

VISUALIZING LEONARDO AND MICHELANGELO THROUGH DIGITAL HUMANITIES, RECONSTRUCTION AND INTERACTION DESIGN

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Abstract

The field of digital humanities incorporates several disciplines, united at the cross-over between computer science and the arts, as well as by the aims of digital preservation, study, and dissemination of works of literature, art, and architecture. In this context, through the presentation of case studies curated by the authors, this contribution intends to share the approach and the research process for three-dimensional modelling designed to enhance appreciation of cultural heritage. This process extends from the selection and analysis of historic documents through to exhibition and interaction design for displaying, incorporating a wide range of advanced digital techniques that permit the analysis, management, and sharing of complex images and information from different spheres of knowledge in an integrated way.

Keywords

Renaissance Architecture, Digital Humanities, 3D Reconstuction, Exhibition Design, Interaction Design

1. *Research and design methods for digital humanities: towards a definition of standards*

The field of digital humanities includes widely different disciplines, joined at the intersection between computer science and the humanities, as well as by the aim of preserving, studying, and sharing, in digital form, works of literature, art, and architecture, both for the purpose of their greater understanding, and for example, so as to incorporate them into a museum. At this point, the field encompasses a wide range of advanced digital techniques permitting the analysis, management, and sharing of images and data in a complex and integrated way among the varied areas of expertise. In this context, through presenting case studies curated by the authors, this contribution intends to focus attention on the approach and the process of research and design for the reconstruction of complex content for permanent museum installations or for temporary exhibits. The discussion will address themes inherent in the selection and analysis of sources; three-dimensional modelling; and the content and media exhibited, both analogue and digital, for different target audiences.

The activation of positive processes of data connection and intersection, with broad

possibilities of pre-configuring solutions and settings, has enabled both virtual reconstruction and 3D modelling to become part of the disciplines of the history of architecture, urban studies, as well as restoration. Meanwhile, we see meaningful and effective examples of sharing and promoting cultural heritage, with the necessity of considering different ways of presenting reconstructions and therefore defining the style and the interactive tools, also calling on the discipline of design. So much so that today, the use of these techniques at the service of museum narration is found increasingly widely as the most suitable means to achieve educational goals with respect to methods established for scientific research, inserting exhibition projects inside of the most broad definitions of ICT (information communication technology) applied to the field of museum exhibit design (Vannicola, 2015).

An example of this is the work on Veneto villas carried out since the 1990s by G. Beltramini of the Centro Palladio of Vicenza and M. Gaiani of the Università di Bologna that has demonstrated how the study and the understanding of the works of an architect as well as the associated creative process, can find effective means of communication through the intuitive reconstructions offered by 3D modelling (Gaiani, 2012).

In the field of preservation, the research of Livio De Luca, director of the CNRS-MAP Laboratory of Marseille emerges as among the most meaningful contributions. The work has, more than once, demonstrated how the creation of different methodologies of non-invasive research, based on different reconstruction interpretations, allows for a preventive verification, and therefore is more respectful and aware when making choices during the restoration of monuments and historic buildings (virtual restoration). De Luca has, in fact, used digital modelling techniques for enhancing appreciation of monumental and museum complexes, recreating a unity of meaning within collections and building complexes that have been taken apart, as for example, in the case of the monastery Saint-Guilhem-le-Désert in France (De Luca & Lo Buglio, 2014).

This methodological approach is also widely used in the archaeological field where it is always increasingly necessary to link geo-referencing systems and 3D models with digital archives of text and visual records, in order to allow comparative analysis and scientific interpretation of extensive archaeological areas (Gaiani, 2012). The sites of Pompeii and Herculaneum, for example, have benefited from numerous projects in the sphere of 3D modelling (Benedetti, Gaiani & Remondino 2010; Irace, 2013).

Specifically, in the field of architectural history research, the introduction of three-dimensional modelling has broken new epistemological ground: this is true, for example, for the virtual reconstructions of architectural projects that were *never made* where the use of 3D models have given visibility to those creations that were never rendered tangible with actual constructions, but that still became part of design history and the shared architectural awareness among artists (Beltramini, 2000).

University research in the humanities has also begun to be receptive to the utility of these methods for representations and, slowly, to incorporate them: the Wired! Lab (2014) of Duke University of Durham, North Carolina, is certainly an example. Here a research group led by Caroline Bruzelius is in fact demonstrating how useful it is to rethink teaching methods in the field of art history according to the new cognitive and interpretative systems that these representative techniques bring with them (Huffman, Giordano, & Bruzelius, 2018): among the most interesting projects are certainly *The Kingdom of Sicily*

database with a geo-referenced database of iconographic sources, *Visualizing Venice* covering an entire area of the lagoon city correlating archival sources and digital tools, and the recent *Santa Chiara Choir Screen* which uses three-dimensional modelling to recreate architecture that has partially or completely disappeared.

At the European level, the need to include 3D modelling in large cultural heritage projects, such as the *Europeana* (2008), a unified European database dedicated to cultural heritage, has given rise to the development of specialized multimedia platforms for sharing three-dimensional digitisations (related to sculptures, buildings or entire urban areas), among which the *3D-Icons* (2012) project for the acquisition and digitalisation of monumental complexes and archaeological sites identified by UNESCO to have “extraordinary cultural importance”. This “initiative aims to expand this form of fruition to the 3D models of all partners in this broad network of participants, with the objective of creating a database of 3D models which is entirely accessible, in much the same way as a textual document or song” downloadable from the internet (Irace, 2013).

It is important to underscore that since the early 2000s, the international scientific community has raised questions about the validity and trustworthiness of digital reconstructions and representations, making it clear how necessary scientific rigor is at the base of any virtual reconstruction (Frischer et al., 2002): in 2009 with the publication of the *London Charter 2.1* (2009) a firm marker was established in the field of digital visualization methodologies for cultural heritage, promoting principles of internal coherence in studies, together with user comprehension and assessment, and simultaneously applying the concepts of accessibility on the internet and sustainability of use for this kind of modelling (Vannicola, 2015).

The methodological guidelines thus identified are then further specified, for the field of archaeological heritage, in the so-called *Seville Principles* (2011). Of great importance is the emphasis on transparency and traceability of multimedia reconstructions expressed through adequate documentation of the research sources used, methods of graphic reconstruction, and the interpretative choices implemented, to render intelligible the logical path chosen to produce the 3D modelling: only in this way is the scientific

value of a digital product ensured (Ioannides, Arnold, Niccolucci, & Mania, 2006).

The *London Charter* takes in its turn the second principle of the *Enane Charter* (2004), a document of 2004 of the International Council on Monuments and Sites (ICOMOS) on the interpretation and the presentation of cultural heritage sites, where it is specified that visual reconstructions should be based on detailed research whose sources must be clearly documented and whose results can be presented in more than one reconstruction version of equal scientific weight. In order to obtain multimedia reconstructions that have scientific value, it is therefore necessary to develop coherent creations, both from the point of view of the visual reconstruction, and from the content point-of-view: rigorous artistic and historic research and a philological analysis of the documents used are therefore fundamental to the creation process and are essential ingredients in a stratification of qualitative standards established over time. In this scenario, a necessary debate has begun and evolved on the ways these products fit into museums, including on their digital interface systems that make aspects of the research process and the resulting reconstructions more accessible (Ferretti & Smalzi, 2017; Ferretti, Merlo & Pini, 2019).

2. Targeting, reconstruction and exhibition design for Leonardo and Michelangelo

Coming to our work, for more than ten years we have been concentrating on projects on the technical and artistic culture of the Renaissance with particular reference to the work of Leonardo

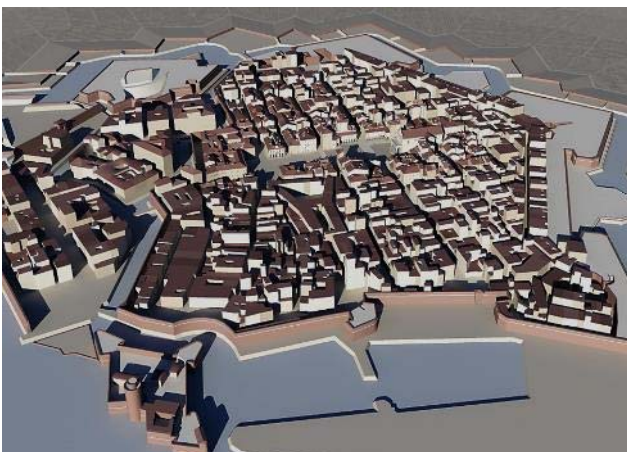


Fig. 1: *Livorno virtuale* 3D urban reconstruction, 2006

da Vinci and Michelangelo Buonarroti but not only, as seen in the first project we curated in 2006 with the historic urban reconstruction *Livorno Virtuale* made in collaboration with the PERCRO Lab (2006) of Scuola Superiore Sant'Anna di Pisa (Fig. 1).

The contemporary influence of Renaissance culture in general, and its major masters in particular, is pervasive and spread through exhibition, publicity, and publishing operations, often rather unscrupulous and superficial which frequently dissolve away the values of this culture in an incoherent accumulation of facts, not infrequently delivered in an anecdotal and sensationalistic key rather than scientifically correct and organically contextualized. Therefore, scholars have the work of organising content and giving significance to the past while approaching its dissemination with awareness and accuracy. In the context of theoretical and practical museology, in relation to the potential of the digital humanities, it is therefore necessary to find a balance between essential scientific needs and delivering the most intuitive and inclusive complex content, with attention for the target users identified each time.

This is what we aimed to do, on one hand choosing museum content that would arouse interest in various target audiences (from schools of every level, to cultural tourism) for their interest in the subjects or for particular historical or biographical circumstances of the creators; on the other hand, participating in an interdisciplinary team in which we were able to develop content for the practical as well as theoretical museum implementation, as we, as scholars, were acting as consultants for many aspects of the design.

First of all, we posed the problem of sources: as is known, both Leonardo and Michelangelo produced an impressive corpus of drawings which also includes important contributions for architecture.

Leonardo's interest for this theme can be painstakingly put together from hundreds and hundreds of pages in his codices: thematic compositions, typological diagrams, construction solutions, observations on the language and syntax of the architectural orders through the drawings of the artist, though without built examples, to make up a palimpsest that still waits to be understood in all of its components (Bambach, 2019; Frommel, 2019).

Beyond any hyper-specialism that risks

decontextualizing the effect of Leonardo on architecture of the Renaissance, innovative digital tools like the platform *E-Leo* (2007, 2019) of the Biblioteca Leonardiana in Vinci - for which we collaborated, - appears essential to nimbly delineate and reconstruct a complete picture often seen only as fragments (Fig. 2).

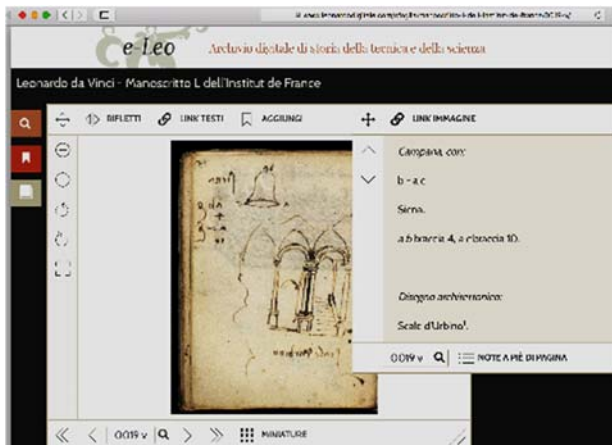


Fig. 2: *E-Leo* digital archive of history of technology and science, 2007, 2019

The platform was designed, beginning in 2007, by our group of interdisciplinary researchers. In this virtual environment, research on Leonardo's corpus of drawings was made possible with a simple and intuitive access method, also thanks to an update and new interface settings inaugurated at the end of 2019. The digital archive enhances appreciation and accessibility of the documents through four different ways shown in the main menu: *browse*, *glossary*, *drawing index*, and *search*. The various access channels, used freely or with different levels of filtration, that are created for Leonardo's corpus, guarantee multiple keys for interpretation and above all, thanks to tools like *text link* and *image link*, facilitate the orientation of the user in establishing correlations that are not always obvious between the drawings and the annotations of the artist (Taddei, 2017).

We carried out the construction of the digital resource, identifying architecture drawings from all of Leonardo's codices, cataloguing with references to the content if they are found on miscellaneous pages, and sorting them by subject represented; then we proceeded to the description of each drawing using a simplified and uniform terminology as much as possible; finally we classified and indexed each drawing based on the subject system of Iconclass (Corti, 2003) which proved itself to be practical for this kind of

application so much as to be used again in the project *Sei secoli di architettura per il luogo dei bambini. Fonti e immagini per una narrazione digitale* (2019) developed in collaboration with the Scuola Superiore Sant'Anna di Pisa (Fig. 3).

The result is a digital cultural product in which the complex and fragmented group of drawings is,



Fig. 3: Six centuries of architecture for the children place. Sources and images for a digital storytelling, 2019

above all, organized and analysed in a logical way, then it is made accessible for different target audiences with entirely innovative ways of consulting and studying the material, appropriate for different users, and resulting as more straightforward with respect to traditional tools for reproducing and analysing Leonardo's drawings.

The example of *E-Leo* reinforces the well-established understanding in the scientific community for the specific role of computer tools especially during the research phase and during the selection of sources in which to scientifically root each analogue or virtual reconstruction project, passing, therefore, from the moment of determining thematic nuclei to the interpretation and contextualization of the artistic proposal, up to the final set up of the guidelines for the reconstruction project (Kamposiori, Mahony & Warwick, 2019).

For Michelangelo, a more stratified tradition of study of his architecture drawings, and above all, the existence of a series of buildings built by the artist, makes analysis through digital methods a process which can enrich the understanding of his single projects or individual architectural examples. But what are the pathways that must guide our research in the context of digital humanities? We can distinguish three approaches

for which we will briefly cite both positives and negatives:

- an approach that we define as "centripetal" or rather projected almost entirely toward a public of specialists, using criteria and tools from within the art history discipline. This is a process that is marked by scientific rigor and characterised by complete traceability of the reconstruction process. In this case, the digital humanities can contribute in a decisive way to improve the interpretive gradient of the project. On the downside, the risk underlying this mind-set is its self-referentiality, besides the poor economic appeal for possible sponsors;
- an approach that we define as "centrifugal" or rather projected primarily toward dissemination, with the objective of targeting the broadest and most general audience. This is an approach that certainly finds a greater possibility of financing, but that may have built-in simplifications and misleading entertainment criteria. In this case, rewarding educational results in terms of clarity and expressive power can be appreciated, as for many projects designed for television broadcast, but are also vulnerable to a tendency to be banal and incorporate serious mistakes;
- finally, the approach that we define as "synthetic" — an interdisciplinary approach between analytical history and design. The pathway is an open comparative and interpretive epistemological type that organizes the three key concepts of museum communication: explanation, understanding, and interpretation with a specific and innovative attention for the interpretive moment. The media bearing this content contribute to the involvement of the spectator, thanks to models that are more or less dynamic, often positively hybridized between analogue and digital, that reconstruct with explanatory tools the hermeneutical operation that has been carried out.

3. *The CARMi Museum, Carrara and Michelangelo Buonarroti: from real model to the virtual reconstruction*

The final products of the so-called "synthetic approach" have various degrees of communicative power primarily in temporary or permanent

exhibitions: from the slightest holographic evocation, passing to the more nuanced materialisation of simple structures with emotional and didactic purposes, up to the complete and complex reconstructions with the maximum value for the specialised audience but also for many other kinds of users, thanks to the engaging appeal of the spatial configuration, as well as for the rendering of detail in artefacts and architecture. All of these results are identifiable in a recent creation we made for the Museo CARMi in Carrara, dedicated to the relationship between Michelangelo Buonarroti and the Apuan marble quarries inaugurated in June 2018 (Fig. 4).



Fig. 4: CARMi - Museum Carrara and Michelangelo, Carrara, 2018

A theoretical and practical museological project that has Michelangelo as its focus is absolutely a complex operation, but even more so when it assumes the function of selecting aspects that illustrate the link between artistic activity and the territory over a broad chronological span, keeping at the same time, the role of curator in mind, or rather that of the link between scientific research and dissemination. This is precisely the case at the CARMi in which, in proceeding with the exhibition narrative from the many pieces that make up the art of Michelangelo, the reconstruction is itself an operation of understanding. The visitor is invited to experience this to form a personal and specific access key to the extraordinary universe of Michelangelo. When pursuing an objective of expanding inclusion to knowledge of such complex and stratified subjects, it is fundamental to define a main pathway on which to structure the itinerary. The definition and highlighting of focus aimed at specific arguments, denotative characters or innovations, has thus

materialized the curatorial approach for the permanent exhibition of CARMI, which would first of all invite the public to reflect (Ferretti & Turrini, 2018).

The work on Michelangelo was in fact deconstructed in a single thematic area to allow differential subjective experiences, developed individually by visitors who then see photographs, video, holograms, facsimiles of drawings by Buonarroti and other artists, and original art works. An important role is played by 3D reconstructions, either real or virtual, and among these, the tangible scale model 1:1 of a part of the cornice of Palazzo Farnese in Rome is significant (Fig. 5): the aim was that of having the visitors vividly perceive the sculptural qualities of this element that Michelangelo had reworked from a classical model (Spolia Christi in the Forum of Trajan in Rome). This object, furthermore, has allowed for us to focus on the characteristic *modus operandi* of the artist in making an architectural design. In fact, Michelangelo created, as he had once for the New Sacristy, a 3-meter-long wood model in 1:1 scale which was placed at the summit of the palazzo during construction to show the patron, Pope Paul III, the sculptural effects of this solution in the context of the redesign of the facade, defined earlier by Antonio da Sangallo il Giovane and expertly revisited by Buonarroti (Ferretti & Turrini, 2018).



Fig. 5: CARMI - Museum Carrara and Michelangelo, Carrara, 2018

On the virtual side, CARMI also presents, among the various products, the reconstruction of Michelangelo's design for the church of San Giovanni dei Fiorentini in Rome (the subject of a first modelling project curated by E. Ferretti and P. Ruschi in 2011). In this case it was a matter of

"constructing" the structure of a building never before built on that plan, on the basis of the assembly of drawings and iconographical evidence (primarily the drawing of a lost wood model), an operation strictly connected to the study of the corpus of drawings of Michelangelo and in comparison with some architecture contemporary to the design of San Giovanni dei Fiorentini. This consideration is sufficient to highlight the complexity of the process at the basis of this reconstruction and the interpretative difficulties underlying it. In fact, when dealing with iconographic evidence that originates with different creators, the information drawn from them presented in certain cases discrepancies, if not outright contradictions (Ruschi, 2011).

All of this required a particularly careful analysis of the various drawings that were brought to light, as reference "documents", the engravings of Jacques Le Mercier (1607) and of Valérian Régnard (1683) that reproduced Michelangelo's wood model. This last is among the most precise depictions with the most details in plan and elevation. In particular, the fact that both the engravings contained a metric scale allowed for the scaling of the digital model (considering the width of the entire building, as indicated by Vasari, 12 Roman *canne*, each unit corresponds to $1/2$ *canna* = 5 *palmo*, 1.117 meters). The reconstruction of the plan and elevation in orthogonal projection has immediately shown — on the basis of sensitivity to the setting and the contemporary standards — some clear incongruences. The most critical aspects concern the sizing of the pilasters and the position of the windows of the elliptical plan chapels, set above three-centred arches. Even the plan and elevation posed some problems for making a geometrically correct and plausible reconstruction of the building.

In some cases, this is a matter of imprecisions in the engraving (but also of approximations or elements that are hard to read), like, for example, the incorrect geometry of the intersection between some volumes or in other cases, the desire to insert alternative solutions in the same drawing (like, for example, the windows of the lantern that are represented mounted flush with both the interior and exterior surfaces). In the final analysis, the project shed new light on the theme of the central plan for Michelangelo, rendering the elevations in a virtual way and showing the contribution of light to the definition of spatial

quality; bringing to a large audience the great effectiveness of complex spatial modelling and at the same time the detailed definition of decorative and architectural elements (Fig. 6).

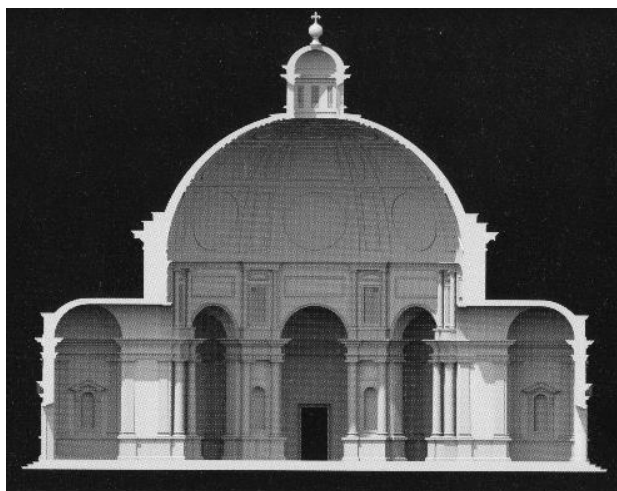


Fig. 6: 3D reconstruction of Michelangelo's project for the church of San Giovanni dei Fiorentini in Rome, 2011-2018

4. An integrated site specific installation for Leonardo da Vinci and Romorantin

Coming to the case studies on Leonardo, it is useful to recall both the fragmentary nature of the architecture in his drawings, and the value of the artist's contribution to the Renaissance reflections on compositional systems, spatial hierarchies, typology, to the language of architecture, and to projects on an urban scale. All this underlies many attempts over the years to create three-dimensional models to make the innovative nature of Leonardo's plans more fully comprehensible, sometimes forcing the scant information inferable from Leonardo's drawings, or above all, failing to recognize some important threads that cross through the codices, and — precisely because of this complexity of the sources — these are hard to detect and to thus bring out.

The production of facsimile editions of the codices has contributed in a significant way to spread this interest in architecture in Leonardo's activity, and today we are at a point to develop new reflections on what architecture is for the artist. Above all, we can ask if it is truly correct to speak of "Leonardo the architect" or perhaps if it is more right to talk of a meaningful interest of his for architecture and so, from time to time, to try to analyse the nature of his approach to these themes

and study the content that appears in his drawings (Di Teodoro, 2019).

With a similar approach, we have concentrated our attention on the theme of the palace in a case study that we illustrate focussing on a three-dimensional reconstruction of the royal palace of Romorantin; a stimulating example of a virtual modelling project with the potential to be physically made for an exhibition space. The project, promoted and coordinated by the Biblioteca and by the Museo Leonardiano in Vinci, from 2010 to 2011, has, in fact, led to the creation of a large model shown at Romorantin on the occasion of the show, *Léonard de Vinci: Romorantin le projet oublié* (Briost, 2011).

The authors participated in the working group that brought an interpretive model into existence from the schematic drawings of the artist and at the same time reconstructing more than one hypothesis for the elevations, operating in this way: first the representations of the complex of building was analysed from Leonardo's corpus of drawings; then reconstructions made previously were studied beginning with Carlo Pedretti's masterfully formulated one.

Successively, to obtain ideas for the delicate transition between two-dimensional and three-dimensional reconstruction, we turned to a thematically wide and multi-scalar investigation, choosing and synoptically analysing the contemporary architectonic and construction typologies that are then routed toward a schematic modelling process. In this way we started what is now an essential process for our reconstructions which is the progressive stratification of the so-called "semantic structure of the model" from the first investigation of dimensional specifics, to the spatial hierarchies and the relationships between openings and constructed volumes. All of this in the firm belief that a contextualized and comparative reading is a tool to give yet more strength and weight to museum communication for different target audiences.

The case of the stables is emblematic in this regard, indispensable for the reconstruction of the rear of the palazzo for which there have been alternative proposals synoptically presented to the public: in the Ms. B fol. 39r, as is known, Leonardo reflects on the theme of the *polita stalla* or clean stables, efficient and functional, for hosting a great number of fine horses (Di Teodoro, 2009). A second reconstruction proposal is inspired by the stables of the Palazzo Ducale of



Fig. 7: 3D reconstruction of Domenico da Cortona’s project for Chambord castle, 2010

Urbino, designed by Francesco di Giorgio Martini and certainly known by Leonardo, a careful scholar of the work of the Sienese architect.

A further requirement concerned making the elevations, with the study of these vertical and horizontal members that would have characterized the modulation of the external facades and the internal courtyards, further feeding the semantic structure of the model in search of the architectural grammar and syntax. In

this case, we investigated, on one hand, the theme of the architectural order in Leonardo's work and that of others, and on the other hand, we made the most of earlier virtual reconstructions that we had already made for the project of Domenico da Cortona for the castle of Chambord (Briost, 2011) (Fig. 7). The knowledge acquired with this type of analysis has allowed us to propose more than one reconstruction idea, scientifically based on congruent documents and on critical considerations developed in the light of the matrix of Leonardo's architectural culture.

Here we summarize these ideas. For the main structure there are two solutions for the plan and elevation: one that is closer to the architecture of Chambord; the other that explores the connections between the classical language of the avant-garde, developed in the Rome of Leo X, by Bramante and his students, and well-known to Leonardo in virtue of his Roman sojourn between 1513 and 1515.

The process of making the model began with the plans from the Codex Atlanticus, fol. 76v; then foresaw the creation of a geometric scaled grid in Florentine *braccia* and the subsequent drawings of the elevations (Briost, 2011). Coming at last to the topic of the exhibition installation itself, the

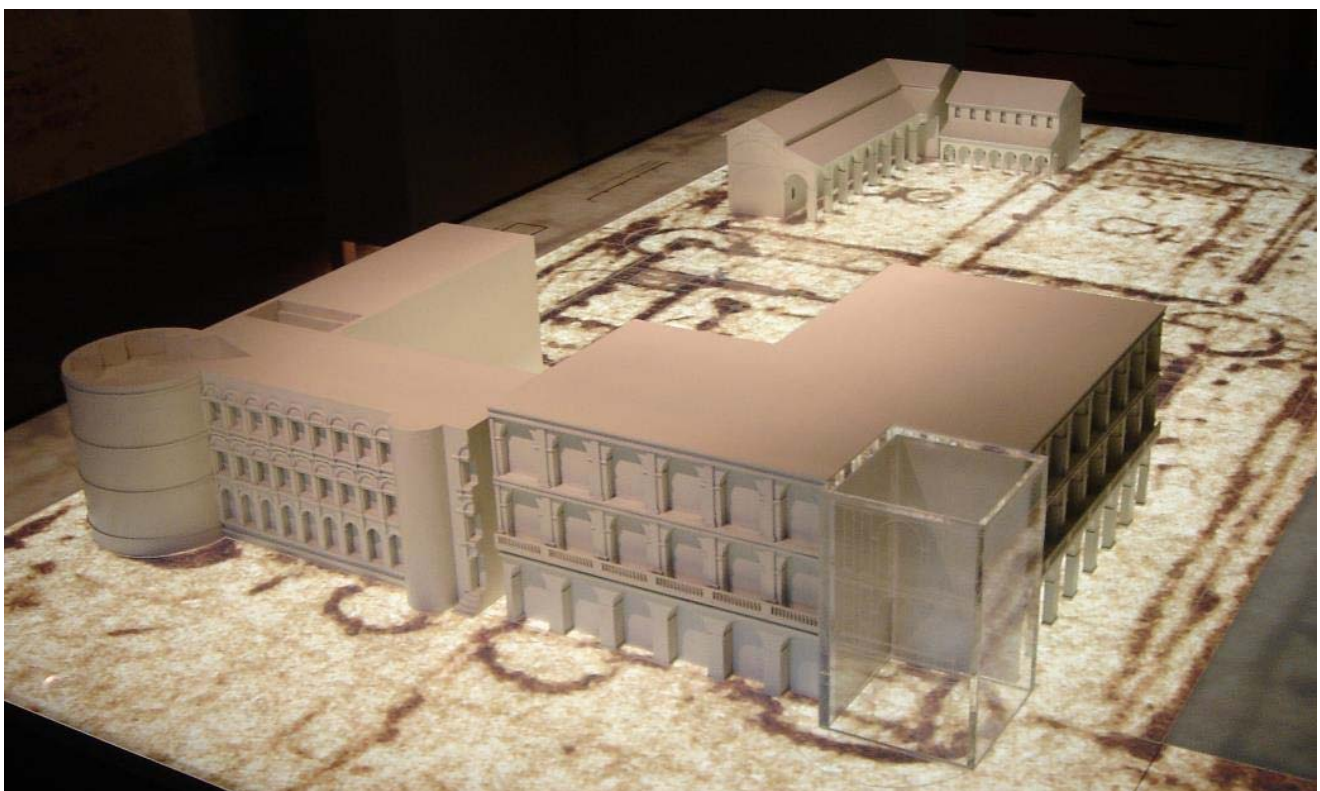


Fig. 8: Site specific installation with the reconstructive model of Leonardo’s project for the royal palace of Romorantin, exhibition *Léonard de Vinci: Romorantin le projet oublié*, Romorantin, 2011

various parts of the model were made in the form of stylized reconstructions, schematic in some ways, but not without some details like for example the detail of a section of the inside of the stable borrowed from the model of the *polita stalla*. The complex was then put together on the starting floor plan, backlit, using some materials and construction devices like transparent volumes (for the parts characterised by a higher degree of uncertainty) or hints of the internal layout in the corner towers. The installation of the exhibition at Romorantin then integrated documentation and communication systems of various natures, more or less traditional (including a gallery of images, videos, partial virtual projections) in a real site specific installation combining analogue and digital to present to the public the whole story of how the model was created and especially the semantic structure of our work, with synoptic and comparative presentations of the sources and the relative thematic and temporal contextualisation (Fig. 8).

5. *Leonardo and the waters: designing interaction with a multitouch digital desktop*

A last design example that is particularly important in this review again concerns Leonardo da Vinci and is characterised by marked features of interaction design. This is an experience that we worked on beginning in 2010, with subsequent updates as part of a general renovation of the Museo Leonardiano in Vinci, coordinated by the then director Romano Nanni and focussing on the theme of "Leonardo and the river waters".

The subject, complex and broad, includes various sub-themes such as water as a driving force, water as waterway, and the regulation of the rivers. It is, in fact, a group of not always organic considerations on Leonardo characterised by numerous facets, making the most intuitive and inclusive museographic reconstruction particularly difficult but at the same time representing questions of extreme interest and relevance for contemporary society, reinforced by possible connections with the geographic reality to which the drawings of the artist reference (Ferretti & Turrini, 2010).

The landscape, the topography, the place names, are in many ways thought to be invariant and can therefore serve as a conceptual diachronic and immediate connection between past and present. Furthermore, the topic raises awareness for a large section of the public to the ever more

urgent environmental problems, not only those connected to hydrogeological risk.

We can see that one of the cultural challenges in presenting Leonardo is that of removing the figure from the dimension of the "isolated genius" to the stature of a prominent personality within a rich and diversified context. For this reason, from the outset, we chose to combine Leonardo's drawings with contemporary or later map-making material, the subject on our part, of previous lengthy and in-depth studies that had allowed for the selection of a series of cartography documents, reproduced in high definition, thanks to a protocol specifically set up with the Archivio di Stato di Firenze.

As is known, in Leonardo's corpus, there are simple sketches for recording first impressions on paper, as for the drawings that are halfway between realistic surveys and design plans, up to formal presentation drawings. Within these graphic genres, again in the field of hydrology, we find various types of content which have been organised and divided by subject in an orderly and coherent grid. The same was done for the historic iconographic documentation of the collections of the Archivio di Stato di Firenze, so as to create thematic clusters that correspond to those found in Leonardo (Ferretti & Turrini, 2015). This all is with the conviction that a contextualized presentation gives even more strength to museum communication aimed at sharing our current understanding of Leonardo's universe. We will see how the technology can profoundly broaden the possibilities in this sense: a comparison in physical reality could only take place through traditional media like photographic copies and drawings, thanks to the use of new computer tools this is transformed with a new narrative perspective, but also one of awareness and reflection. We have therefore enumerated three levels of inquiry:

- the choice of museum content, in the absence of "original" works: that is the waters in Leonardo and in particular river water, a very complex theme that has however found a strong link with the territory in which the museum is located and can acquire further specific significance;
- the museographic requirements specific to a medium-small setting which is that of Vinci, which offers insights on Leonardo the scientist and engineer, targeting a broad section of the public (from schools of every level, to cultural tourists);

- the possibility of work groups to develop the theme both for the theoretical as well as practical museum implementation, as the figure of the scholar plays the role of the consultant for the design and therefore for the development of both plans.

The Museo Leonardiano of Vinci, created in the early 1950s was renovated and re-installed once in the 1980s recuperating and re-contextualising — especially the section dedicated to "Leonardo and the waters" — exhibition elements from the previous layout with innovative reconstruction systems (Nanni, 1994).

The re-installation represented an important step toward the greater involvement of the spectator, thanks to dynamic models that reconstruct, with the virtual, and with explanatory apparatuses, the function of objects and mechanisms. However, our project, carried out based on the most up-to-date criteria for interactive design for museum settings, was decisive in the section dedicated to water with interactive elements for the participants, which by now have become cornerstones of a contemporary museum project (Vannicola, 2015; Irace, 2013).

An open approach, dynamic and engaging, was the guiding star of our work for the Museo Leonardiano of Vinci. We were called in as scientific consultants as a team made by ourselves,

Leonardo Dolfi, and Alexander Neuwahl, to museumify, as we have, complex content, determining the themes, selecting documentation, and organizing the design of the technological devices, up to curating the concept of the interface with the final objective of applying digital technologies for the delineation of new creative and experimental scenarios (Bosco, 2019).

The first question to answer is how to introduce an average visitor to materials that are usually inaccessible, both in terms of direct observation — physical examination of the document and comparing documents — and in terms of intelligibility and content?

The solution was to choose a multitouch interactive digital desk panel that allows us to create links between documents and themes in a free and participatory way. The panel is both a screen for visualizing and a surface for working; it helps the visitor discover, understand, and study in-depth, with simple and intuitive navigation through content. It is possible to zoom with finger movements on images of very high resolution, visualize interactive maps with points of interest highlighted, select and move objects, or read, write, and draw with graphic notes. The response to gestures is rapid and natural and it is also possible to activate more than one menu for



Fig. 9: Multitouch digital table dedicated to Leonardo and the river waters, Museo Leonardiano, Vinci, 2010, 2018.

navigation on the panel so as to share and manage the content between more than one person sitting at the panel at the same time (Fig. 9).

The first operation that we carried out was that of imposing a conceptual order on the drawings to be presented with an index of the main themes and sub-themes that have influenced the classification of Leonardo's drawings, both in the documentation of the Archivio di Stato di Firenze, or that produced by the institutions that have governed the territory over the centuries. The addition of a common classification and interpretation grid for the two groups of documents has allowed for the activation of a comparison, with the view of stimulating observations and considerations in the visitor beginning with the circular menu (a configuration thought to be more intuitive for entry in the touch navigation system) subdivided in radial sections corresponding to the thematic classifications of the drawings (Fig. 9).

Each image was given its own caption with subject, date, and archive notations, so as to allow for various types of observation: from the simplest, purely visual approach; to an analytical orientation interested also in the nature of the document; up to a more complex hermeneutical approach. An added feature of the project is the referencing, where possible, of the Leonardian documents, and the cartography of the river channel, so as to create an immediate visual link with the surrounding territory. This section of the interface of the panel had a complex genesis: beginning with discursive descriptive solutions and progressing to more pictographic or schematic ones which ultimately proved to be more effective for audience comprehension (Fig. 9).

Moving toward the conclusion of this discussion, it is necessary to underscore that the undoubted potentiality of the interactive panel and the absolutely positive feedback from the public, at least on a qualitative level, in the first phase of its use, ought to be evaluated within the more complex picture formed over the lifetime of the installation. It is dynamic, susceptible to continuous verifications, modifications, and updates, both technological and content-based, and these correlate to a risk of compromising the initial coherence of the project.

Tools like the interactive panel — according to the international guidelines — invite a quantitative evaluation of user feedback, collected on different cohorts of visitors, hopefully also with

the use of devices to verify eye-tracking used for example, on the drawings of Leonardo da Vinci, by the Lutin Userlab (2019) in Paris.

Unfortunately, in the case of the Vinci museum institution, they have not carried out this kind of data collection over time, and they have made changes to the version currently in use at the museum, making a comprehensive analysis impossible. The interface has been redesigned with a loss of organisation and recognisability of content; the geo-referencing has been eliminated; the rich information supplied, such as for example in the captions, has been almost completely erased; the peculiar combination between intuitiveness and stratification of information levels for different target audiences is thus hopelessly lost. The absence of scientific and curatorial proficiency during the updating of the system has resulted in the total loss of the identity of the project.

6. Conclusions

All of these experiences document a path of scientific and design growth inescapably rooted in interdisciplinarity, fuelled over the years with prestigious technical collaborations providing the possibility for the authors to carry out curatorial roles in context in selecting and study of themes and sources, besides the role of consultant for practical museological planning, meaning contributing analogue, digital, and interactive exhibition choices.

Carrying out research based on an interdisciplinary approach involves great openness of mind and respect for mutual disciplinary identities. There is also a need for great availability to 'contamination' and flexibility in the organization of data, as well as in designing their informatic structure and visualization-form. Among the projects presented, the most fruitful experience was undoubtedly that linked to Leonardo's studies on architecture, both for the diversified composition of the skills put in place, and for the perspective that has opened up in recent times to lead to a further phase of the project, with new forms of evaluation of user satisfaction in the use of the E-Leo database.

The results of the work up to now described certainly mark a trajectory characterised by valid and meaningful acquisitions but for their nature, strongly connected to the context and at targets specific to which they were created, they leave open, at the same time, considerations susceptible

to further solutions more complex and dynamic than ever. The open questions that follow are offered to the scientific community to address the future design themes unravelling essential problematic knots in the field of digital humanities.

How to introduce an average visitor to a set of materials that is very dense and usually inaccessible, both in the sense of direct observation or of physical comparison, and in the sense of content intelligibility?

What is the right kind of media and the right mix to put together with the scope of creating a

clear and engaging exhibit in the physical space of an exhibition or a museum?

How do you create a completely new narrative point of view, but also facilitate comprehension and reflection on complex issues and interpretative processes?

And last, how to take on opportunities, in the most efficient way possible, for powerful and engaging tools that are also dynamic and multiform, and that necessitate quantitative and qualitative evaluation of user feedback, as well as maintenance and curatorial processes that continue over time?¹

¹ The article is a result of the research fully shared by the two authors. The authorship of the texts should be attributed

in a shared manner for sections 2 and 6; Emanuela Ferretti for sections 1 and 3; Davide Turrini for sections 4 and 5.

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