfab, founded in 2012 in Paris, is undoubtedly the most used application for viewing and sharing 3D models created by different users. Initially, these users found it very difficult to show the 3D models to the public because of the intrinsic difficulty involved in finding the right tools to handle models in three dimensions. The release of *Sketchfab* was a success both at individual level (involving artists, designers, architects, or engineers) and at institutional level (museums, schools, businesses, etc.). Today, there is a community of more than 1.5 million registered users, with more than 3 million shared 3D models. The statistics on the number of downloads and views of models on this social network, as well as the number of followers, reveals the level of interest in this way of sharing virtual information. *Sketchfab* provides a good amount of resources with a very flexible configuration in

lighting, appearance of textures, postprocess filters, etc. The part reserved for metadata is, in our opinion, something that needs to be improved for the reasons explained in the previous paragraph.

Sketchfab has been used to disseminate 3D models from archaeological objects obtained by both 3D scanner and IBM techniques and catalogued in different collections (Fig. 6). The whole process involves scanning, processing, and uploading the 3D model, which usually takes between one to four hours depending on the size and complexity of the object.

The 3D model can be downloaded in OBJ format, according to Creative Commons Licenses. These licenses are a) attribution, others can distribute, remix, tweak, and build upon the model as long as they credit the author, b) Non-commercial, the model cannot be used commercially c) no derivatives, the model can be redistributed but not modified, and, d) share alike, the users can remix, tweak and build upon the model but the new creation must be under identical terms.

Every 3D model not only provides information about the technical procedure used, but also a historical description of the piece.

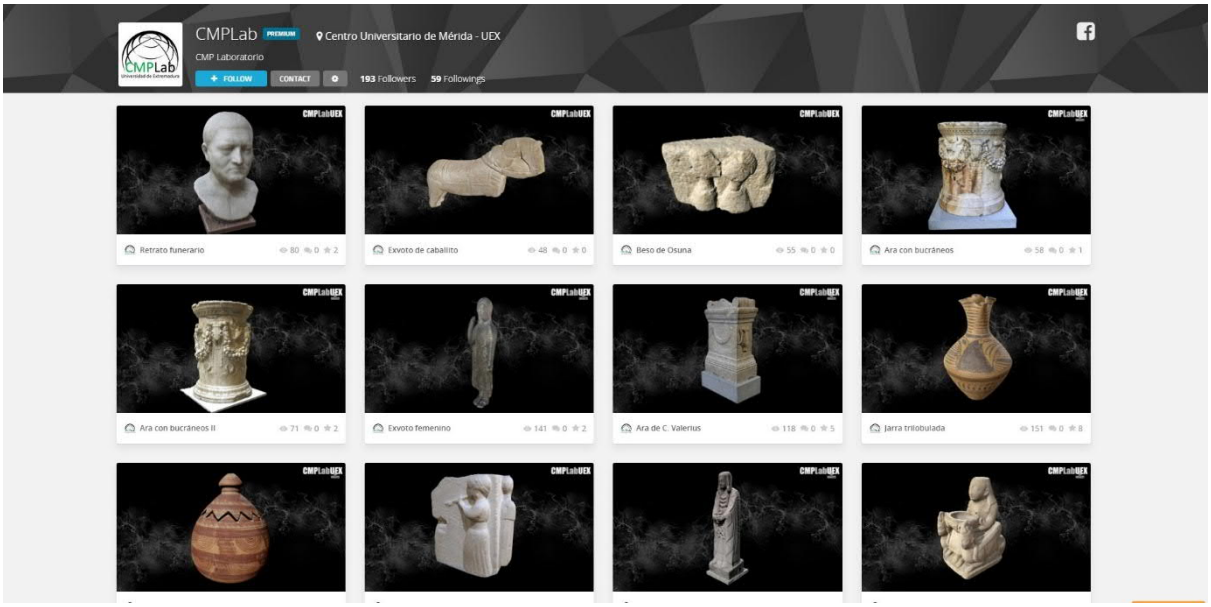


Fig. 6. 3D models obtained by both 3D scanner and IBM techniques and uploaded to Sketchfab[4]

Flickr is a website that allows users to share, store, sell, buy and download photos and videos over the Internet. It was created by Ludicrop in 2004, bought by Yahoo! in 2005 and finally owned by SmugMug since April 2018. Using free or professional accounts, authors tag their creations with metadata with the geographical location, and the type of license used (Creative Commons license) (Fig. 7). Of course, there are a number of rules of use and good practices related to privacy and copyright, with the idea of making images available to the public with a much higher photographic quality than those normally available in the online catalogues. Moreover, Flickr is a social network used to search and link photographs to personal blogs and other social networks. Flickr offers a free storage space for 1000 photos but it is possible to upload unlimited images in the paid version.

Usually, making and processing a high-resolution photography takes about thirty minutes. The process includes importing the images, adjusting the colour temperature, correcting the background, adjusting the texture level, resizing the image, and exporting it. Some specific protocols (filter or special techniques) may take one hour.

[4] https://sketchfab.com/secad

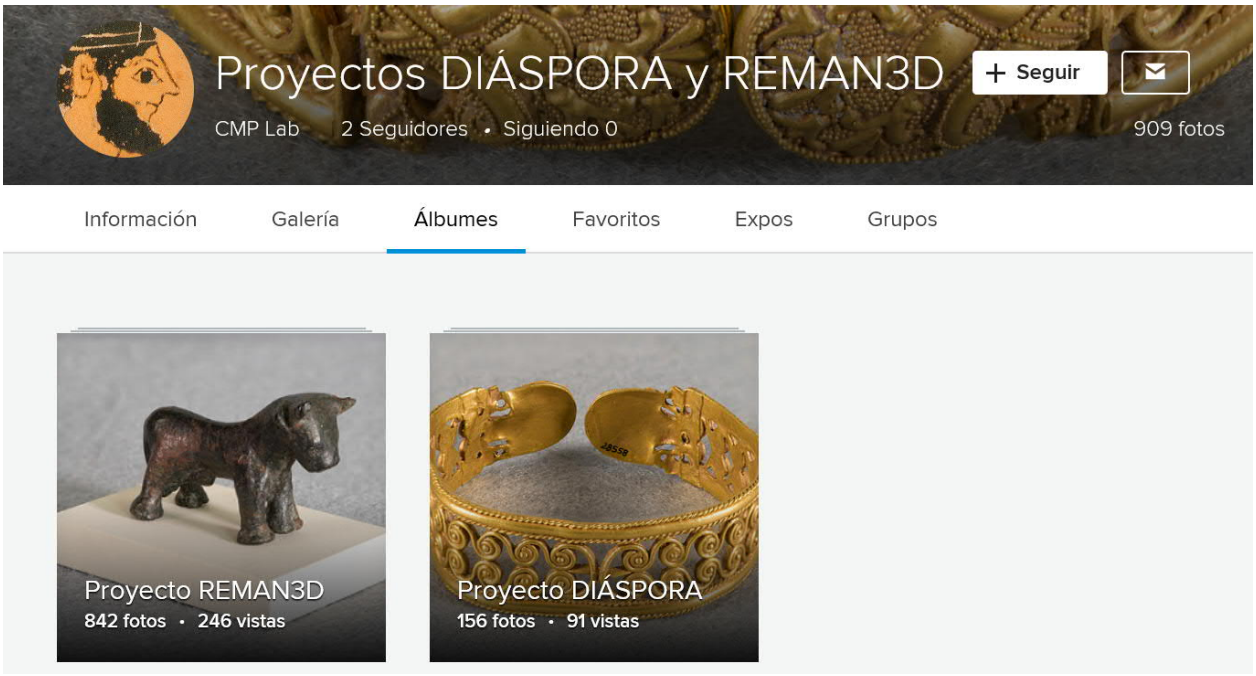


Fig. 7. Flickr page showing two collections and an example of the metadata.

In order to jointly disseminate texts, models and images, Wikis can be created (Fig. 8). This collaborative site, which can be edited by users, makes it possible to include all of the information about the piece – such as its original location, current location, description, history, image, 3D model, bibliography, or specific details and anecdotes –in such a way that it becomes a complete virtual catalogue of the historical objects. Links to Sketchfab, Flickr, official databases, or any other interesting resources are also included.

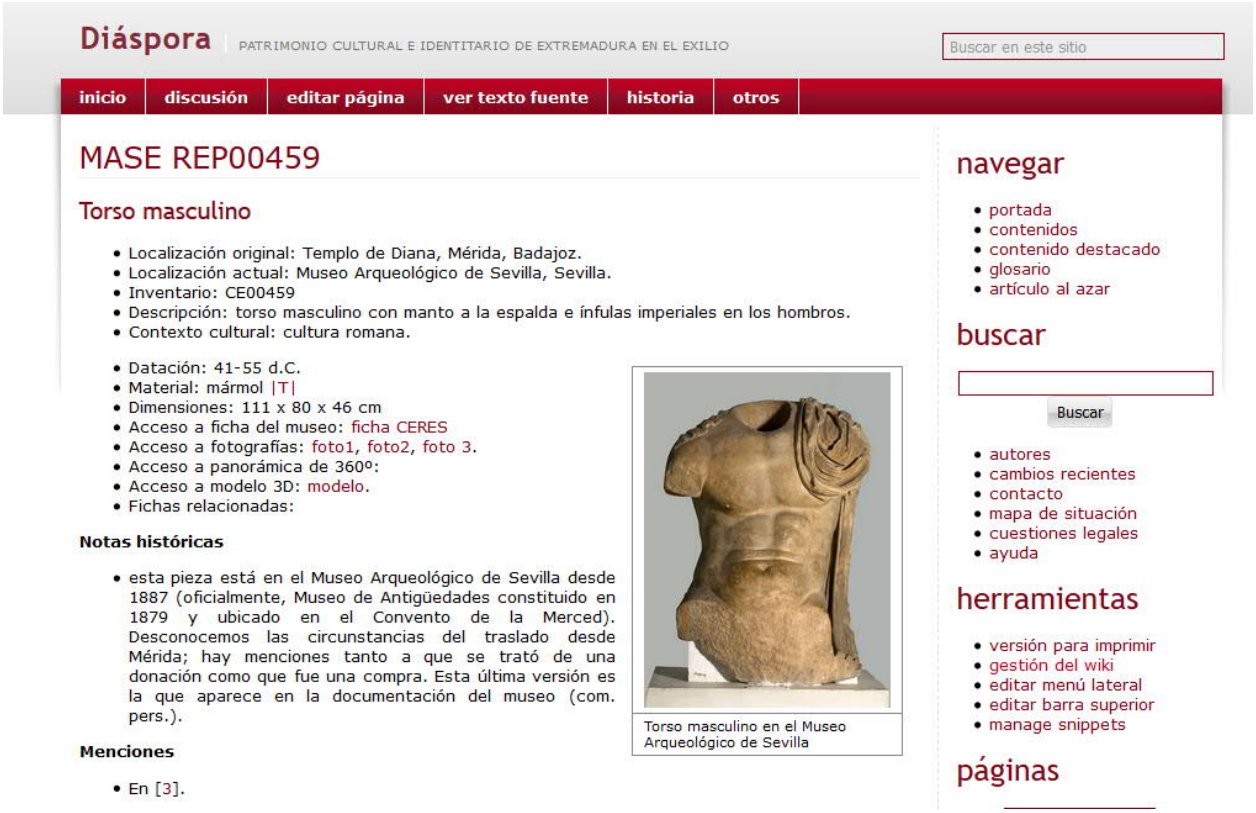


Fig. 8. Example of jointly disseminated texts, models and images using Wikis (currently in progress)

At this point, it is necessary for a multidisciplinary team (historians and technicians) to work together in order to achieve an accurate graphic documentation of the piece without losing the historical perspective.

INTEGRATING THIS TECHNOLOGY INTO ARCHAEOLOGICAL STUDIES

So how should researchers integrate these technologies into their studies?

Projects of this kind[5] should be approached from the perspective of transversality, both in terms of the working instruments that are used (files, objects, etc.) and of the interdisciplinary nature of the working team itself (Fig. 9). 'Objects' are approached through biographies in which it would be possible understand both the useful life of these pieces, which corresponds to their archaeological use, and the historical part that corresponds to their discovery up to the present day. Their varying steps - through different museums or collections - are defined both by historical contexts and by personal circumstances, sometimes resulting in their different national or regional identities prevailing in different episodes, and whether or not they have formed a part of the creation of these histories [Tortosa et al. in press].

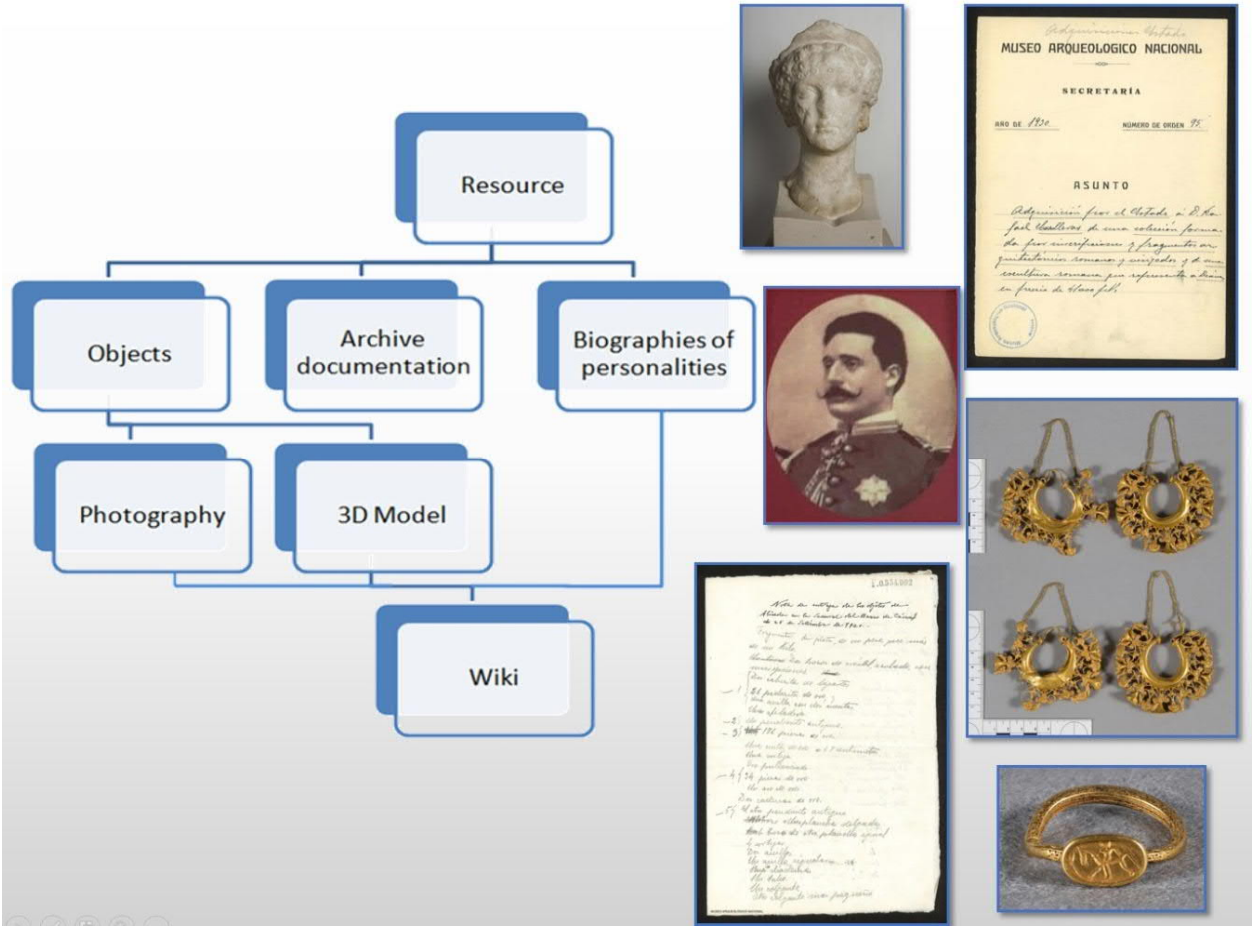


Fig. 9. Flow chart showing the working process.

Obviously, being able to access any kind of catalogue of elements is a 'treasure' in itself. The question is what do researchers require in order for this investigation to be effective and useful? Both technological and knowledge-based protocols should be created for these objects, in which their biographies should be integrated, considered as biographies of the entire useful life of an object, from when it had a specific function in the past, until it was discovered and forms a part of contemporary history as a reference of the past [Gosden and Marshall 1999] [Ballart

[5] Diáspora, a heritage in exile (Proyecto de I+D+i de Extremadura, IB16212); REMAN3D (Project HAR2017-87897, Ministry of Economy, Industry and Competitiveness of Spain).

Hernández 2012]. In this way, similar units of information would be obtained for different cultural contexts. In all likelihood it will take some time to achieve all these objectives, but it will be necessary to work towards them.

Another point of discussion is if the technology is being used to surprise. The analogue image of material heritage is replaced with its digital version, assuming that it is the best approach in order to achieve a more comprehensive dissemination of information, without questioning whether the archaeological context is being marginalised. The authors believe that the traditional analogue information of these objects can and should be included in this virtual proposal. Of course, as scientists there is an obligation to combine both choices. The answer can be found through transversality, both in terms of the study instruments as well as the research team (historians and engineers) and the globality, from a variety of study instruments (biographies, 3D models, high resolution photography ...) up to the multidisciplinary nature of the research team. This consideration about multidisciplinarity served as the basis for planning the projects.

One proposal is to create protocols that combine the technological and historical aspects of the pieces. With this aim in mind, a series of 'notebooks' have been created in collaboration with the National Archaeological Museum, called 'Iberian Notebooks in 3D' [Felicísimo et al. 2017] (Fig. 10). The aim of these notebooks is to show how building 3D models creates a new form of communication, through which archaeological objects can be presented and understood both by specialists and the general public, recognizing that all information has diverse audiences and goals.

Fig. 10. Iberian notebooks in 3D[6]

CONCLUSIONS

Through the historical discourse which has taken us from photography to 3D models, we have learned these techniques are not only useful to spread archaeological knowledge but they also become receivers of the objects' volume, helping to preserve their physical characteristics within a specific time frame, as it happens with the paintings of the Iberian receivers we have already seen. At the same time, the graphic representation of archaeological heritage facilitates the dissemination and conservation of these types of objects and, in some cases, the accurate virtual information would become an improved source.

These techniques of creating graphic documentation for heritage purposes have reached a stage of maturity, therefore it is possible to disseminate this kind of information through the Internet, using public and private

[6] http://dehesa.unex.es/handle/10662/7470

initiatives, social networks and websites, that support different formats, in order to achieve an effective channel of communication, allowing more effective sharing of material culture in large volumes.

In an image-based society, it is easy to abuse technology so the virtual representation of the archaeological objects replaces the historical background of the pieces and it produce a loss of its historical sense. The graphic documentation of the object can be studied from both a scientific and dissemination-based perspective considering that these perspectives are useful for researches and general public, who have different objectives. With this proposal we present a method of analysis extracted from the work experience in our two indicated research projects, in which we propose the integration of technologies based on volumetric representation and archaeological objects. A totality concretized in pouring all is information in the *wikidot*, an online instrument where the public can interact and choose the level of information they wish to access.

Another issue to emphasize is the lack of standards for metadata, not of the archaeological object itself, but of its representation or model.

In conclusion, at an informative level, the creation of these 3D models and graphic documentation in general is perceived as beneficial, above all because of their enormous accessibility. However, at a scientific level, as often occurs in processes that are constantly being modified, it seems that there is often a lack of reflection to confront and interpret historical processes: we are witnessing a digital explosion often from a solely positivist perspective; something that can also be seen with other technological methods applied to archaeology. It has been observed that there is a lack of deliberation about the proper application of new technology in cultural heritage. As a result, it is necessary to appeal to the normalization of the organization and management of all this information, in order to obtain these vast amounts of information that provide us with an overview of the historical processes that can be extracted from archaeological objects.

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