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Digitangibility: a digital prehistory for a sustainable society

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Abstract: The specific characteristic of archaeological research and of archaeological sites is the prominent dimension of materiality. Archaeological sites are places with material remains, archaeological museums are places with archaeological objects and archaeological interpretations are rooted in that materiality. This imposes a potential difficulty when considering the digital technologies in the context of museums and sites education: how to convene this materiality through a digital framework of reference, knowing that sensitive experiences are determinant in structuring options and concepts. I.e., how to escape from the potential neglect of the materiality prominence (which, if it occurred, would dissolve the archaeological dimension of the knowledge process) once the main vehicle of cognitive stimulation is perceived as... intangible? In this study, a first experimentation of gesture technology, through Microsoft HoloLens®, let to at least three reflexions about the future development of this technology for the promotion of archaeological researches and for the diffusion of knowledge and awareness about sustainability issues. Four conceptual levels have been identified and set in order to communicate and transfer to the user the results of the research and to explain the implications behind historical objects. These levels reflect the process of the archaeological research.

Keywords: Transdisciplinarity, archaeology, mixed reality, technological innovation, cross-cultural communication

Resumo: A característica específica da pesquisa arqueológica e dos sítios arqueológicos é a proeminente dimensão da materialidade. Os sítios arqueológicos são locais com vestígios materiais, os museus arqueológicos são locais com objetos arqueológicos e as interpretações arqueológicas estão enraizadas nessa materialidade. Isto impõe uma potencial dificuldade ao considerar as tecnologias digitais no contexto da educação de museus e sítios: como convocar esta materialidade através de um quadro digital de referência, sabendo que experiências sensíveis são determinantes em opções estruturantes e conceitos. Ou seja, como escapar à potencial negligência da materialidade (que, se ocorresse, dissolveria a dimensão arqueológica do processo de conhecimento) uma vez que o principal veículo de estimulação cognitiva é visto como... intangível? Neste estudo, uma primeira experimentação da tecnologia de gestos, através do Microsoft HoloLens®, permitiu pelo menos três reflexões sobre o desenvolvimento futuro desta tecnologia para a promoção de pesquisas arqueológicas e para a difusão do conhecimento e sensibilização sobre questões de sustentabilidade. Foram identificados e definidos quatro níveis conceptuais para comunicar e transferir para o utilizador os resultados da pesquisa e explicar as implicações por trás de objetos históricos. Estes níveis refletem o processo de pesquisa arqueológica.

Palavras-chave: Transdisciplinaridade, arqueologia, realidade mista, inovação tecnológica, comunicação transcultural

1. INTRODUCTION AND SCOPE

1.1 The nature of the project and the problems we are addressing:

In the last years, especially because of the financial crisis, the debate about the sustainability of prehistoric museums and archaeological research has increased. At the same time, we are witnesses of a cultural and technological development that is not always sustainable. Tourism moves huge masses of people all over the world generating a considerable impact on the environment and on monuments (Bhati & Pearce 2016; Lim 2016). Moreover, the web-of-things approach, not only to professional domains, is changing the way humans interact with the surrounding reality. On the other hand, war situations and complex political balances are contributing to turning people away from their common roots. The aim of the project is to build shared and aware knowledges of the present world starting from

communication of prehistory through the digital technologies. Energy, human impact, climate change, exploitation of raw materials and innovative technologies are all words that take part in the debate about the sustainable development, but they are also part of the daily life of each one of us because they represent the main challenges of our era. Finally, the same words have played a key role for human evolution since prehistory.

Archaeology and in particular prehistoric research can help rebuild the bond between people and their common roots, as they investigate relations among humans and the mutual influences between humans and the environment, that are the basis of the modern human society which is also the primary object of study of many disciplines such as ecology and economy (Mannoni &Giannichedda2014; Segrè2013). The results of this kind of studies, in the end, can be traced back to the analysis of sociocultural matrices and of human impact (Oosterbeek et al. 2016). Moreover, the understanding of prehistory conveys the understanding of evolution, cultural change and long-time processes within spatial diversity of resources and constraints, that are critical competences to face the contemporary challenges of climate change and sustainable development. The way the sources of energy has been intercepted by past humans for the first time and how the exploitation of raw materials has increased and changed till the present day are, for example, are well explained talking about the beginning of agriculture during the Neolithic era and the development of metalworking afterwards (Cavallini & Montanari 2003; Smil 2000). Unfortunately, the visibility of prehistoric evidence and archaeological sites is very reduced if compared with artworks and museums of arts and this is due to taphonomic issues related to the constituent materials of prehistoric artefacts (Figure 1).

Fig. 1 The Iceman and his equipment. The discovery of the so-called Iceman (a), on the Similaun mountain, thanks to special conservation conditions, has brought unique informations about the use of organic material during prehistory to create clothes and artefacts. The Chalcolithic man wore two leggings made from strips of domestic goat and sheep hide (b); a bearskin cap (c); shoes made up of several layers (the right one was found on his foot) The inner shoe consists of string netting made from lime tree bast (d); a belt that consisted of a calfskin strip (e). See: http://www.iceman.it/en/clothing/.

Fig. 1 O Iceman e o seu equipamento. A descoberta do chamado Iceman (a), na montanha Similaun, graças a condições especiais de conservação, trouxe informações únicas sobre o uso de material orgânico durante a pré-história para criar roupas e artefactos. O homem calcolítico usava duas leggings feitas de tiras de couro doméstico de cabra e ovelha (b); uma tampa de pele de urso (c); sapatos compostos por várias camadas (a direita foi encontrada no pé) O sapato interno consiste em rede de cordas feitas de basto de árvore de lima (d); um cinto que consistia de uma tira de pele de vitelo (e). Ver: http://www.iceman.it/en/clothing/.

The first tools produced by humankind, in fact, were probably made of wood, a material that is easily degraded by humidity and other environmental factors; moreover, even after the discovery of the metallurgical technique, a big part of the metallic artefact has been lost due to the reuse of the precious metallic materials. On the other hand, prehistoric archaeological sites don't show masonry, so archaeologists have to read the differences of the ground in order to detect ancient structures.

It should be also noticed that, as they are historical documents, prehistoric evidence need to be interpreted in order to be understood and communicated and often visitors at prehistoric archaeological sites don't have proper bases to understand what they are looking at. More should be done about didactics of prehistory: while in school programmes this topic is often under-treated, its educational potential, instead, is very high and worthy to be understood and reappraised.

All the facts exposed above could generates understanding dilemmas, both for general public and archaeologists, leading to the mentioned debate about the sustainability of prehistoric research. Forgetting the importance of prehistoric studies, means losing knowledges about our past and evolution and so the perception of a common root of the modern society, which is directly related with the rising of conflicts and wars, as well as non-sustainable behaviours.

Prehistory, instead, can tell us a lot about social and environmental transformations, exploitation of natural resources and development of human ability.

The prehistoric period represents a shared imagery of the past and a transdisciplinary field of study that integrates different disciplines (such as botany, zoology, geology and anthropology) to make interpretations of the archaeological remains. Thanks to those features, it can break down geographical and cultural barriers and it can also contribute on creating new and aware knowledges for social innovation and sustainable development, for instance, rethinking and improving the use of energy sources to reduce the human impact on the environment.

Digital technology is what can make the past visible. It is the *trait d'union* between past and present day. If on the one hand it could turn people away from reality, on the other hand it can becomes a new interpretative tool. The fact that, on our devices, the only tap of our finger is the cause of a variety of action can lead to some forms of alienation because to the same gesture are associated many different results. Therefore, in our opinion, it is important to invert this trend, improving the gestures through technology. With this in mind, digital technologies can become a new interpretative tool for at least two reasons:

- As they use the direct language of images, they allow to compare and integrate different concepts at the same time, without using any words. Thus, they are a valuable tool for the representation of data coming from transdisciplinary studies and for a cross-cultural communication.

- As they are a daily and widespread tool, they make visitors, especially the young ones, more comfortable in the exploration of the past. When visitors come to face an unknown and far world, digital technologies allow them to start the experience from a sort of comfort zone: a starting point wherewith people are comfortable.

Moreover, digital technologies can connect people with very different times and spaces and offer a visible context for the archaeological evidence.

1.2 Background information about the work and its significance:

In recent years the use of digital technologies for the promotion and fruition of cultural heritage has increased and many examples can be made looking at the international experiences (Madirov & Absalyamova 2015; Cirulis et al. 2015; Valentina et al. 2015)storage and research into collections, to use

multimedia, which include both traditional static visual information and dynamic information (such as speech, music, video footage and animation. Starting from the reproduction of Chauvet cave, to the reconstruction of the ceiling of the Bel's Temple in Palmira, destroyed by ISIS in 2015 (AA.VV. 2016), which phases are shown in Figure 2, cultural heritage is increasingly experienced through new digital technologies and their potential.

Storytelling techniques are often used for this purpose and, thanks to advantages in ICT, a big variety of smartphone application are developed in order to improve and favour culture tourism (Table 1)(Martins et al. 2017). However, it doesn't always happen in a sustainable way and more suitable tools to make it happen are required (Bhati & Pearce 2016; Torres-delgado & Palomeque 2014). In this regard is good to remind that the United Nations 70th General Assembly has designated 2017 as the International Year of Sustainable Tourism for Development (A/RES/70/193).

Augmented reality (AR) and 3D technologies are suitable tools for the representation and communication of the results of archaeological researches, especially

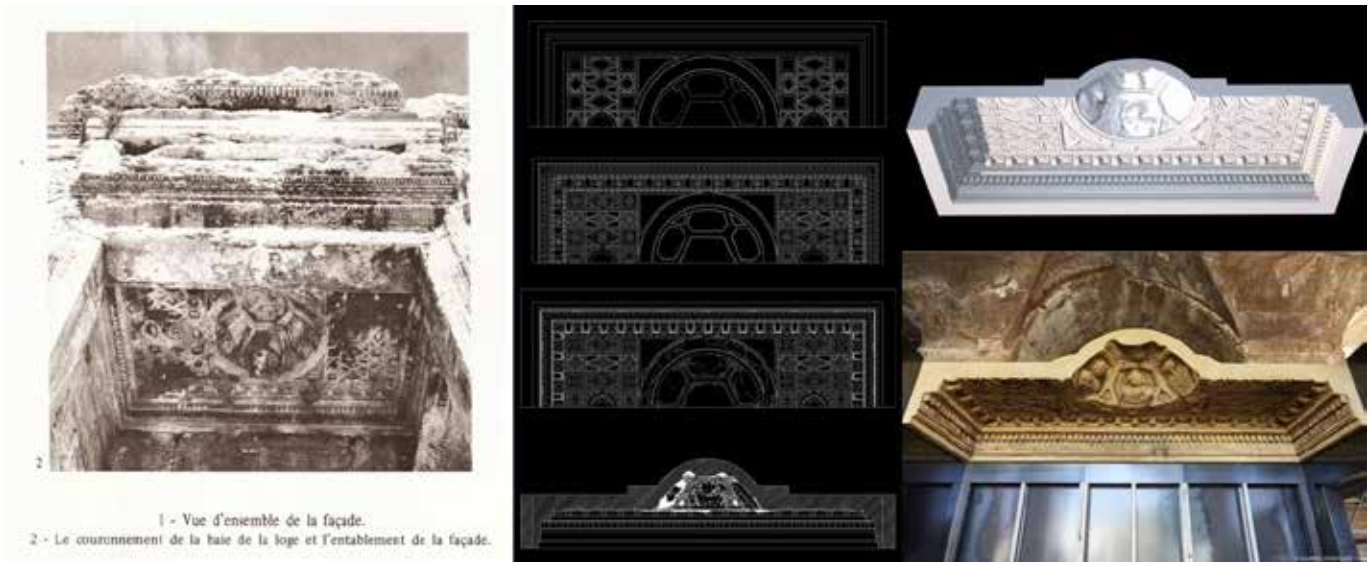

Fig. 2. The phases of the reconstruction of the ceiling of Bel's Temple in Palmyra: starting from the historical sources, through their vectorization and three-dimensional modelling, till the physical copy.
Fig. 2. As fases da reconstrução do teto do Templo de Bel em Palmira: partindo das fontes históricas, através da sua vectorização e modelação tridimensional, até à cópia física.

of prehistoric ones. One of the major advantages in these technologies is that they can make visible what has been transformed by time and difficult to see.

Augmented reality is intended as the combination of real world elements captured through a camera with multimedia elements such as text, images, video, or 3D models and animations(Martín-Gutiérrez et al. 2015). It comprises both a hardware and a software part. For what concern the hardware part it is constituted by a processor, a display, sensors and input devices. Many kinds of hardware devices exist, the most common ones are smartphones and tablet devices, that we often keep in our hands, but also smart glasses and head-mounted displays exist, that are increasingly used.

Mixed reality (MR), to which this study is addressing, is something more. It is an interactive augmented reality that involves the user's gesture. It allows to manipulate both virtual and real object all around as it is the result of blending the physical world with the digital world. The application of mixed reality goes beyond displays, but also includes environmental input, spatial sound and location. The opportunity to create true mixed reality experiences is set by combination of computer processing, human input, and environmental input (Figure 3 - https://developer.microsoft.com/en-us/windows/mixed-reality/mixed_reality). Thanks to *mixed reality* it is possible to put together in the same place and at the same time different kinds of information, what is

Tab. 1. Applications of digital technology for cultural heritage.
Tab. 1. Aplicações de tecnologia digital ao património cultural.

TECHNOLOGY	PRODUCTS	EXAMPLES OF APPLICATIONS IN CULTURAL HERITAGE
Reverse engineering (3D scanning, modelling and printing)	Virtual and physical certified copies of an object, at different scales. Printable 3D models of an object.	Reproduction at real scale of Chauvet and Lascaux cave: starting from the 3D acquisition of the sites (http://lacavernedupontdarc.org/en/la-replique/). Reconstruction of the destroyed ceiling of Bel's Temple in Palmira: through 3D modelling.
Augmented reality (AR)	Mobile apps to visualise additional informations about an object, just overlaying them to the sight of the real environment.	Skin and bones app at the Smithsonian Museum: to see the real aspect of the animals, framing fossils or bones (http://naturalhistory.si.edu/exhibits/bone-hall/).
Virtual reality (VR) and gaming technology	Virtual and interactive environments.	*Ara Pacis* virtual tour (http://www.arapacis.it/en/node/1007168). Garofalo Virtual Museum (http://www.muvig.it/it). Klimt experience, a multimedia exhibition (http://www.klimtexperience.com/). *Father and son*, the edugame of the National Archaeological Museum of Naples (www.museoarcheologiconapoli.it/it/father-and-son-the-game/). The Studio Play gallery at the Cleveland museum of art (www.clevelandart.org/blog/2016/10/20/experience-studio-play).

basically the final scope of every transdisciplinary research. This feature helps a lot not only during data analysis, to formulate interpretations, but also during the communication of the results to the public. The immersive environment, together with the display options and the interactivity of the contents, enable to explain the several steps of the research process and the implications that reside behind an object, for example a museum artefact.

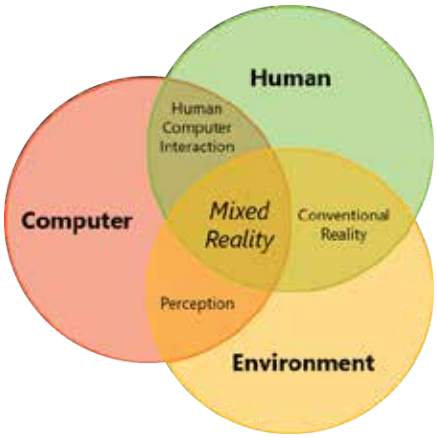

Fig. 3. A scheme representing how mixed reality combines inputs coming from three different fields of our daily life.
Fig. 3. Um esquema que representa a forma como a realidade mista combina entradas provenientes de três campos diferentes da nossa vida quotidiana.

3D manufacturing technology comprises different processes, in particular modelling, acquisition and printing.

- 3D modelling allows to design virtual object working with polygons.
- 3D acquisition of real object at different scales can be carried out using different solutions and avoiding the contact with the object, that is a key feature dealing with preservation of cultural heritage: photogrammetry and laser scanning are the most suitable techniques, both in indoor and outdoor environment, while structured-light scanners can be also employed but only indoor. Photogrammetry allows to obtain a three-dimensional model starting from the photos of the object. In this case the precision of the result depends on

the number of photos and on their resolution (dpi). 3D laser scanning can acquire shapes of real objects with a very high degree of definition (0,01 mm), transforming them in mathematical models (point cloud or triangulated mesh, depending on the instrumentation).

- Finally, 3D printing can use different techniques and materials to transform the virtual model, coming from modelling or from acquisition, into a physical object. Specific kinds of printers are required depending on the chosen material (gypsum, plastic, metal, etc.), on the precision requirements and on the intended use of the product.

For its educational potential, the combination of AR and 3D technologies is a valuable tool for in situ musealization of prehistoric archaeological sites and for communication: it allows to recreate past landscapes, modelling reconstructions of ancient structure and visualising them right where the remains has been discovered (Dieck & Jung 2017; Nincarean et al. 2013; Martín-Gutiérrez et al. 2015) Moreover, the georeferencing of these informations allows to create an interactive satellite navigator that can improve forms of sustainable tourism such as *slow tourism* (Ghadirian & Bishop 2008). This kind of representation of the archaeological record is of a particular interest also for the promotion of the territory, as virtual objects, obtained from the 3D scanning of the original artefacts, can go back from museums and deposits to their original contexts, so both tourists and local people can enjoy them. Looking at the present situation it seems that, thanks to technological development, society is losing its connections with the environment: we can boast an apparent independence from the environmental constrains, to the detriment of environmental considerations. Technology, that is now part of our ecological niche called *culture* could drive us away from reality, and sometimes it does. The isolation between people is increasing, despite of the large use of social media. An entire working tradition called handicraft is getting lost together with the knowledges about raw materials and with the ability of people to perceive spatial and historical contexts or to recreate them. Thus, we are probably living in a paradox where, even if we have access to a huge mass of information, we are putting in danger our world and our species, forgetting our past and how we got till here. History, in terms of awareness, can reverse this dangerous course but sometimes it's also so complex that becomes difficult to collect all the information in a comprehensive thought that makes us feel comfortable with our historical perception.

The present project aims to demonstrate that archaeological research, supported by digital technology, can help: (1) communicate knowledges about sustainability and sustainable development; (2) preserve and rediscover a heritage of gestures and the importance it had for the human evolution. The challenge we have accepted is to involve the gesture of experimental archaeology in education and communication, in order to develop a learning-by-doing approach to the study of prehistory, thanks to *mixed reality*.

2. MATERIALS AND METHODS

2.1 Methodology

The experimentation was carried out in a framework called MIX-Museum Interaction eXperience, which articulates knowledges and skills from different fields: academic and professional. Therefore, the aim of the platform is to *mix* contents and expertise coming from enterprises and academic research, in order to transfer new knowledges in the productive ecosystem. This may enable the development of a sustainable strategy for the promotion and fruition of cultural heritage through the use of ICT technologies applied to Humanities.

The workflow has followed several steps. First, a conceptual structure has been set looking at the

main features of the archaeological research, at its issues and at the message to be communicated. Then it has been necessary to collect materials and acquire content information. The focus has been put on the communication of the technological evolution during prehistory, so different kinds of digital content has been prepared for this purpose. They come from the documentation of the archaeological record and from the results of both traditional archaeological researches and experimental archaeology. Nowadays many three-dimensional models of archaeological artefacts are independently created by researchers and museal institution and are available on-line, as happens for some artworks of the British Museum. The 3D models used in this study has been selected on web sharing platforms, on the base of high quality requirements in terms of number of polygons, texture and quality of acquisition technology. Documenting production process through videos is an integral part of experimental archaeology and many scientific and didactic videos can be found on-line, often collected together in dedicated channels. An expert is able to recognize the operational chain corresponding to each object. Once selected the digital contents they, had to be prepared in order to run in a mixed reality environment.

2.2 Instrumentation

The Microsoft HoloLens® smart glasses are the elected tool to create and experience *mixed reality* environments with holographic contents, as they blend cutting-edge optics and sensors to deliver 3D holograms pinned to the real world around the user. Holograms are objects made of light and sound that appear in the world around the user, just as if they are real objects. They respond to users' gaze, gestures and voice commands, and can interact with real-world surfaces around the person (Figure 4).

In this study the volumes disposition has been generated using Unity®, a software for the development of video games and simulations for computers, consoles and mobile devices. All the virtual objects have been imported, modified and set in order to fit with a flat surface of reference, e.g. a table (surface recognition). Lights have been manually set to generate condition of lighting and shadows like the ones of a closed environment (ambient occlusion). Virtual objects have been imported and linked to actions generated by script in C# language for the following interactive use on HoloLens®**.** Finally, the application has been debugged and deployed in the Visual Studio 2017 environment in order be later tested on the HoloLens® emulator.

Fig. 4. Wearability of the HoloLens® ***glasses (a); the basic user interface with the starting menu (b); example of a three-dimensional hologram*** (c).
Fig. 4. Usabilidade dos óculos HoloLens® (a); a interface básica do utilizador com o menu inicial (b); exemplo de um holograma tridimensional (c).

2.2.1 Technical specifications:

Hardwares used:
-Microsoft HoloLens®
-PC desktop: Intel Core i7-5820K CPU 3,30GHz; 32 GB RAM
-64 bit Windows 10 Pro
-VB NVIDIA GeForce GTX 970
-Doble monitor EIZO EV2450

Softwares used:
-Visual Studio 2017 with Universal Windows Platform development and Game Development with Unity

-HoloLens Emulator and Holographic Templates (build 10.0.14393.1358) with Hyper-V support
-Unity 5.5.0f3

3. RESULTS

The process explained above have led to the creation of a mixed environment that combines real and virtual elements and with which the user can interact through his movements, his gaze and his voice (Figure 5). Once imported into the device in the form of an application, in fact, the three-dimensional models of the artworks can be dragged and explored by the user wearing the smart glasses. The user can also walk among the contents to get closer to objects or videos and to query for additional information interacting with the holograms.

The conceptual informations and the data coming from archaeological researches has been organised in spatial levels that overlay to the real environment. The framework comprises different kinds of multimedia supports: images, videos and three-dimensional models. The conceptual structuring of the data is reflected by the spatial distribution of the contents, which focus is the operational chain and the evolution of technology (Figure 6). The scope is to employ the possibilities of by *mixed reality* technology in order to make people aware about the implications that reside behind a museum artefact, in terms of human impact, environmental exploitation and technological development.

Therefore, four conceptual levels have been identified and set in order to communicate and transfer to the user the results of the research and to explain the implications behind historical objects. These levels reflect the process of the archaeological research:

Level 1 – the archaeological record. It is an overview of the technical evolution along the epochs and it is represented by archaeological artefact made of different materials (from the first lithic tools, through pottery, till metals) placed in stratigraphy.

Fig. 5. The user interface generated using Unity® software and the different typologies of input through which the user can interact with the contents.
Fig. 5. A interface de utilizador gerada usando o software Unity® *e as diferentes tipologias de entrada através das quais o utilizador pode interagir com os conteúdos.*

Level 2 – the operational chain. A 3D interactive model associated to a video of experimental archaeology allow the user to understand the specific features and the technical process that have generated the artefact. The user can physically drag off the object from the stratigraphy, using his hand, and place it on the facing table. This is possible thanks to Microsoft HoloLens® special mapping, that recognize virtual reference point in the real environment.

Level 3 – the exploitation of resources and the cultural landscape. A virtual reconstruction of paleoenvironment and of deposits of raw material used to create the object emphasise the close relation between humans and the environment.

Level 4 – the use. Reenactors and experimental archaeologists show something we wouldn't be able to see otherwise: how tools could had been employed by past humans.

4. DISCUSSION

The specific characteristic of archaeological research and of archaeological sites is the prominent dimension of materiality. Archaeological sites are places with material remains, archaeological museums are places with archaeological objects and archaeological interpretations are rooted in that materiality. This imposes a potential difficulty when considering the digital technologies in the context of museums and sites education: how to convene this materiality through a digital framework of reference, knowing that sensitive experiences are determinant in structuring options and concepts. I.e., how to escape from the potential neglect of the materiality prominence (which, if it occurred, would dissolve the archaeological dimension of the knowledge process) once the main vehicle of cognitive stimulation is perceived as... intangible?

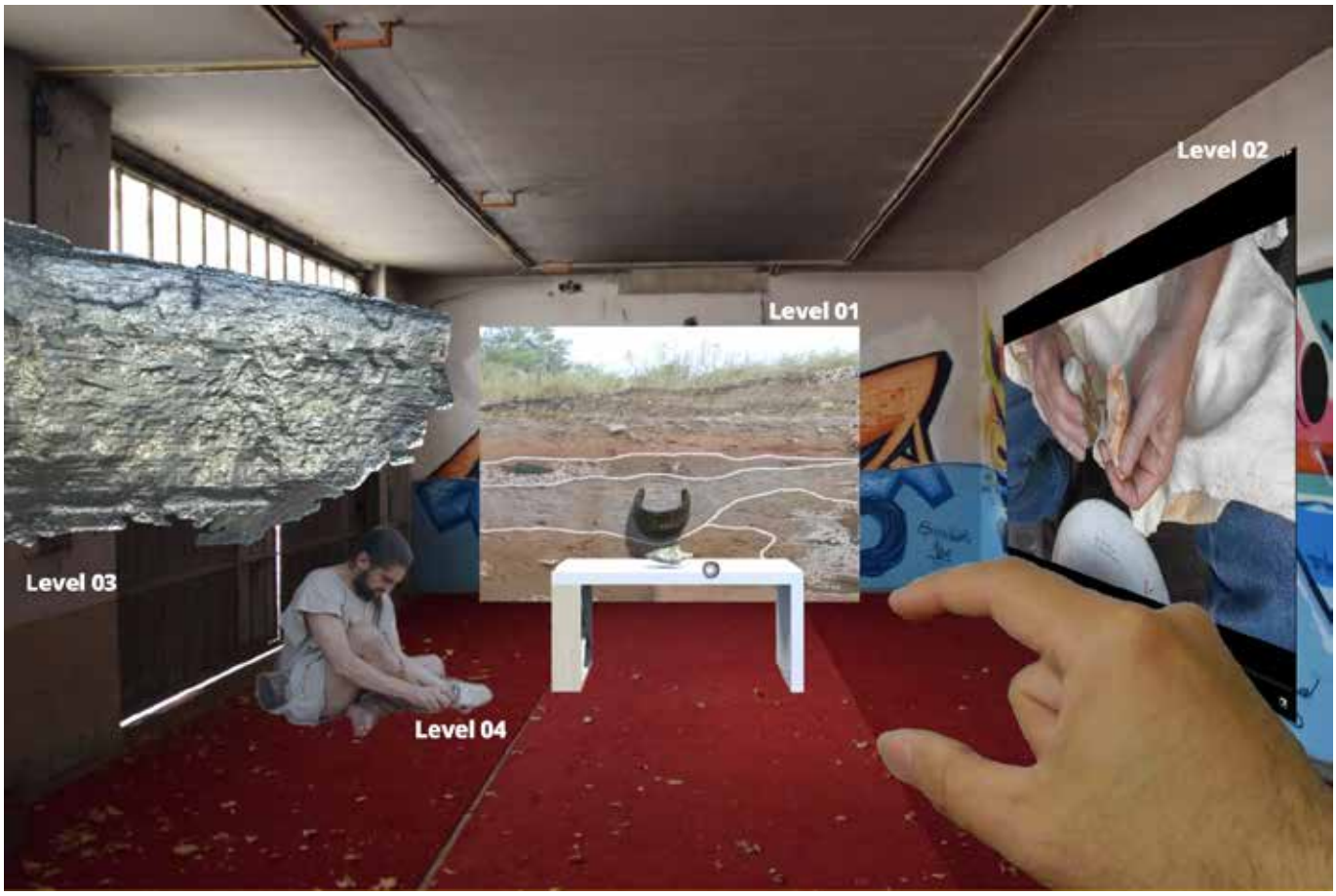

Fig. 6. The spatial distribution of the four conceptual levels.
Fig. 6. A distribuição espacial dos quatro níveis conceptuais.

This is perhaps the reason why the use of digital technologies has largely been restricted to a dimension of enhancing the attractiveness of sites and museums, and not as much as a means to convey proper archaeological knowledge. Experiments of this type tend to look for a compromise that seats in the sphere of scenography and cultural tourism, and not as much of education for a critical understanding of the archaeological knowledge process.

For sure those experiences are not negative per se, but they cannot in most cases, be considered as being embedded in a transdisciplinary exercise: the digital technologies are added to the, separate, process of knowledge production and education (as opposed to the properly transdisciplinary approaches of experimental archaeology, for instance, where the performance of the participant simulates past gestures and behaviour, thus allowing for a tangible experience).

Why do we think it is important to pursue research for a true transdisciplinary integration of digital technologies and other museological and archaeological processes? Not as much to "let know how it was in prehistory" (such type of passive assimilation of knowledge can actually be well served by existing interactive media), but because archaeology offers the possibility for citizens, children and adults, to strengthen their notions of time (by understanding its length), space (by understanding the diversity of material constraints of distinct places) and of cause (by understanding how phenomena separated in time may relate in given spaces thus establishing logical, rational and not magic causal nexus). Again, experimental archaeology helps in this direction, but its attractiveness has decayed, in face of the digital data tsunami. But can we convey the understanding of materiality through the digital alone?

Certainly, there are very good examples of the use of digital documentation to produce tangible contemporary simulations of the past (e.g. the replicas of Lascaux or Altamira). There are also excellent examples of digital accessibility through the media using complex technologies (the website of Lascaux, or the access to Chauvet). But these tools are either restricted to information dissemination (the websites) or restricted to very few sites due to their very high costs (the scale large size replicas). How can we conceive tools that will allow for a wider use, for the benefit of the majority of the population, with a non-primarily touristic purpose (even if this may also be of major relevance) and, above all, will educate people in building knowledge through the full use of their cognitive and sensitive competences.

In this study, a first experimentation of gesture technology, through Microsoft HoloLens®, has brought to at least three reflexions about the future development of this technology for the promotion of archaeological researches and for the diffusion of knowledge and awareness about sustainability issues.

Spreading knowledges about operational processes and exploitation of natural resources by humans is not just timeless, but instead is a very relevant topic even nowadays. Technologies are permeating and changing our way of life, but deeper and transdisciplinary scientific studies are necessary in order to make the development sustainable. The management aspect of energy and landscape, developed by ancient humans during prehistory, can suggest reflexions and favour debates about the exploitation of raw materials and about the reduction of waste. The advantage of *mixed reality* is that it is involving and interactive, so it put the user right in the middle of the operational chain, that is at the basis of production. This feature contributes on reinforcing critical thought and on making people aware about the whole set of relations that intervene between humans, energy and the environment. Moreover, from a general point of view, *mixed reality* helps to recreate logical and historical contexts for any object thanks to the power of images: a shared language that can be always creative and different. In the new, mixed space people are the protagonists of the learning process and this mean to be responsible for one own knowledge.

For what concerns the documentation of the archaeological artefacts and remains, it is increasingly carried out through the new digital technologies. Using the photogrammetric technique, for example, is possible to create and upload in the web digital 3D models of an object directly in the field. The same can be done using 3D scanners that allow also a very high precision of the acquired data, even if this last kind of instrumentation is more expensive. A first experimentation of Microsoft HoloLens® for cultural heritage done in this study, allows a consideration about the possibility of use directly the 3D models generated that way to build mixed reality application, without work on the models in order to reduce file size and, as a consequence, the data quality. This fact suggests that maybe a technological equalization, between the acquisition technology and the communication technology, is approaching and opens interesting possibilities about the direct use of 3D museal databases for the communication and promotion of cultural heritage.

This second reflexion lead to a third one: if coupled with an hardware for mixed reality, the possibility of digitize the archaeological material through 3D acquisition techniques, of record the operational chains of experimental archaeology and of modelling virtual environment through computer graphic, allows not only to reconstruct past scenarios, but also to build portable rooms of knowledges and bring them all over the world (with the artworks they keep).

Therefore, future perspectives could be the digital transportability of cultural heritage, the virtual implementation of museum collections, the fruition of those monuments destroyed or no more accessible due to war situations and, finally, the communication of the results archaeometric investigations and restauration interventions carried out on museum artefacts.

5. CONCLUSION

Every day people deal with digital technologies and society will not go back from this point. This fact makes the challenge of the research on the promotion and fruition of cultural heritage even more interesting, because it suggests the possibility and the need to design a strategy to use digital technologies against alienation mechanisms.

This first experimentation aims to be an example of the idea that the articulation of knowledges about cultural heritage with management skills and technological tools can generate innovation processes which could have a sustainable impact on society, as they can cross cultural and disciplinary borders while addressing organisational demands. In this view creativity, rooted in human beings, plays a central role as it is the driving force for changing.

Communication technology, collaboration between teachers and archaeologist, integration and involvement of the socio-cultural matrix through practical activity based on experimental archaeology and gesture technology can improve both prehistoric researches and transmission of timeless knowledge. In this process people and their daily context should be the centre and the starting point, in order to awake global consciousness and civil sense of each one. Thereby, it would be possible to think about resilient strategies to face social and environmental changes of our present.

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