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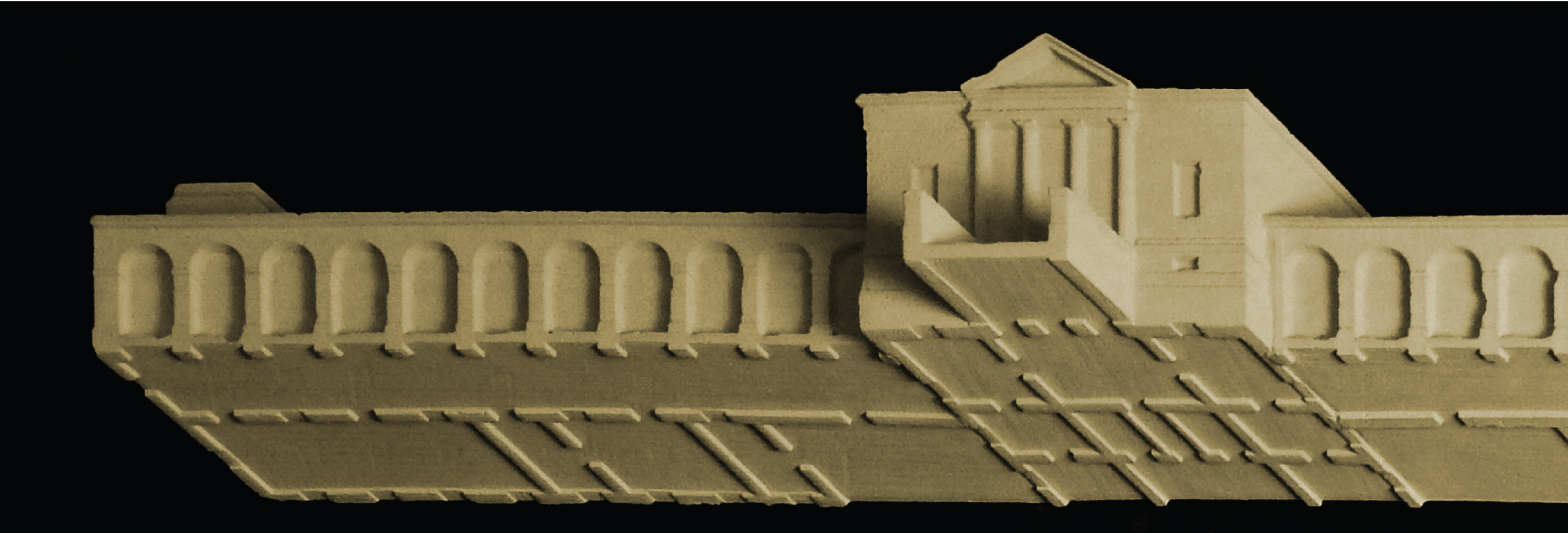

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ANALOG MODELS

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Cover
Oblique analog model of Andrea Palladio's Villa Emo, plaster, detail (A. Sdegno with B. Gernand, Protoservice realization, 2007).

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Editorial

Francesca Fatta

«Small is beautiful».
[Schumacher 1973]

For a journal that deals with architectural drawing and representation, the topic of this issue No. 14, *Analog Models*, edited by Alberto Sdegno and Pedro Manuel Cabezos-Bernal, is certainly of great appeal, and this is demonstrated by the high number of contributions arrived at the editorial office at the end of the call for papers.
Architecture, in its scalar reduction, arouses a fascination that is not limited to its seductive dimension as an object, but proves to be fundamental for its function of representation, which is valid, to use the words of Pierre-Alain Croset, "as the crystallization of a thought and as an anticipation of a constructive reality" [Croset 1987].
Even today, in the field of architecture teaching, the model constitutes a formidable support for depicting, simulating, experimenting, designing and expressing one's idea before creating a product, but also for communicating through the use of the volume, using the three dimensions: length, width, height, which leads to dealing with positioning in space: longitude, latitude, altitude.
Talking about models today is even more interesting given the increased awareness of the potential of digital; in this field the practice of drawing has received important stimuli to innovate and prove to be a decisive tool in graphics, as in design and, above all, in architecture. We believe, in fact, that it is impossible to think about architecture without drawing, and the physical model constitutes a closely related expression.

Already from the call for papers reference was made to the well-known essay by Massimo Scolari *L'idea di modello* [Scolari 1988] which clarifies the use of the model both as a tool of representation and as an object of communication of the architecture. In this issue we want to highlight the theoretical and concrete meeting point between geometry and drawing, between digital and analogue, in consideration of the contributions that 3D printing has introduced into the practice of architecture, from mock-up to the model defined in scale.
The index opens with a *Cover* entrusted to the curators who, for years, have characterized their research in the field of new representation and communication technologies such as 3D modeling, virtual reality and 3D printing.
The *Image* chosen to comment on for this issue is the axonometric model of House X by Peter Einsenman, described by Paolo Belardi. The three-dimensional representation follows an unhinging geometric principle that relates the 'three-dimensional reality' and the 'axonometric transformation'.
The selection of contributions took into account four focuses: the first, *Micro Architectures and Mock-ups* is opened by the essay by Marco Gaiani, curator of the exhibition *Palladio designer* (Vicenza, Palladio Museum, 12 April - 5 May 2024). The contribution frames the production of both analogue and digital models in a theoretical and experiential context, also taking into consideration the motivations that guided them.

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For the second focus, *New Materials for New Technologies*, the editorial team has chosen to open with an essay by Eduardo Carazo Lefort and Álvaro Moral-García which deals with the importance of the material with which the maquette is made, considering it not so much a casual physical support, but an expressive quality chosen by the craftsman, such as, for example, the great Renaissance and Baroque production of wooden models for architecture.
Riccardo Migliari opens the third focus affording the theme *Models as Drawings* taking us back to the essential value of projective geometry and the geometric relationships that are established between the different elements of the object for the reconstitution of the forms represented in space.
Finally, the fourth focus, *Models of Structures, Structures of Models*, opens with Adriana Rossi's contribution on the need to use the model to understand complex structures.
The theme of the model also found further confirmation in the *Readings/Rereadings* column with the intervention of Veronica Riavis in the famous monographic issue *Rassegna, (Maquette)*, No. 32, of 1987.
Speaking of recently published volumes, this issue features reviews of: the curatorship by Laura Farroni, Manuela Incerti and Alessandra Pagliano *Rappresentare il tempo. Architettura, geometria e astronomia* (Representing time. Architecture, geometry and astronomy); the volume *Linguaggi Grafici. Fotografia* (Graphic Languages. Photography) edited by Enrico Cicalò, Valeria Menchetelli and Michele Valentino, the monograph by Adriana Rossi titled *Sant Cugat del Vallès. Verso l'accessibilità dei dati* (Sant Cugat del Vallès. Towards data accessibility); the monograph *Città sospese fra capi e fiumare. Strategie identitarie* (Cities Suspended Between Capes and Rivers. Identity Strategies) by Marinella Arena; the proceedings of the second conference *DAI. Il Disegno per l'Accessibilità e l'Inclusione* (Drawing for Accessibility and Inclusion, Udine, 1, 2 December 2023), edited by Alberto Sdegno and Veronica Riavis.
Finally, some of the main events organized or sponsored by the UID that have taken place in recent months have been reviewed: the new edition of *1 libro : 1 disegno* (1 Book : 1 Drawing) which marks the fourth year of life and has maintained a large following among all UID members; the *Seminario informativo, formativo sulla valutazione* (Information and Training Seminar on Evaluation) held in Rome on 14 March 2024 and organized by the UID commissions on Training and Research; the *Giornata di studi internazionale eXploЯA* (eXploЯA International Study Day) organized in Rome on 15 March 2024 by the group of young winners of the 2023 Cardone prize; the event *Dialoghi con gli archivi di architettura* (Dialogues with Architectural Archives) scheduled in Pescara on 10 May 2024 by the Archives commission; the symposium *Giornate della Rappresentazione e Conservazione del Patrimonio culturale contemporaneo - Prima Edizione. Un Dialogo Possibile: Rappresentare e Conservare il Contemporaneo* (Days of the Representation and Conservation of contemporary cultural heritage - First Edition. A Possible Dialogue: Representing and Preserving the Contemporary), curated by the School of Conservation and Restoration of Urbino, DIAPReM/TekneHub and the Department of Architecture of Ferrara, on 30 November 2023; and the symposium *Innovazione e Internazionalizzazione della Ricerca. Esperienze nazionali e internazionali innovative a confronto tra memoria e amnesia* (Innovation and Internationalization of Research. Innovative national and international experiences comparing memory and amnesia) organized in Ferrara by the Internationalization and Innovation commissions of the UID, on 19 March 2024.
Numerous other meetings that have taken place and are taking place in recent days will be present in the next issue.
Finally, I would like to give a preview of issue 15 of the journal which is currently being prepared for December 2024. The theme is *Representation Inside and Outside the Landscape*, edited by Maria Grazia Cianci with the studio Balmori Associates and Darío Álvarez Álvarez. Once again a dialogue has been chosen with one of the disciplines of Area 08 Engineering and Architecture, and the landscape, as the curators write in the call for papers, intends to address scholars of these themes, inviting them to reflect on the relationship between representation and landscape, between description and interpretation, between "being inside" and "being outside" of the landscape itself.
I conclude with sincere thanks to the authors, the editors and the reviewers of this issue, to the entire editorial committee, and in particular to Valeria Menchetelli and all the editorial staff for the great work carried out once again with great quality and punctuality.

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Oblique Analog Models

Alberto Sdegno, Pedro Manuel Cabezos-Bernal

Introduction

Every architectural drawing is by its nature the result of a combined operation of projection lines and intersection with a plane, which is usually a sheet of paper. Even a sketch, in its rarefied figuration, evokes such operations for a representation of a design idea or an executive work, in an unequivocal icasticity.
To the physical model of architecture different attention is given, involving a concrete materialization in reduced, real or dimensionally enhanced form of an equivalent morphology. Nothing to do with projection or intersection, but it's an extension into real space. Those who study representation theory cannot exclude to question the possibility of associating the two afore mentioned operations with the stereometry of a physical model.

Since the advent of the digital, among the few adjectives that can uniquely connote the three-dimensional, plastic, material model, undoubtedly is to be ascribed the term 'analog', which qualifies an architectural object for a peculiarity of its own: it clutters our tables and gives us –in addition to the visual sensation– the haptic pleasure, the smell of the material of which it is composed or the sonority at the simple touch; in clear contrast to a processing all contained exclusively within a computer.
So many can be the declinations that describe the model: from architectural micro-models to full-scale mock-ups, in the ideal path linking the two cities of Mildendo and Brobdingnag in Jonathan Swift's novel

This article was written upon invitation to frame the topic, not submitted to anonymous review, published under the editorial director's responsibility.

[Swift 1997], in which Lemuel Gulliver first finds himself disproportionately overdone by a multiplication factor of twelve units, and then underdone by the same multiplier. But also models made with new materials and innovative technical devices, at any scale of reduction, from casts to thermal supports, constructive stratagems that have received special attention especially with the advent of new technologies. Or anamorphic and deformed models that simulate graphical representations –which we will focus on in this essay– whose theoretical value becomes indispensable both for making the object and for fully understanding its figurative stratagem, as in the case of early Eisenman's houses or ephemeral models used in the field of visual perception and in exhibition, stage, and film. And finally, functional models, such as structural solutions –from Antoni Gaudi's catenaries to Pier Luigi Nervi's prototypes– or for sound and visual verifications, to which the contents present in some treatises, from Vitruvian machines to Leon Battista Alberti's "bare and simple" models versus "embellished" ones [Alberti 1546, p. 27v].
Unlike the drawing, however, the physical model can distract attention from its natural peculiarity, namely, being –as Massimo Scolari recalled– "an instrument of initiation for generations of architects who in the realization of objects in the form of small architectures were preparing themselves to build in a big way" [Scolari 1988, p. 16] and considered by Scolari himself "ultimately the best representation of architecture" [Scolari 1988, p. 16]. If we want to question the not immediately noticeable potential of maquettes, we must associate it with a strong theoretical value in the course of its realization. That is, we refer to the generation of deformed models of architecture that evoke specific geometric projections. It is not a coincidence that such experimentation is reserved for a small part of work in the history of figuration, to which only a few scholars have decided to devote themselves, with the aim of linking theoretical contents of the discipline of drawing to artifacts of a purely practical nature.
We will focus our attention on the oblique deformation of architectural models, which can only be done downstream of a rigorously theoretical investigation of the axonometric projections that hold the key to understanding such artifacts.

Axonometric deformations of digital models

Oblique axonometry is one of the representation systems that has had the greatest impact in the field of architecture. Its main advantage lies in the possibility of observing in true size some faces of the model, those parallel to the projection plane, while the edges perpendicular to it are affected by a reduction coefficient that depends on the direction of projection. This way of evoking three-dimensionality on paper is simple and intuitive even without knowing that it is the result of an oblique projection and, therefore, has mathematical concreteness and graphic operability. In fact, very ancient representations have survived that intuitively depict a drawing that could be equated to an oblique axonometry, such as, for example, some first-century frescoes found in Pompeii or Leonardo Da Vinci's drawings of the famous war machines.
Nevertheless, oblique axonometries have not always been well regarded by geometry purists, such as Gaspard Monge, as drawings without mathematical rigor.
According to Joel Sakarovitch [Sakarovitch 1997, p. 133], Monge did not want his students to see illustrations of treatises such as Jean-Baptiste de La Rue's stone-cutting one [de La Rue 1728], which contained some sort of oblique axonometries.
However, when Pohlke's theorem [Pohlke 1860] was proved by his disciple, the German mathematician Hermann Schwarz, in 1864, such representations were mathematically legitimized. From then on, oblique axonometry reached the status of a rigorous representation system, especially in its two particular cases such as military and cavalier axonometry.
A military axonometry is obtained when a model is projected obliquely, onto a projection plane that is parallel to its horizontal faces. Its name comes from the fact that it was a type of axonometry widely used in treatises on military fortifications, to see the ground plan in true magnitude. When the model is projected obliquely onto a projection plane that is parallel to any of its vertical faces, a cavalier axonometry is obtained. Its name derives from the certain similarity of this type of views to the way a rider mounted on horseback would appreciate constructions when observed frontally, saving the differences in what the horseman would see, more similar a frontal perspective.

Undoubtedly, human vision is closer to a perspective representation. Spatial perception can be evoked by two perspective images forming a stereoscopic pair, which is the basis of virtual reality devices. The visual system perceives depth by means of certain pictorial-perspective cues. These monocular cues play a fundamental role in the theory of visual perception. For this reason, perspective is one of the most widely used representational systems to convey the spatiality of the scene to people who are not accustomed to the graphic reading of other types of projections such as axonometric ones.
It is difficult to assess the similarity of the mental image evoked in our mind by an axonometric representation, whether oblique or orthogonal, with respect to what we perceive when we visualize the real model with our eyes. Our brain is able to interpret the pseudo-perspective cues offered by axonometries because of their resemblance to perspective. An axonometry is quite similar to perspective when the point of view is far from the observed object, since, in this case, the projective rays are almost parallel and the convergence effect of the parallel lines, typical of perspective, is less evident. However, the lack of convergence of axonometries tends to induce certain perceptual distortions that the viewer has to get used to and learn to interpret, in the same way as a newborn child has to learn to see, relating the visual cues he perceives to the world around him.
Axonometric drawings are more abstract than perspectives because they lack pictorial depth cues that help establish scale and distances, such as height relative to the horizon and relative size between near and far objects. This grade of abstraction is even more noticeable in oblique axonometries, since they can be distorted to a greater or lesser degree depending on the projecting direction angle.
For istance, when projecting an object with an oblique direction of 45° with respect to the projection plane, the reduction coefficient in the axis perpendicular to the projection plane would be equal to one. This means that it could be measured in real magnitude on any of the coordinate axes of the resulting oblique axonometry, but this representation would be highly distorted and its three-dimensional evocation would be far from the real perception of the model. For this reason, especially in Anglo-Saxon countries, the so-called 'cabinet projection' has been widely used. It is basically a cavalier projection in which the reduction factor is 1/2 This reduction makes that the represented model is perceived more natural and similar to the real model. So, what would be the ideal reduction factor to evoke the shapes and volumetric features of an object with an optimal fidelity?
In order to determine this value, we can perform a perceptual experiment like the one shown in figure 1. There are shown several oblique projections of a cube using different reduction coefficients in military and cavalier projection. The aim is to determine the option in which the cube is perceived as closest to our mental image of an ideal cube. This perceptual test is carried out year after year with a new group of architecture students and very similar results are always obtained. In the case of military axonometry, the majority of students choose the cube represented with a reduction coefficient of 0.7 as the most proportionate option, while in the case of cavalier projection they choose the one corresponding to a reduction coefficient of 0.6. It is curious how our perception works so the value obtained for the military is slightly different from that of the cavalier projection, given that both representations of the cube are identical images that have simply been rotated one with respect to the other.
Therefore, it is up to the designer to choose between a reduction coefficient that offers a closer and more proportionate image in relation to the real object, or to opt for a simpler and more abstract option in which, using a coefficient of 1, the graphic model can be measured in true magnitude in all axes.
Certainly, this degree of abstraction is what arouses the interest of many architects of the modern movement and Bauhaus artists in these kinds of representations, such as the well-known axonometries of Theo van Doesburg or some of Piet Mondrian's drawings (figs. 2a, 2b). With these drawings, the authors delve into art movements such as neoplasticism and elevate architectural representations to the status of artworks.
The maximum abstraction level was reached with the drawings by John Hejduk (fig. 2c), who creates his masterly style by projecting the object in such a way that one of its coordinate planes is parallel to the projection direction, that forms 45 degrees with the rest of the

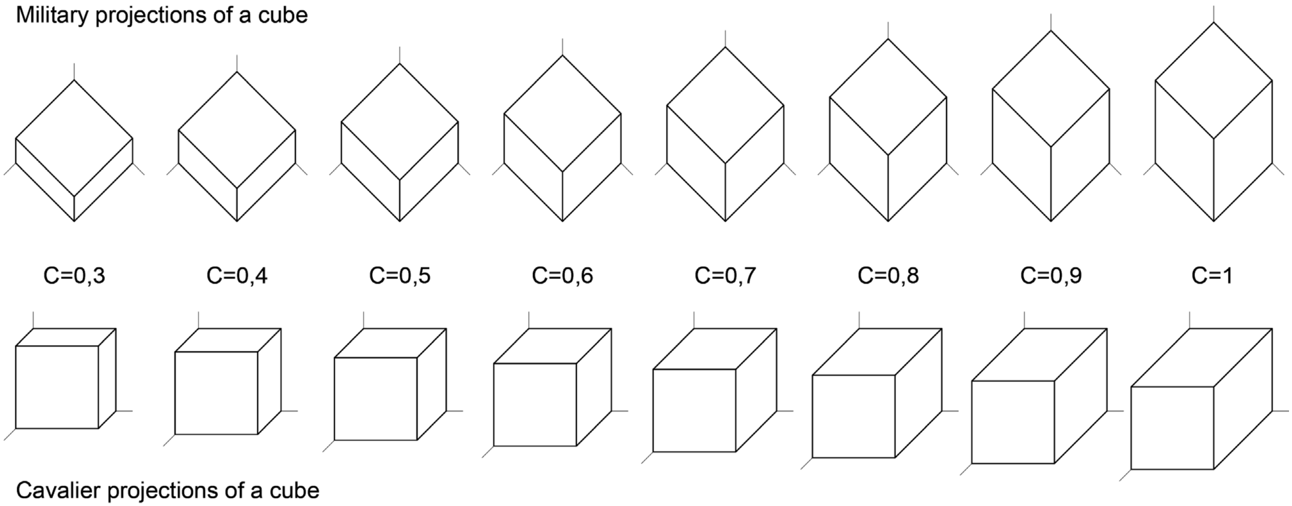


Fig. 1. Different oblique projections of a cube to determine the proper reduction coefficient C (P.M. Cabezos-Bernal).

coordinate planes. The work acquires a certain cubist character, as two of the coordinate planes are projected in true maagnitude, which remind some of Le Corbusier's paintings (fig. 2d).
The interest in this type of representations remained alive in renowned architects, such as Peter Eisenman or Arata Isozaki but, in recent years, oblique axonometries suffer a worrying abandonment, mainly due to the change of paradigm that supposed the arrival of CAD software. Most programmers must consider more convenient or simpler to allow only obtaining orthogonal projections and perspectives from a 3D model and not oblique projections.
In the current scenario, in which modeling in three dimensiona is mandatory, this limitations imposed by the most widespread CAD programs lead most users to use only orthogonal axonometries and perspectives in their representations, so it is the easy way. To overcome this drawback and obtain military or cavalier models from a three-dimensional model, it is possible to perform a projective or affinity transformation, which consists in transforming an orthogonal axonometry into an oblique projection. An affinity relationship can be established between an orthogonal projection and an oblique one, as shown in figure 3. It shows how a cube is projected onto two planes by means of a cylindrical projection. One of the planes is orthogonal to the projection direction, therefore, an orthogonal projection of the cube is obtained on it. The other plane is oblique with respect to the projecting direction and also parallel to the horizontal faces of the cube, so an oblique projection is obtained on this plane, specifically a military axonometry of the cube. The affinity relationship between both projections is defined by three elements. Firstly, by the affinity axis, which is the intersection between the two planes of projection. Secondly, by the affinity direction, which is perpendicular to the affinity axis, and thirdly by the affinity ratio *R*, which can be determined by means the relation $R = A_2S/A_1S$.
It can be observed that this affinity relationship is equivalent to perform a non-uniform scale change in the direction of affinity. Therefore, an orthogonal axonometry can be easily obtained from a 3D model with any CAD software and then transformed into an oblique projection, which can result in a military or cavalier projection, by being scaled in the direction of one of the coordinate axes of the axonometry (fig. 4).
This operation can be carried out by means any graphics software that allows non-uniform scaling.

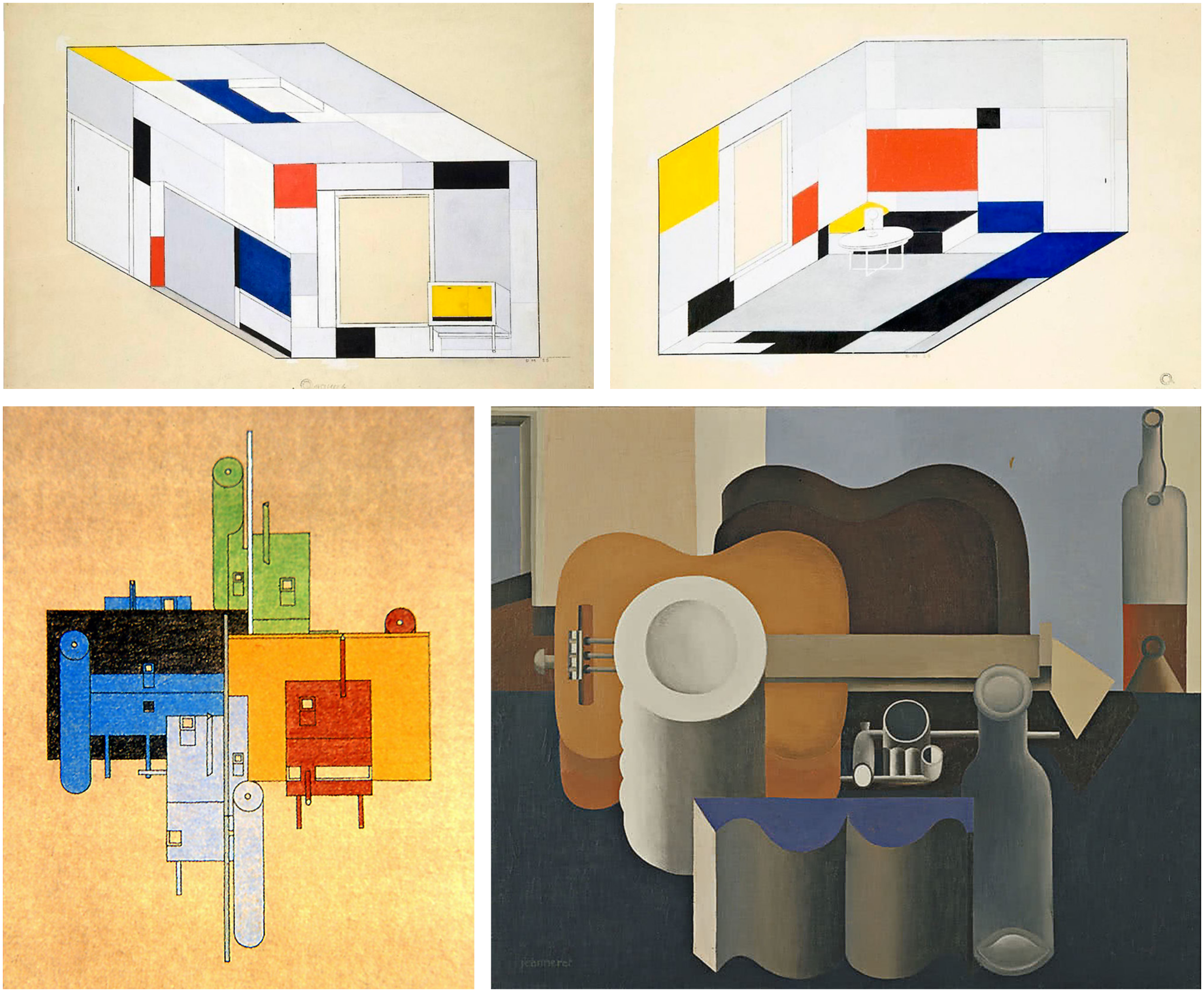
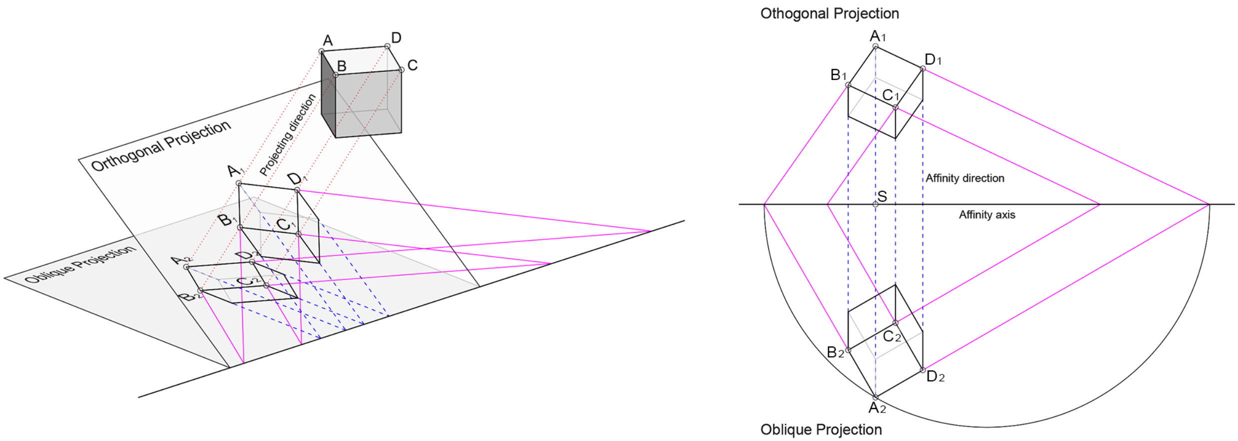
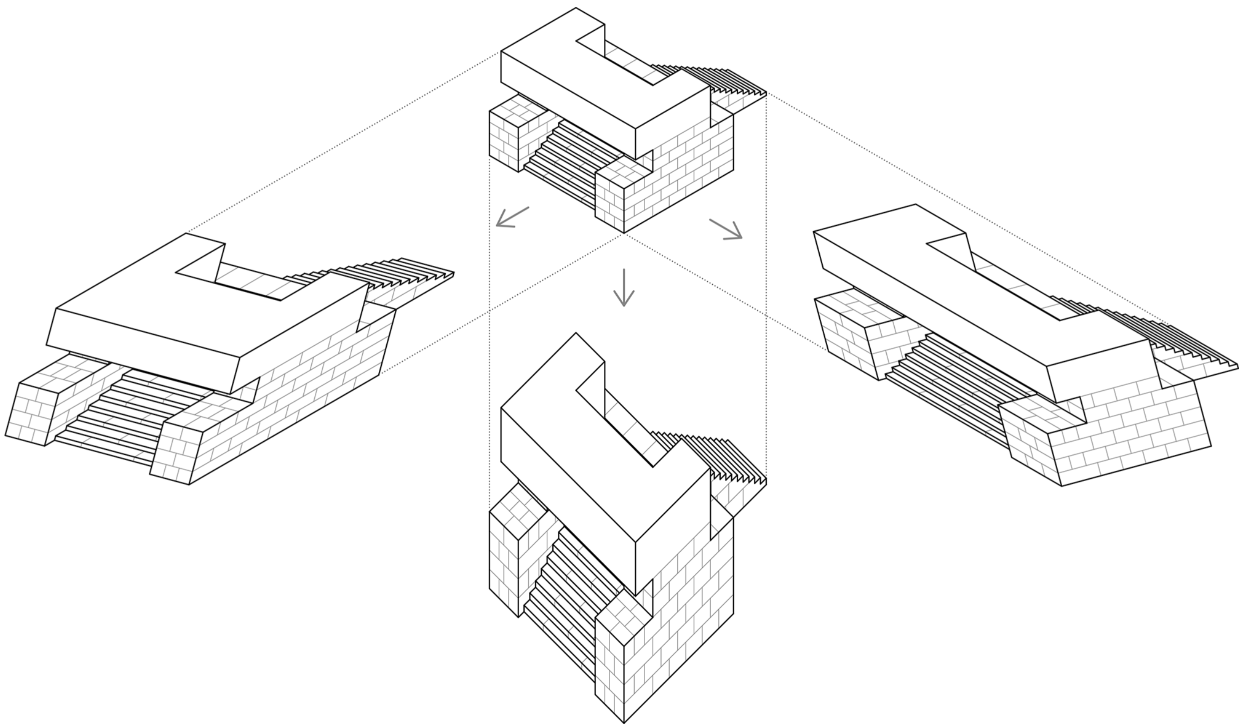


Fig. 2. a, b (top): Piet Mondrian, Color drawings for the salon of Ida Bienert, 1926 (Dresden, Staatliche Kunstsammlungen Dresden); c (bottom left): John Hejduk, Oblique axonometric drawing of the North East South West House, 1977; d (bottom right): Le Corbusier, Still Life, 1920, MOMA (Museum Of Modern Art).





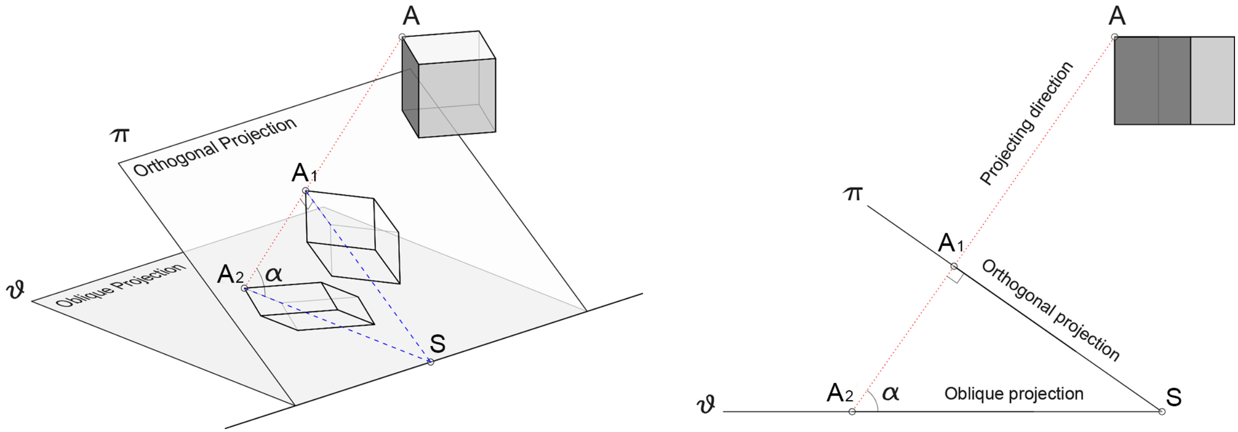
FFig. 3. Affinity relationship between orthogonal and oblique projections (P.M. Cabezos-Bernal).

Fig. 4. Transforming an orthogonal projection into oblique by applying a non-uniform scaling (P.M. Cabezos-Bernal).

For example, in *AutoCAD* this option is possible when working with blocks, since their *X*, *Y*, *Z* scale coefficients can be changed independently.
The scale factor will be equal to the affinity ratio *R*, which can be calculated graphically with the relationship $R = A_2S/A_1S$, seen above in figure 3. The position of point A_2 is determined with the help of the half circle shown in figure 3. The affinity ratio or scale coefficient can also be determined analytically as a function of the angle α formed by the projection direction with respect to the oblique projection plane (fig. 5).
Analyzing the right triangle A_1SA_2 and applying the laws of trigonometry, it can be deduced that the affinity ratio or scale coefficient $R = A_2S/A_1S = (A_1S/\sin \alpha)/A_1S = 1/\sin \alpha = \csc \alpha$ [Cabezos-Bernal, Cisneros-Vivò, 2003b; 2010; 2016].
The choice of projection angle is not a trivial matter, since it would affect the distortion of the represented figure. As can be noticed in figure 6, the oblique axonometries obtained from the orthogonal projection show excessive distortions resulting in inadequate reduction coefficients. As previously discussed, an appropriate reduction coefficient for a military projection would be $C = 0.7$, while for a cavalier projection it would be $C = 0.6$. The projecting direction corresponding to these coefficients would be 55° and 59°, respectively. The scaling coefficient to be applied for these angles would be $R = \csc 55° \approx 1.22$ and $R = \csc 59° \approx 1.1666$.
Figure 6 shows the transformation of two orthogonal projections to obtain a military projection (left) and a cavalier projection (right). In the case of the military projection, the orthogonal axonometry has been obtained with a view that forms 55° with respect to the horizontal planes of the model, which are what we will see in true magnitude after the transformation. In the case of the cavalier, the visual forms 59° with the vertical planes of the model, so they will be seen in true magnitude after the conversion. By using these angles, more proportionate oblique projections are obtained after the scaling operation.

Designing oblique analog models of architecture

There is no doubt that anyone who is in the presence of an axonometric model of an architecture feels a sense of discomfort and disorientation not immediately understanding from which point the work should be viewed or why the author decided to make the physical deformation of the object. This sense of visual detachment is similar to the concept of estrangement that Viktor Šklovsky described in addressing his studies of the work of art: "I have already examined estrangement in Tolstoy. A variant of this artifice consists in fixing and emphasizing only one detail of an image, thus changing the usual proportions. Thus, in the illustration of a battle, Tolstoy develops the detail of a moist chewing mouth. This detail placed in the foreground causes a particular shift" [Šklovsky 1974, pp. 100, 101]. As is the case of an anamorphic projection, the axonometric model predicts that it is only possible to understand the underlying visual logic by viewing from a privileged view point that, unlike anamorphosis, simulates a 'parallel' projection and not perspective. We have already recalled some theoretical contributions elaborated by authors such as Ginés Martinez de Aranda, Alonso de Valdevira and especially Juan Caramuel de Lobkowitz between the sixteenth and seventeenth centuries in another essay to which for brevity we refer [Sdegno 2019b], along with others on the subject [Cabezos-Bernal, Cisneros-Vivò 2003a; Sdegno 2003].
The reference to specific case studies such as some early houses by Peter Eisenman and Massimo Scolari's installation at the I Venice Biennale of Architecture is functional to present the outcomes of the experimentation conducted by the authors on the theme of oblique generation of models.
As it is well known, Eisenman has from the beginning favored axonometry in his cognitive inquiry. He did so in his doctoral dissertation –recently published [Eisenman 2009]– in which we find architectures reproduced in parallel projection: from Le Corbusier's villas to Giuseppe Terragni's Casa del Fascio, just to mention the most significant examples. The purpose is to analyze their morphological characteristics, especially in the rigorous relationship between mass and surface.
Later, he continued to use axonometry in his early designs of single-family houses, for example from House I to House IV, reflecting specifically on the type of projection adopted. Precisely in the case of House IV, in fact, the author writes that if "frontality is the preferred point of view of modernism in



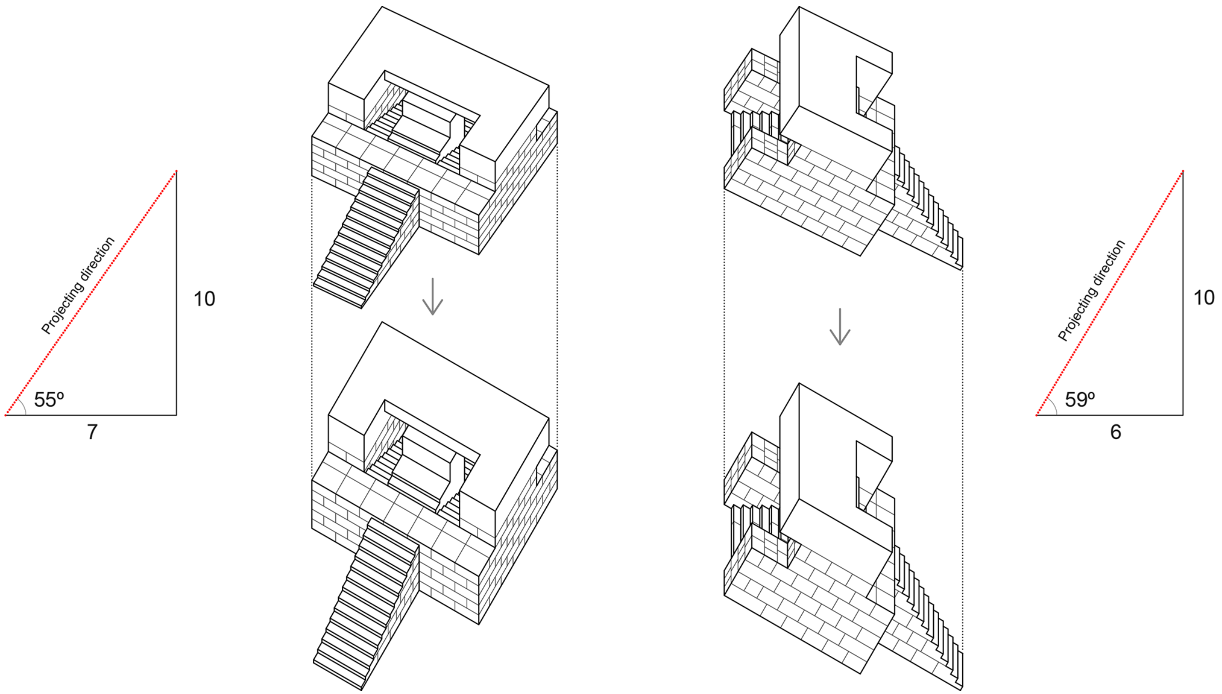


Fig. 5. Projection direction angle and geometric relationships that allow determining the scaling factor in an analytical way (P.M. Cabezos-Bernal).

Fig. 6. Transforming orthogonal projection into obliques. When using appropriate projection directions to obtain the initial orthogonal axonometric views, the resulting oblique projections have the proper reduction factor (P.M. Cabezos-Bernal).

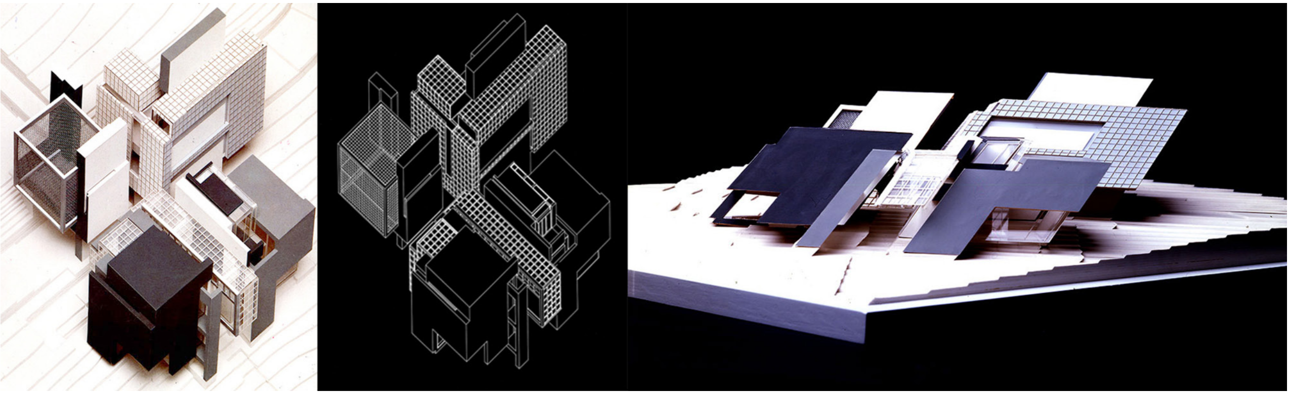


Fig. 7. P. Eisenman, House X, Bloomfield Hills, Michigan, 1975; a (left): top view of oblique model; b (center): military axonometry drawing; c (right): side view of oblique model (from <https://eisenmanarchitects.com/House-X-1975Z>, accessed 10 May 2024).

House IV the oblique view has been equated in importance with the frontal one" [Aureli, Biraghi, Purini 2007, p. 72] [1]. Also from such considerations Eisenman will come in 1975 to propose for House X [Eisenman 1982] an architectural solution that he will comment as follows: "Houses are, in general, conceptually vertebrate: in addition to possessing a necessary structural dimension, that is, they are metaphorically 'vertebrate'. They have a center, usually a hearth or a staircase: the roof pitches from the middle and an overall centrality emerges from their configuration. [...] House X is non-vertebrate" [Aureli, Biraghi, Purini 2007, p. 88]. It is not a coincidence that the conceptually 'invertebrate' house will also take on such a configuration visually, when it materializes physically in the form of an oblique model (fig. 7a), deformed so that it can be superimposed on an oblique military axonometry (fig. 7b) when viewed from above, but unequivocally invertebrate when the eye subtracts from that zenithal vantage point and rotates around the object (fig. 7c). If, in such a case, architecture interrupts its constitutive semantic relationship to reduce itself to pure syntax, the axonometric model can be properly semantic –when it declares its affinity with military oblique projection– while it abandons both values –semantic and syntactic altogether– when observed from any point of view, becoming pure abstraction.

A second project by Eisenman, the House El Even Odd, from 1980, presents itself as an oblique model, at once concrete in its material description, but abstract in its theoretical conceptualization: "the House El Even Odd," –as the author observes– "is an axonometric object that explores the criteria for reading representation in architecture and thus addresses the issue of disciplinary limits. [...] An axonometric model, in antithesis to an axonometric drawing, is the transformation of the three-dimensional representation of a three-dimensional reality: process and real thing at the same time" [Aureli, Biraghi, Purini 2007, p. 100]. A detailed and articulate description on the theoretical level shows how the figurative stratagem has now become a real working hypothesis, in which representation is not a final outcome of thought but accompanies the design process.

Along with oblique models on a small scale we should mention the work of Massimo Scolari, who has devoted an entire volume to axonometry [Scolari 2005], collecting some theoretical contributions already published since 1984, to which he has added further essays on the subject. His *Elementi per una storia dell'axonometria* [Scolari 1984] has undoubtedly provided rigorous keys for all those wishing to study this particular form of representation, both historically and theoretically. The "anti-perspective", as axonometric projection is called by the author

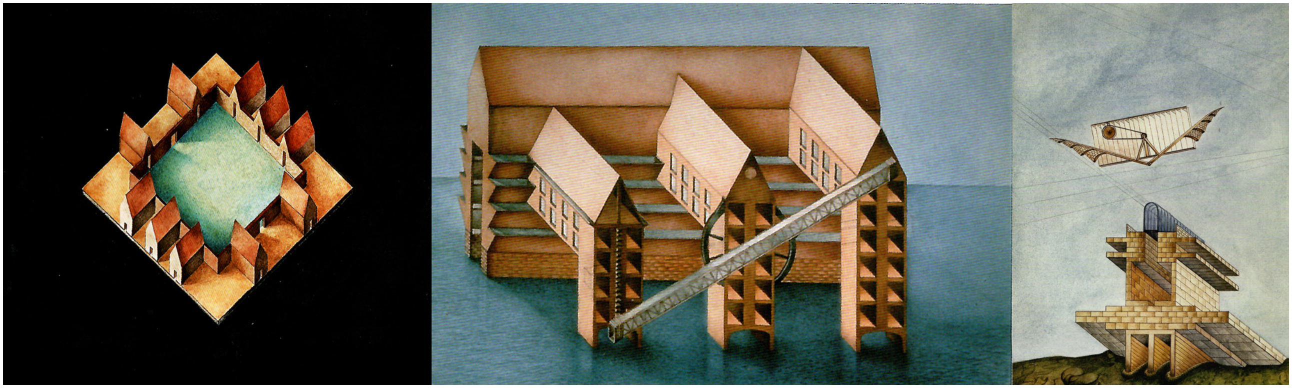


Fig. 8. a (left): M. Scolari, Urban enclosure, watercolor on paper, 1979; b (center): M. Scolari, Architettura lagunare, watercolor on cardboard, 1980; c (right): M. Scolari, Gas Station Inn, watercolor on paper, 1975 (from Marzari 2007, pp. 70, 77, 79).

since the volume's subtitle [Scolari 2005], now requires the same attention that has been devoted to perspective studies so far. Indeed, it is not only a functional expedient for a technical figuration of a scaled object, but can reserve other qualities, both on the level of pictorial representation and architecture. It is not a coincidence that architectures in parallel projection are among the prevailing subjects of many of his pictorial works, such as the watercolor *Recinto urbano* of 1979 (fig. 8a), *Architettura lagunare* of 1980 (fig. 8b) or the work *Gas Station Inn* of 1975 (fig. 8c) whose symmetrical pattern will be recognizable in the oil painting *Porta per città di mare* of 1979 (fig. 9a), which we have already discussed in a previous issue of this journal [Sdegno 2019a], which will see its physical transformation within the *Strada Novissima* created for the 1980 I Venice Biennal of Architecture, curated by Paolo Portoghesi entitled *La presenza del passato* (The presence of the past) [Portoghesi 1980]. The *Porta*, in fact, will materialize at the natural scale in a mock-up (fig. 9b), rigorously traced in technical form and accompanied by the dimensions (fig. 9c) that will ensure its realization along with the other nineteen installations of the *Strada*. As the author himself will describe the project, "the door was constructed as a footprint-calculus of the pictorial image so that the geometry of the two converging parallel projections would be maintained in the actual construction" [Scolari 1987, p. 54]. In further clarification Scolari clarifies the mechanism adopted in figuration: "Usually the pictorial image of an architecture is an oblique parallel projection or perspective. To become an architectural drawing and project this image must be rendered in plan and elevation. An oblique projection 'alla cavaliera' (axonometry) usually shows the receding side in true measure, but with a distortion in the corners. We 'read' by custom and indoctrination those angles as right angles even if they are drawn acute or obtuse" [Scolari 1987, p. 54]. As the author would reveal in a 1991 interview with Léa-Catherine Szacka, "I made a manifesto about the representation of architecture instead of a manifesto about my architecture. I started with a painting and built it in 3D. The idea was to start with representation and make a construction" [Szacka 2016, p. 168]. Having crossed the threshold of the oblique model, in fact, the visitor was confronted with the pictorial work on the opposite wall: "to remove any design ambiguity" –Scolari comments– "I placed, immediately after the entrance, the painting '*Porta per città di mare*' (1979): so that upon entering the representation one could find nothing but a representation" [Scolari 1987, p. 54].
Eisenman's small-scale military oblique model and Scolari's full-scale "cavalier" oblique model show two distinct lines of research, although in –if you will pardon

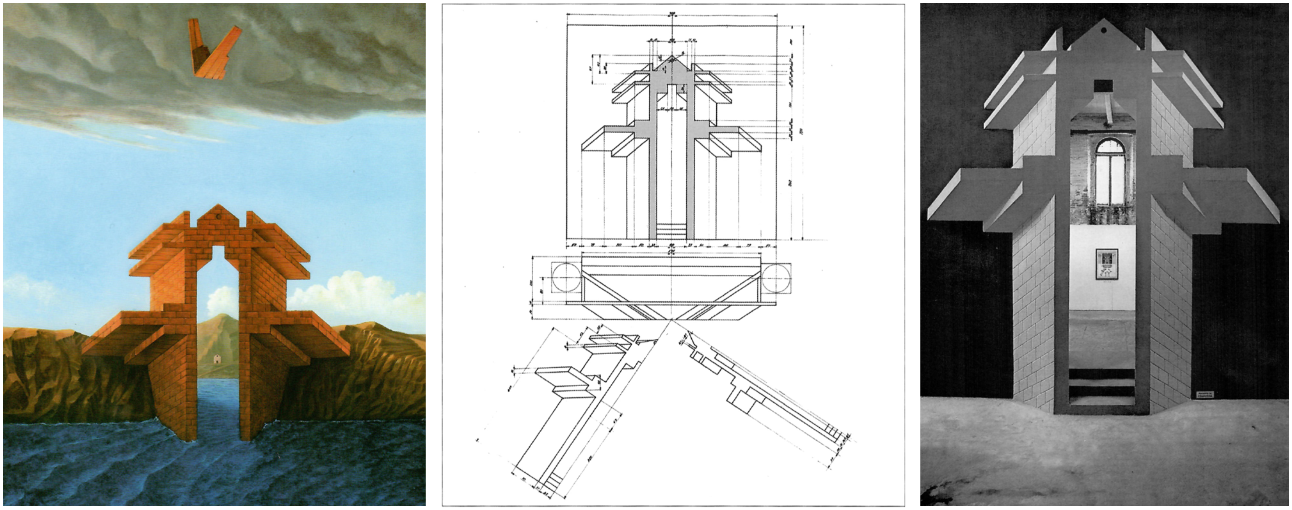


Fig. 9. a (left): M. Scolari, Porta per città di mare, oil on paper pasted on board (1979-1980); b (center): M. Scolari, Executive project of the installation Porta per città di mare for the I Venice Biennale of Architecture (1980); c (right): M. Scolari, Installation Porta per città di mare at the I Venice Biennale of Architecture, 1980 (from Marzari 2007, pp. 86, 87, 89).

the term– parallel progression: areas of research of definite interest although the peculiarity of such an experimental approach does not seem to have been grasped in those concerned with the discipline of figuration.

Downstream of these investigations on the subject, some experiments were initiated that could combine the study of oblique axonometry, the potential of computational modeling and physical prototyping of digital models. The activity-conducted by one of the authors of this paper [2] at the European Ceramic Workcentre (EKWC), has seen further development with application to other case studies. The objective of the research was to investigate a method of representation that could complement the specific contents of physical representation by maquette with those related to the disciplinary nature of parallel axis drawing.

Therefore, it was decided to focus on some of Andrea Palladio's works with the specific investigation of some significant details, such as architectural orders. The first case study is Villa Emo [Palladio 1570, *Book II*, p. 55], whose linear configuration with the main body of the building in a central position and the two lateral *barchesse*, allows us to propose an oblique model in parallel projection such that the elevation can be visualized in true form and the axonometric restitution of the plan and side elevation. By preserving the measurement of the *x* and *z* axes, and tilting the y axis of the digital model by 45° in the negative direction, it was possible to highlight the previously prepared plan layout through a reduced extrusion of the wall structure to transform it into bas-relief. In this way, plan and elevations immediately declare the contents of the villa, although, in this case, the mirror symmetry of the entire layout is negated by the necessity required by the oblique projection. The deformed model was then subjected to rapid prototyping procedure with the process of Selective Laser Sintering (SLS) in nylon powder at the scale of 1:200, and then translated into silicone mold and reproduced in plaster (fig. 10). Making the mold in silicone negative has the potential of being able to replicate the object while avoiding further production with SLS systems, which are far more expensive than manual reproduction.

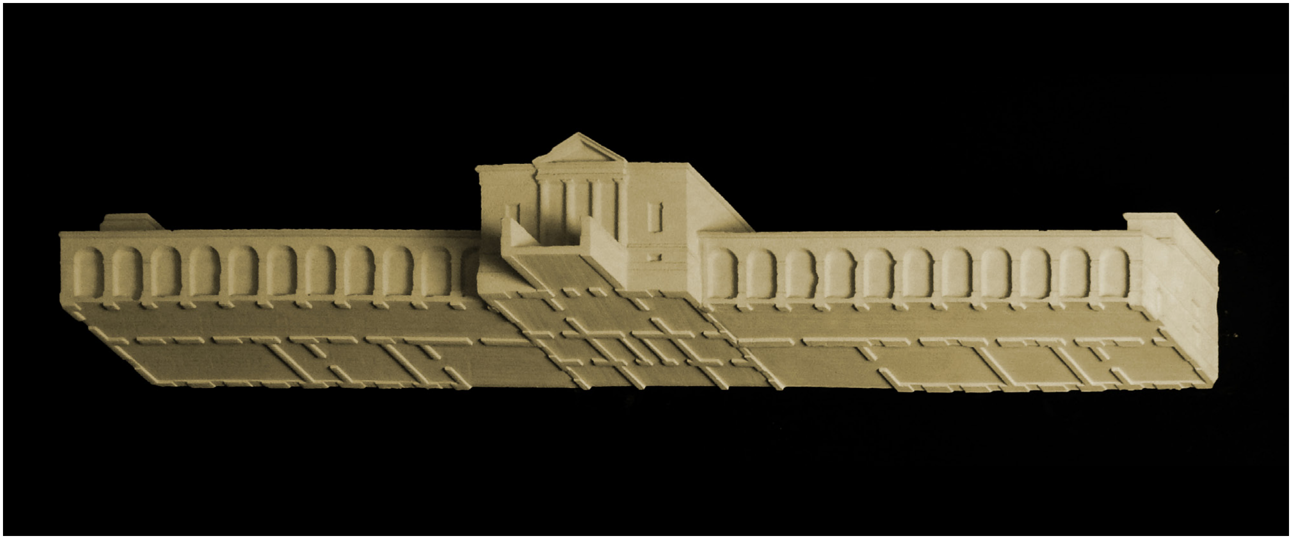


Fig. 10. Oblique analog model of Andrea Palladio's Villa Emo, plaster (A. Sdegno with B. Gernand, Protoservice realization, 2007).

A second case study dealt with one of the most iconic pieces of architecture: the Villa Capra known as "*La Rotonda*", designed by Andrea Palladio and made in a different way –as far as the roofing is concerned– than the drawings in his treatise [Palladio 1570, *Book II*, p. 19]. The double figurative register, related to the roofing, urged research in the field of representation that, while taking into account the initial objectives dictated by the theme of oblique deformation by computational means, would allow some significant aspects of the work to become evident. We therefore proceeded in synchronous work on two distinct models: that published by Palladio in *I Quattro Libri dell'Architettura* and that published by Ottavio Bertotti Scamozzi in his treatise [Bertotti Scamozzi 1778, pp. 8-13]. The main elevation was then analyzed, dividing it into two quarters of the entire work, which, as is known, has a configuration with double mirror symmetry in the pronaos, although the internal distribution does not present the same logic. Wanting then to make the section evident, we went to a computational deformation in the opposite direction of the digital models related to the two solutions, such that –placed in appropriate positions– they could preserve the symmetrical layout of the villa, although altered in the two different morphological configurations. Keeping the *x* and *z* directions in true form, a negative value was given to y in the slope coefficient equal to half a right angle (-45°) for the original solution and an equivalent positive one (+45°) for the model derived from Bertotti Scamozzi's treatise, so that the on-axis section would also be visible, albeit in its non-straight configuration. These two obliquely deformed models, too, following the rules of cavalier axonometry, were then reproduced at a scale of 1:200 with a selective sintering rapid prototyping system (SLS), resulting in an opaque nylon maquette with a quality of 1/10th of a millimeter (fig. 11).

A final experimentation involved the realization of a Doric order –again modeled from information in Palladio's treatise [Palladio 1570, *Book I*, p. 27]– of which several solutions were made. On the one hand, an oblique model that repeated the computational work done previously, although this time applied to a single architectural detail. On the other, the multiple restitution of the same subject, to which a recursive

Fig. 11. Sections of the oblique analog model of Andrea Palladio's Villa Capra, plaster (A. Sdegno, Protoservice realization, 2008).

Fig. 12. Composition of one straight and eight oblique capitals, lactic acid polymer (A. Sdegno, 2019).

deformation was applied starting from the centrally located straight model. While in both situations the decision was made to opt for the deformation of a semi-model capital, in the first case a ceramic solution was landed with a thousand-degree firing –again starting from a physical SLS prototyping then treated with a negative mold on silicone rubber– while in the second a reduced size was used, using a lactic acid polymer filament for FDM additive printer, which could allow rapid identification of objects in the determined tilt, at an angle of 0°, 45°, 90°, 135°, 180°, 225°, 270°, 315° (fig. 12).
The rigorous method of geometric construction of the deformation –both in the works of Eisenman and Scolari described above, and in those we have proposed here for the Palladian villas and the Doric order– does not preclude that to the sense of figurative precision of the oblique objects, observed from the privileged point of view –albeit not axonometric– is counterbalanced by a sense of estrangement toward the same when examined from different views, such as to raise in the observer a perceptual sensation similar to the estrangement described by Šklovsky that we have mentioned before, although declined now in the field of figuration of architecture.

Credits

Although sharing the general layout of the essay, the paragraphs *Introduction* and *Designing oblique analog models of architecture* are by Alberto Sdegno and the paragraph *Axonometric deformations of digital models* is by Pedro Manuel Cabezos-Bernal.

Notes

[1] All descriptive texts of works in the volume Aureli, Biraghi, Purini 2007 are by Peter Eisenman and are taken from <https://eisenmanarchitects.com/Projects> (accessed 10 May 2024).

[2] The activity was carried out by Alberto Sdegno in early 2007 at the European Ceramic Workcentre (EKWC) in 'S-Hertogenbosch in the Netherlands, in collaboration with London artist Bruce Gernand.

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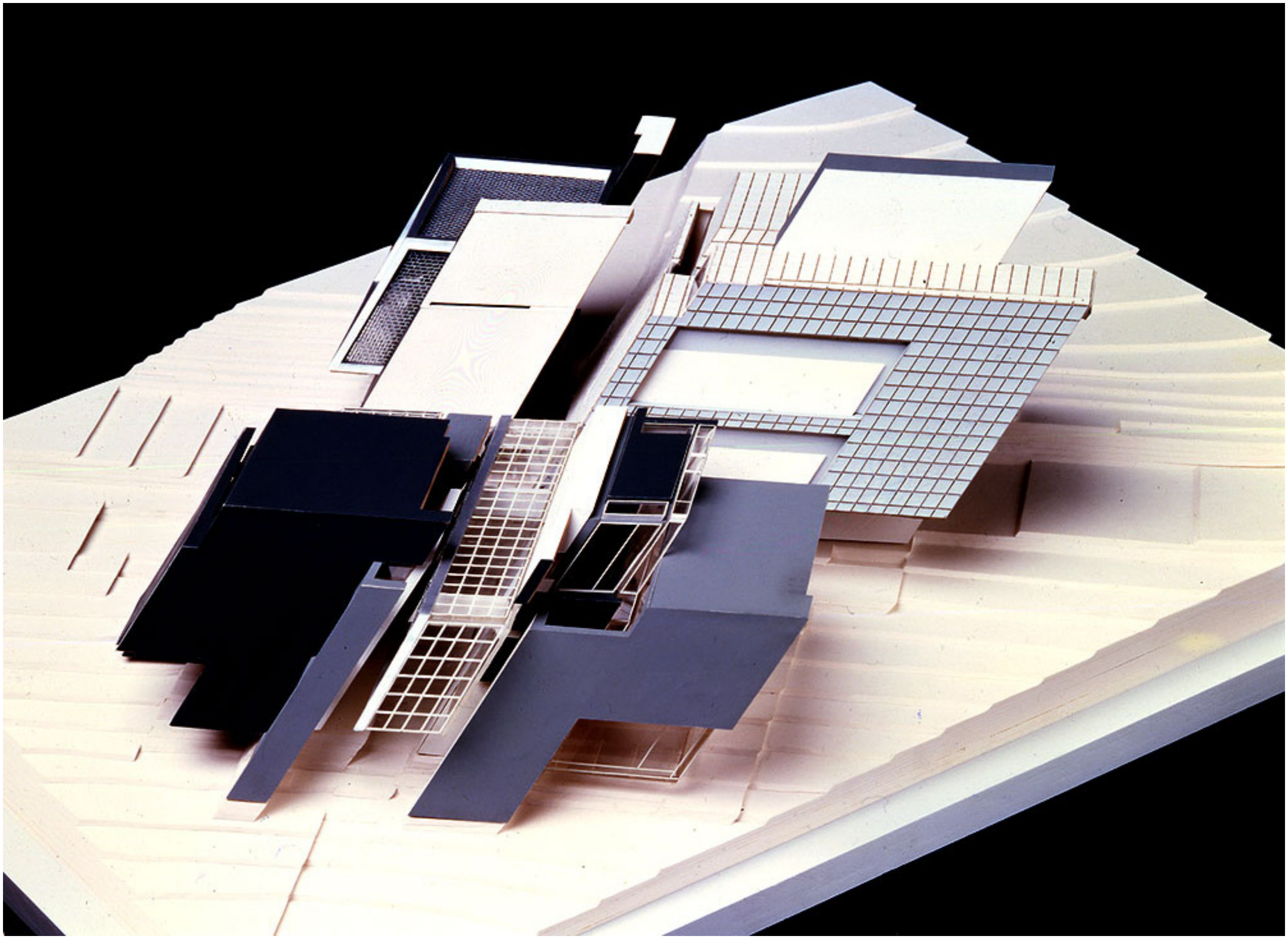
House X

Peter Eisenman



Idea as Model, Model as Idea. The Axonometric Model of House X by Peter Eisenman

Paolo Belardi

"The axonometric model of House X is a three-dimensional construction made to provide the image of a two-dimensional drawing. It does not provide knowledge of the object in a dimensional sense; it is not about reality, but about fiction; it provides phantasmagoric images –a sequence of anamorphisms– among which the 'right' image is very difficult to discover. It makes the 'normal' image appear to be an anomaly: we perceive it only at the instant where we see the false image –the model as a two-dimensional drawing– while the 'abnormal' images are in fact the only ones that describe the true nature of the three-dimensional object, the model" [Gandelsonas 1979, p. 25] [1].

Albeit with discontinuity, the history of representation is punctuated by imaginative impulses apparently lacking operational results, and for this reason dismissed as *caprices* or at most as *divertissements*, but which conversely, if taken up and developed, could have opened up new horizons. In art, as well as in architecture. I am thinking of Opicino de Canistris's maps, where autobiographical memories mingle with topographical elements [Belardi 2022], of Lorenz Stöer's fantastical landscapes, in which a mix of polyhedral solids and ruinous architecture provides paradoxical visions [Wade 2015, pp. 169-204], and of Ennemond-Alexandre Petitot's grotesque costumes, conceived by ingeniously combining anatomical parts and classical fragments [Cirillo 2002]. Just as I think of Juan Caramuel Lobkowitz's perspectival obliquations, interpreters of an architecture legitimized by divine perfection [Sabaino, Pissavino 2012] and with these, coming to the present day, I think of Peter Eisenman's conceptual diagrams [Eisenman 1999]. Above all, I am thinking of the axonometric model of House X: a "strange anamorphism" [Falzea 1993, p. 176] built by

This article was written upon invitation to frame the topic, not submitted to anonymous review, published under the editorial director's responsibility.

Eisenman using wood and cardboard [1], and on whose polysemic value Eisenman repeatedly confronts Vittorio De Feo, author in the same years of an equally singular perspective device aimed at simulating the functioning of an exhibition pavilion based on specular reflections [2]. And, just as De Feo's model betrays the author's interest in the illusionistic virtuosities of Andrea Pozzo, in that it is substantiated by the perceptual ambiguity between real plan and virtual plan, Eisenman's model betrays the author's interest in the figurative implosions of Giuseppe Terragni, in that it represents "an architecture that has become merely a language that explodes into itself" [Saggio 1996, p. 16].
The story of House X is well known [Eisenman 1982a], but, on closer inspection, it is worth retracing, because it marks a clear watershed not only in the context of Peter Eisenman's professional career, but also, and perhaps above all, in the context of his life story. In 1975, Mr. and Mrs. Arnold Aronoff commissioned Eisenman, at the time director of the Institute for Architecture and Urban Studies in New York City, to design a single-family residence in the vicinity of Bloomfield Hills, a small municipality located in the state of Michigan, specifically in Oakland County. The chosen site was strongly characterized from an environmental standpoint because, being part of a steeply sloping wooded area, it was very panoramic and contained three pre-existing structures: a swimming pool, a tennis court and a summer house. Eisenman, aspiring to design a work worthy of joining the exclusive club of Iconic Houses (from Robert Venturi's Vanna Venturi House to Richard Meier's Smith House, from Stanley Tigerman's Marion House to Frank O. Gehry's Gehry Residence), was strongly motivated to take his design idea all the way to the building site phase. So much so that, for the first time, he abdicated ideological abstraction and rooted the project in the site. [Perbellini 1998, p. 65], while articulating the building into four autonomous bodies to reduce the volumetric impact, introducing an annular path through the house to connect it to the three pre-existing structures, and by juxtaposing the orthogonality of the Cartesian grid of the planimetric layout on the sinuosity of the contour lines of the terrain to enhance the orographic irregularities. But, above all, he created a striking micro-city, in some ways similar in figurative abstraction to the models held by patron saints in medieval pictorial representations: a micro-city marked by the idea of ruin and decay, composed by means of an agglomeration of forms, positioned at different levels and of different heights, traversed by a system of vertical communications open to the surrounding landscape, enlivened by an arrangement of jutting volumes and hollowed-out corners, as well as characterized by unusual finishes such as metal mesh, modular glazed cages and aluminum panel cladding. Finishes that would later be taken up and elevated to veritable *griffes* by Frank O. Gehry, Oswald Mathias Ungers and Richard Meier.
However, luck was not on Eisenman's side. In fact, his clients decided not to realize the project, melancholically relegating House X to the realm of paper architecture. It was a decision that plunged Eisenman into a state of severe depression, prompting him to embark on psychoanalytic therapy [3] which, in the following years, would lead him to reconsider the radical nature of his theoretical approach and equip himself to compete professionally by founding a full-fledged architectural firm. But, before moving on, Eisenman confirmed the research carried out from House I to House VI, marked by the propensity to recognize the value of an architecture in the abstraction of the ideational process rather than in the concreteness of the constructive translation, by integrating the project drawings, notably the ever-present axonometric exploded views chosen as a "compositional method" [Trentin 1999, p. 41], with an axonometric model that, almost freezing the still-image of the building's spectacular collapse following a devastating seismic event, affirmed its "nonvertebrate" nature [4]. Nor could it have been otherwise, given Eisenman's predilection for the use of axonometric projection [5]. What resulted was a model "in which photography can only be taken from a single point of view" [Franco Taboada 2019, p. 315], that is, an axonometric model that, while claiming the autonomy of representation, where the ultimate reality is the model and not the built building [6], also undermines the very foundations of representation, where it tends to invalidate the constitutive rules of axonometry. For, while axonometry "implies the rotation upon itself of the object in space as seen by an observer unrelated to the object or the rotation of the observer around the object, the axonometric model as conceived by Eisenman negates the rotation of both the object and the observer, forcing this and that into the immobility of the one determined point of view from which the axonometric view is had, not unlike a single perspective point of view" [Ciucci

1993, p. 9]. After "four hundred years of latent classicism" [Eisenman 1992, p. 17], both the linearity of the subject-object relationship and the consequentiality of the ideation-realization relationship are challenged by a model that, in ratifying "the End of the Classical" [Eisenman 1984], is promoted from a communicative tool, aimed at illustrating the functioning of the design idea, to a heuristic pretext, aimed at exploring the valences, even unforeseen, of the design idea: it is no longer the model that is the representation of the design idea, but it is the design idea that is the representation of the model. Idea as Model, Model as Idea [7].

Notes

[1] "The result, drawn up by the architect himself, uses mainly wood and its derivatives, such as different types of cardboard" [Franco Taboada 2019, p. 315].

[2] "The perspective depth of the pavilion is illusively constructed, relying on the virtualities of the reflections of angled mirrors. The project has demonstrative value; in fact, it tends to highlight, to the limit of paradox, the ambiguous relationship between structure and image in architecture" [Conforti, Dal Co 1986, p. 110]. The comparisons between Peter Eisenman and Vittorio De Feo on the demonstrative value of the two devices, which took place in the early 1980s in the Roman studio in Via Angelo Brunetti, are referable to the direct testimony of the writer.

[3] "House X was the end of a certain phase. I started psychoanalysis when I went to Venice to do Cannaregio instead of House X. The clients wanted to start that summer and I said 'No, I want to do Cannaregio' and when I came back the house has been abandoned. It is then I felt that I needed to go into therapy. I was really upset, having spent so much time on an house and then not having it built" [Eisenman 1988, p. 51].

[4] "Most houses are conceptually vertebrate. That is, in addition to their literal, necessary condition of structure they are metaphorically vertebrate. They have a center, usually a hearth or a stair; their roofs pitch from the center, and their construction exhibits a concern for an overall centrality. [...] House X is nonvertebrate.": the text, written by Peter Eisenman and taken from <https://eisenmanarchitects.com/House-X-1975> (accessed April 5, 2014), is cited in Aureli, Biraghi, Purini 2007, p. 88.

[5] "Eisenman declared a specific predilection for axonometric projection especially early in his career. Already in his recently published doctoral thesis at Trinity College, the author conspicuously uses the tool of axonometry to explore architecture. There are many works of architecture reproduced in parallel projection in the three geometric axes of reduction within the thesis: ranging from several of Le Corbusier's villas to Terragni's *Casa del Fascio*, just to mention the most significant examples. The aim is to analyze their characteristics, especially in the mass-surface relationship which, as he states, "received its initial definition in Le Corbusier's '*Quatre compositions*'." From this work of decomposition Eisenman was to initiate a precise operation of objective description of his early projects by making use of parallel projection: for example, House I of 1967-68 or the subsequent House II (1969-1970), of which he would say that "the house looks like and is constructed like a model." Compositional diagrams show the ideational stages, also re-proposed for the following House III (1969-71) and even more so in House IV" [Sdegno 2019, p. 1378].

[6] "Generally, a scale model is a three-dimensional representation of a three-dimensional reality. An axonometric drawing is a two-dimensional representation of a three-dimensional reality. An axonometric model differs from an axonometric drawing in that although it is a representation, it does not represent a real object, but the transformation of an object. It is both process and reality and as such represents the drawing rather than the building" [Eisenman 1982b, p. 70].

[7] *Idea as Model* is the title of an exhibition, curated in 1976 by Peter Eisenman at the Institute for Architecture and Urban Studies in New York, in which models of the most significant works in the history of architecture of the second half of the twentieth century were presented [Frampton, Kolbowsky 1981].

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ANALOG MODELS

Micro Architectures and Mock-ups

See, Touch, Feel: a Cognitive and Educational Journey through Maquettes

Marco Gaiani

Introduction

The Rijksmuseum in Amsterdam has three dolls' houses in its collections.
The most famous was realized between 1686 and 1710 by Petronella Oortman, a well-known wealthy heiress of a Dutch silk merchant (fig. 1). The model was made to 1:9 scale and measured 255 × 190 × 78 cm. For its creation, the lady spared no expense, calling on an inordinate number of artisans, painters, carvers, glassblowers, and cabinetmakers who furnished the house with some 700 custom-made pieces, all functional and made from the same materials that would have been used in the construction of their life-size counterparts. The amount spent would have been enough to buy a large house on a canal. She designed the interiors like real rooms of her own home with miniature masterpieces including oil paintings, Delft pottery, canopies made of the finest Chinese silk, carpets, tapestries, and inlaid furniture. A scenic representation showing how a mansion was laid out, the arrangement of the spaces and furnishings, how rooms were inhabited, the lifestyle: in short, a complete picture of life in a fashionable 17^{th}-century home. Such exquisite and detailed work soon became known and admired not only locally, but also abroad, attracting many visitors, as though it were a work of art. In the 17th century, dolls' houses were not toys, but a hobby, the equivalent for women of the curio cabinets kept by men. Owning a dolls' house was, among the women of Amsterdam, a way to exhibit high social status, and it was important to

This article was written upon invitation to frame the topic, not submitted to anonymous review, published under the editorial director's responsibility.

Fig. 1. Petronella Oortman's dolls' house, Rijkmuseum, Amsterdam, 1686-1710 (photograph from the Rijksstudio collection).

have the most beautiful house to show off to high-ranking guests. Seen through today's eyes, one wonders what prompted Petronella to invest so much money and effort in a miniature model instead of a real house, where she could have received and entertained her guests, and why a small object, inscribable in a volume of just over one and a half cubic meters, was so extraordinarily successful. I think the answer to these questions can be twofold.
A rigorous answer could be sought in the perceptual studies of the past 20 years. However, for our purposes, it is sufficient to note how a scaled physical model allows easy comparison with the real object, exploiting the mnemonic component more than the perceptual one, and at the same time, the model allows us to observe the object as a whole and in its details as a three-dimensional entity. Even this path, it should be pointed out, is not without criticism, as to date there are no proven experimental studies in the field of architecture. More simply, we can answer the question by trying to exploit two concepts that are quite common to architecture: those of analogy and of copy, which are the properties of Petronella's maquette, and of all architectural maquette.
Basically, the creative design process of architecture proceeds inductively and by analogy, rather than deductively as occurs, according to classical logic, in scientific reasoning. One of the best explanations of this aspect of the architect's method is still provided by Leon Battista Alberti. The city, Alberti wrote in the mid-15th century, is like a large house, and the house is like a small city [Alberti 1966, pp. 64, 65]. This phrase did not indicate that the house was the most important building type in the city: rather, it stated that the structure of human settlement, its topology, is so consistent that its two opposites, the city and the house, that is, the maximally public and grandiose and the private and more modest, embody identical, or at least analogous relationships.
One of the clearest examples of this way of proceeding is the La Conica coffee maker designed by Aldo Rossi between 1980 and 1983, which translates a prestigious silver object into a steel product, easy to market, and with new characteristics of sturdiness and manageability. The cone is the symbol par excellence of the dialectical relationship between architecture (or rather, urbanism) and the 'domestic landscape' that this miniature monument fits into.
If we leave aside the result and return for a moment to the process, we find that the relationship between analogy and design is even deeper and closer because the representation itself, that is, the medium with which we produce the design, works by analogy. Indeed, it is, for the designer, not so much an *a posteriori* illustrative means as an active mediating tool that provides the possibility of objectifying ideas in a space structurally similar to real space, through a series of conventions that refer to complex associative systems and identity- and opposition-based criteria that organically order them.
When, with the digital revolution of the 1990s, object design shifted from construction by representation to the direct realization of a mathematics –at the same time representation and final object–, the elimination of the schema left analogy only as a generic design criterion, neglecting its inherent possibilities, such as the reuse of existing objects and the creation of descriptive forms that represent both the idea and the reality in a physical and not just virtual way. In doing so, it overlooked part of the means of architectural representation as they were already indicated by Nikolaus Pevsner's *A Dictionary of Architecture*: "Architectural representation is the depiction of buildings, their parts, and interior environments by pictorial and graphic means or three-dimensional models, for the purpose of theoretical reflection, of elaboration of the project by the architect" [Pevsner et al. 1981, p. 548].
Thus in the digital age, the analog architectural model has often been erroneously declared dead, taking advantage of the progressive development of computational digitization/visualization techniques and methods only for electronic versions very close to the original, except for the materiality. Ultimately, we have forgotten that possessing a miniature analog reproduction of an object and its attributes has always been a basic condition for our learning to perceive and then to re-cognize. However, this forgetfulness does not reflect the characteristics of digital representational techniques. The development of three-dimensional modeling programs, together with CNC (Computer Numerical Control) milling, 3D printers, and robots, has made possible the seamless translation of a virtual model into a physical product. Since in theory the same data can be used to generate a virtual model and to fabricate a physical maquette, the difference between virtual and analog has not only not increased, but has greatly diminished. Therefore, while architectural drawing has gradually been dematerialized and replaced by digital media, digital and physical models can and will continue to exist side by side.

Instead, with the advent of digital, the result of physically ‘copying’ an existing or merely conceived architecture has changed, therefore the discourse on the ‘copy’ is a nodal element for making self-aware the entire distance that separates the real from the represented and to also include these new maquette in the long series of attempts, from antiquity to the present day, to produce copies. The development of digitization/visualization techniques has permitted the creation of electronic versions very close to the originals, even in their materiality. A digital copy can express emotions and knowledge, reinterpreting the ideal of the classic serial copy and serving as an analysis and simulation tool for architectural models, with a more strategic role than models before the advent of numerical systems.
In this paper I will illustrate three of my experiences with analog models in the digital age that touch on three distinct and complementary themes: the characteristics of the model derived from digital processes, the use of maquette for educational purposes in an age when the output is practically always numerical, and finally, the use of the analog-digital processing model for both research and communicative purposes.

Analog models, digital models: the copies for the University Museum Network of the University of Bologna

To provide an answer to the great unresolved problem of three-dimensional digitization of museum objects at limited cost and of high quality, my working group at the University of Bologna [1] has been developing, for a few years now, a new approach based on an automated combination of acquisition, making use of smartphone cameras, and visualization in Real-Time Rendering of high perceptual quality, possible on various devices (PC screens, mobile devices such as tablets, large touch screens etc.) and open to different output techniques, up to Virtual and Augmented Reality systems [Apollonio et al. 2021].
The system developed was applied to, among others, four case studies belonging to the collections of the Museum of Palazzo Poggi of the Sistema Museale di Ateneo (SMA) of the University of Bologna. These objects represent some of the most common problems of three-dimensional acquisition and restitution and are also emblematic of the collections: a porcupine fish (*Diodon antennatus*) with a volume of 35 × 19 × 25 cm from the collection of the naturalist Ulisse Aldrovandi, a globe of the astronomer Guido Horn d’Arturo (1879-1967) with a diameter of 31 cm, a bust of the scientist, soldier and geologist Luigi Ferdinando Marsili (1658-1730) with a volume of 41 × 67 × 99 cm, and a sandstone statue of Hercules with a volume of 100 × 90 × 275 cm.

Fig. 2. Rendering of digital models of museum objects belonging to the collections of the Sistema Museale di Ateneo (SMA) of the University of Bologna (render by F. Fantini).

Of these artifacts, starting from the digital 3D models, in addition to the on-screen visualizations (fig. 2), a series of maquette were also realized. These were obtained by 3D printing with treated gypsum powder (ZetaCorp 310) and FDM (Fused Deposition Modeling) with PLA (Polylactic Acid) with or without carbon fiber reinforcement (fig. 3).
The feature that was attributed to these printed copies is inferred by an observation by Salvatore Settis: the glossary associated with ancient copies refers with great frequency to terms such as ‘*aemulatio*’, ‘*imitatio*’, which indicate how it was not the accuracy of the copy that was crucial, but rather the ability of the copyist to approach a thought [Settis 2015]. Therefore, rather than making pure documentary replicas, new balances were sought between constants and variants destined to provide a new character to the copies, as was done in ancient times.
It is well known how in the testimonies of ancient Mediterranean culture one finds miniatures in every age and in most archaeological contexts. Over time, it has been discovered that most of them were copies of a few selected subjects. We know that casts began to be taken from

the statues that adorned shrines and squares in Greece and that these casts then served as models in copyists' workshops, while the original bronze statues were replicated in marble or plaster [Anguissola 2012]. This change of materials indicates that no matter how mechanical the method of reproduction was, the precision of the result was accompanied by some shift in emphasis and taste. Even more frequent and widespread were replicas in small format, a practice that later became commonplace among Renaissance artists, allowing them to carry copies to use as references and to elaborate hypotheses about the missing parts of classical originals. The process of miniaturization was not a simple reduction, but occurred at various semantic levels that ordered the small-scale representations of people, objects, and architecture, identifying the most appropriate categories of materials and levels of detail. Thus, for example, the level of detail of miniatures and the minimum size were decided to fulfill the desired function in terms of content and aesthetics.
In creating the new 3D-printed objects of the artifacts belonging to the museums of the University of Bologna, we followed this path, creating miniature reproductions intended to ingage in dialogue with their references, whether absent or present: "The copy pays homage to the original, and thereby acknowledges its superiority; but at the same time it claims to replace it, and therefore disputes its uniqueness", Settis again explains [Settis 2014]. Of the original, they no longer have the aura [Benjamin 2012, p. 25]: they want to recall it in form and, at the same time, detach themselves from it being as their appearance declares their belonging to the time in which they were created. The synthetic materials they are made of and the colors that characterize them belong to other contexts and processes of chemical synthesis, not biological or found in nature, far removed from the originals (fig. 4). 'Citation', symbol and metaphor of a culture, a taste, a social belonging, they aspire to inscribe themselves in the long path that goes from ancient art to the Renaissance up to the present day, to tell of not only the identity, the pose, and the fame, but also the ubiquity with their new appearance and with the different scale (from 1:2 to 1:20) (fig. 5). Therefore these copies, ephemeral objects born in the immaterial memory of the digital, almost seem, in this spaceless and timeless nature, a logical consequence of the themes that have always belonged to their essence, but also the image of these times in which all certainty has become precariousness. Furthermore, Alessandro

Fig. 3. Analog models of the bust of Luigi Ferdinando Marsili produced from digital models resulting from smartphone-based photogrammetric survey (photograph by G. Bacci).

Fig. 4. Analog models of the porcupine fish (Diodon antennatus) from the Ulisse Aldrovandi collection produced from digital models resulting from smartphone-based photogrammetric survey (photograph by G. Bacci).

Fig. 5. Analog models of the statue of Hercules belonging to the University of Bologna obtained from digital models resulting from smartphone-based photogrammetric survey (photograph by G. Bacci).

Mendini recounted, now almost twenty years ago, how a Murano vase designed by Carlo Scarpa, a symbol of beauty, and a transparent plastic bottle –in the shape of the Madonna– filled with holy water from Lourdes, were resting simultaneously on his bedside table: "The fragility of the Kitch figurine competes on a par with the vase, with *élite* design, posing difficult questions for me. Two contradictory transparencies" [2].

Didactic models

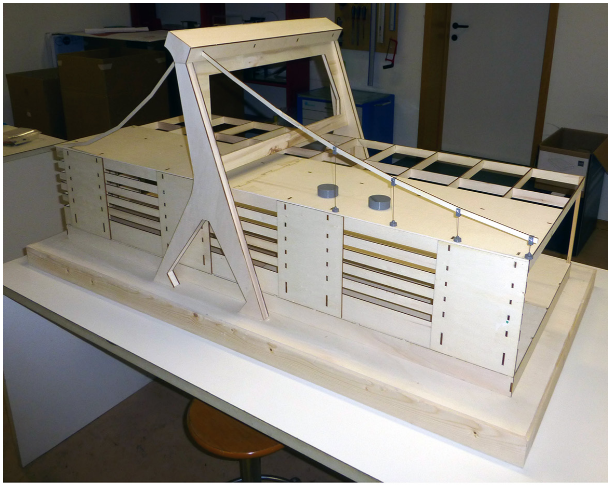
In the 16th century, models began to be used in philosophy and mathematics, and their ability to facilitate access by laymen or children to abstract or mathematical insights began to be recognized [Oechslin 2011]. This pedagogical and didactic value, rooted in the physical visibility of the models, continues to the present day and leads, beginning in the 19th century, to the construction of didactically designed toys for children. It is from the last decade of the 18th century, however, that architectural models gain further importance as tools capable of conveying in physical form the architecture of antiquity and of the Renaissance. This is why the large collections of plaster models and casts were formed, serving as illustrative material for work and educational purposes [Seelow 2017].
Instead, the use of maquette as a means of creative work relative to industrial product design dates back to the late 20th century, as Tomás Maldonado indicates in one of his famous essays [Maldonado 1987, p. 58]. Thus models are no longer used only as a tool of formal and constructive control and presentation but as a means of simulation. "The model is an artifice that is placed in a design process thanks to its (variable) simulation capabilities", explains Jacques Guillerme [Guillerme 1987, p. 29]. Such a process is, in fact, nothing other than "the manipulation of a model in its operation in space and time to allow the perception of interactions that are not immediately apparent" [von Bertalanffy 1975, pp. 149-169]. The 'manipulation' of models allows one to 'experiment with' their reaction to certain changes and to control aspects and behaviors that escape empirical observation. Moreover, models allow for rapid learning of both the experiment and the abstractions underlying traditional schematic design (productivity, scale, contour line drawing, etc.) so that, even within the design disciplines they also prove to be a formidable didactic system.
This ability proper to the maquette to also be an extraordinary didactic tool for the design disciplines was the starting point of my attempt to reorganize the drawing curriculum in the industrial design and architecture degree programs in which I started teaching twenty-five years ago, a reorganization that was necessary because of the progressive replacement of the system of representation by projection and section on a sheet of paper with the completely virtual one based on three-dimensional digital models, that is, the technique that is now progressively more and more used by architects to produce designs.
Riccardo Migliari recalled, as early as the beginning of this millennium, how "the construction of models, which we call 'computer models', is by no means automatic; it originates in the designer's thoughts and is controlled by his ability to shape the three-dimensional forms of architecture and to compose them together" [Migliari 2002, p. 7]. Although many intend to liquidate the problem of training in the knowledge and know-how related to digital three-dimensional models of architecture by reducing it to that of teaching the knowledge related to enabling digital technologies, Migliari's statement clearly indicates how this educational solution is wholly inadequate for a subject that requires formidable manual skills and spatial vision.
This means that there is a need for education based on these models that explains their characteristics, that does

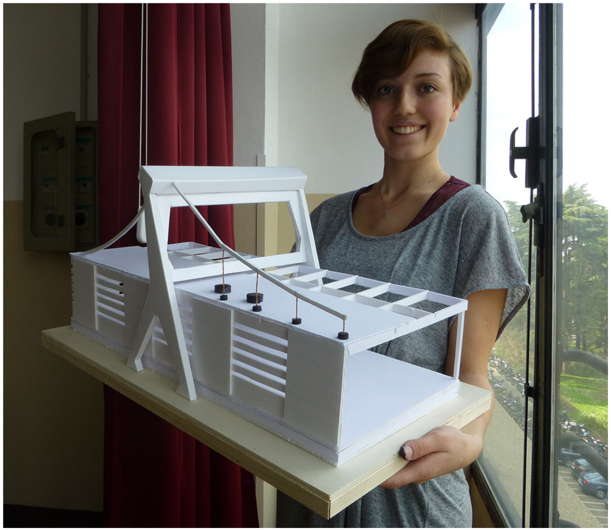
not take for granted means and degrees of virtualization of processes and results, and that considers representation as a form of knowledge within a broader cognitive process that also includes all that knowledge that in the pre-digital design and construction workflow was distributed among the different actors and the various workers.
Within this framework, outlining a program for teaching representation using models means addressing four fundamental issues:

- the virtual/material relationship, that is, the relationship between the physical model (maquette, photograph, but also simple handwriting) and the digital model (going back to the question of models in the broader sense);
- the human/technology relationship, that is, the use of the model as an active design tool;
- the metric/perceptual relationship, that is, the problem of the representative form used to design;
- the designer/interface relationship, that is, the question of tools for representing and their use as design tools.

This overall program clearly places the digital model at the center of the representational process, but at the center of the educational system is the model in all its forms: digital, full-scale analog, but especially small-scale because of its characteristics of easy manipulability, its ability to allow us to fully define an architectural object (which is difficult to construct, manipulate, observe, and communicate at 1:1 scale), and above all because of its characteristic of allowing a multimodal experience, involving combinations of sight and touch in a single perceptual experience. And because we respond more strongly to multimodal stimuli than to the sum of each individual modality (an effect called the 'superadditive' effect of multisensory integration), it is clear how learning using analog scale models is faster and its quality far better [Meredith 2002].
Operationally, this model-based study plan has as its general guide the principle of learning by doing and an interactionist-constructivist pedagogical approach that takes as its central dimension the student's active participation in learning and thus in the construction of meanings from experience [Reich 2010].
The purpose of this study plan is to increase students' ability to observe, think, and represent objects in three dimensions.
The activities (lectures, workshops, seminars) were aimed at stimulating the skills of critical observation of reality through the study of some objects on which operations of decomposition, recomposition, and reproduction are carried out with particular attention to the scales of representation, the materials, and the executive techniques, within a discourse of understanding the finalization of the model (for study, control of volumes, presentation to the client, production purposes…).
These activities require teachers to build a few reference models, 'objects' always at hand in the learning phase.
Thus various maquette were built over time. Initially, they were actual objects in 1:1 scale (for example, Gerrit Thomas Rietveld's two chairs, Red Blue (1918) and Crate (1938), re-constructed by Paolo Padova), later they became reduced-scale models of architecture reconstructed by Giovanni Bacci. These architectural maquette were not realized according to a canonical reduction scale, nor did they faithfully represent the original. Rather, they were models designed to summarize the elementary problems of the architect's technical drawing that drew from the original the basic formal characteristics and static strategies. Students were then required to construct their own small-scale models, the equivalent of Renaissance artists' pocket models, so that they were obliged to understand the forms, measure them correctly, and think of the best technique for 'reconstructing' them, experientially learning the basics of semantic modeling. The change of material (cardboard instead of the wood of the original models) placed the student before a real re-design of the object, so that between original and copy there remained only a relationship of similarity that allowed the operativeness and degree of reflections to be freed from the minimal ones of the identical replica. Later, this model of the model was the subject on which students first experimented with the graphic techniques of architects by reproposing it in orthogonal projection, axonometry, perspective etc. Similarly to the small statuettes of subjects from antiquity that Renaissance artists carried with them, it always accompanied the student-architect, designer or engineer-architect, as a reminder of what had been learned and a reference for experimenting with the new object to be verified collectively with the rest of their colleagues in the course.
Of these experiences, I would mention the extraordinary models (extraordinary not for their beauty but for their ability to be a synthesis of the problems related to the architect's education in representation) inspired by Pierluigi Nervi's Burgo Paper Mill in Mantua (whose 'large' model was in 1:70 scale and the one reproduced by the students,

Fig. 6. Teaching model inspired by Pier Luigi Nervi's Burgo Paper Mill and a model of the teaching model of a student at the University of Bologna (photographs by G. Bacci).





in 1:2.5 scale in relation to the wooden maquette) (fig. 6) and by Le Corbusier's Ville Savoy in Poissy (whose 'large' model was in approximately 1:20 scale, and the one reproduced by the students was in 1:4 scale in relation to the wooden maquette).
Alongside this exercise, the student was required to complete two other lab works: cardboard models of a chair and a table in a scale of 1:10 and a representation of their living spaces in a scale of 1:20.
The first model addressed the theme of proportions, ergonomics and small-scale analysis of the load-bearing features of architectural elements. Students were given a paper pattern with templates representing a middle-aged person 175 cm tall. The cut-out pieces were to be assembled into a mannequin, which was used to test the constructed models: it had to sit naturally on a chair and under a paper table, without causing deformation to them (fig. 7).
Instead, the representation of one's living spaces was an exercise that required the student to understand three-dimensionally the space in which he lived and become aware of the level of detail of a given scale of representation and of the dimensions, both absolute and in relation to the human body, of a space.
These are in each case study models, miniature objects like Petronella Oortman's dolls' house, able to form an awareness of what human architectural space is made of and what it is like (fig. 8).

The models for the *Palladio designer* exhibition

Andrea Palladio is universally known for his architecture, but few know that he was also the designer of the 'little things' inside his buildings, such as fireplaces, washbasins, sinks, wellcurbs, and even a cabinet for the coin collection of his friend Alvise Mocenigo, for whom he designed two villas, a palace, and the family chapel.
The exhibition *Palladio designer*, staged at the Palladio Museum in Vicenza from April 12 to May 5 2024 in conjunction with Milan Design Week and curated by Guido Beltramini and the writer of this paper, told the story of Palladio as a designer of micro-architectures by presenting scale models of 46 fireplaces, two washbasins and a sink, alongside drawings, videos and interactive applications based on digital models rendered in real-time (fig. 9).

Fig. 7. Body measurement paper pattern and cardboard model of a chair and table by a student at the University of Bologna (drawing and photographs by G. Bacci).

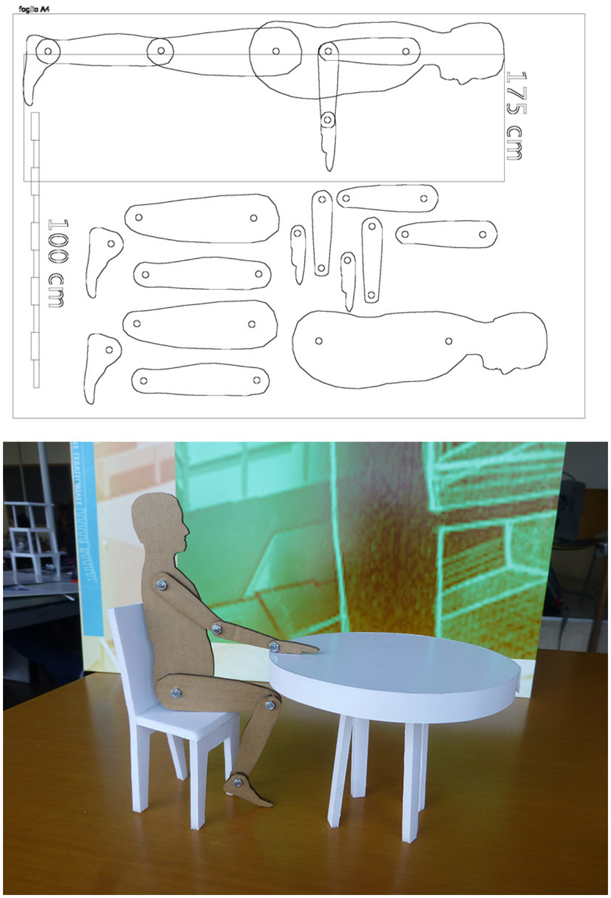


Fig. 8. Two models by University of Bologna students inherent to the representation of their living spaces (photographs by G. Bacci).

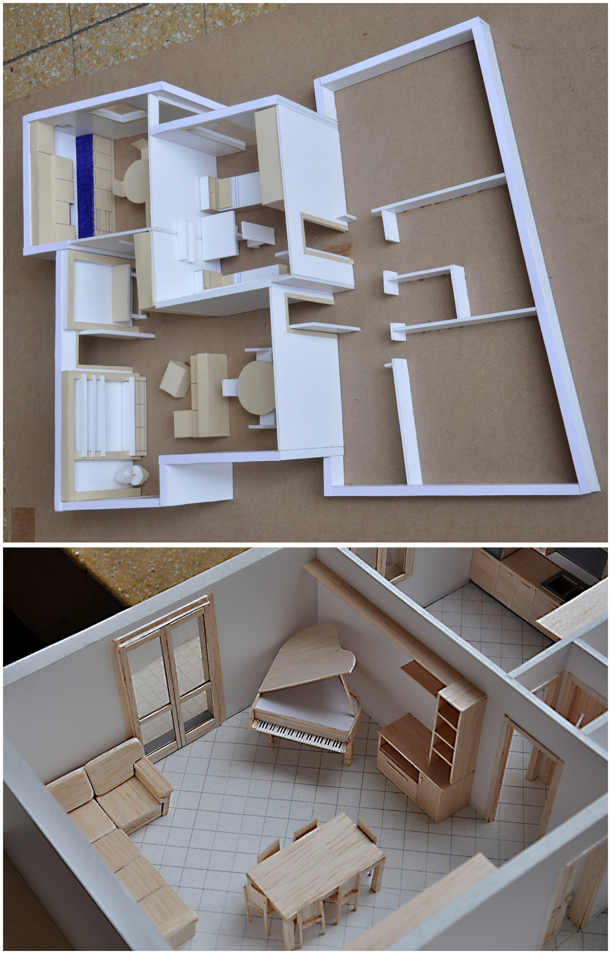


Fig. 9. Analog maquettes of 49 design objects by Andrea Palladio displayed in the Palladio designer exhibition (photograph by S. Garagnani).

Underlying the exhibit was the work of the students attending the *Fotogrammetria per l'architettura* (Photogrammetry for Architecture) course at the University of Bologna, who captured in 3D various artifacts scattered throughout thirteen buildings –from the Rotonda to the Doge's Palace in Venice– using a commonly used tool, a smartphone, and photogrammetric techniques [Kingsland 2020]. By using a workflow and software developed by the University of Bologna, it was possible to reconstruct the three-dimensionality of the objects with millimetric accuracy (fig. 10).
As regards our specific interests, the exhibition had two fundamental themes with the aim of creating knowledge in order to examine Palladio's micro-architectures: the construction of 3D models and 2D drawings from measured data and the making of analog models, copies of real objects.
Here we will focus on the latter topic, which is most directly related to the exhibition's overall theme of making architectural research engaging and understandable.
No models of Palladian buildings or designs have come down to us, nor did Palladio use them as design techniques for the construction of his many palaces and villas [Puppi 1987]. However, several Palladian models are documented: for example, a probable drawing of a model for San Giorgio Maggiore in Venice and a painted representation of another model for the Church of the Redeemer. These were basically meant to illustrate construction problems (an observation by Inigo Jones in his notes to the Palladian treatise, *The Four Books of Architecture*, published in Venice in 1570, also suggests that Palladio, on at least one occasion, carved sample details for masons to follow, thus providing a 1:1 three-dimensional model for capitals and the like) as well as communicative problems (the Vicentino City Council had a life-size wooden model of a bay of the future Basilica built as the basis for a final decision on the project) [3]. Because of their effectiveness in these uses, Palladio used them as a complementary system to drawing, his design tool par excellence.
This complementary use of models and drawings was a common practice in the 16th century and had received theoretical consecration from Leon Battista Alberti. In his *De re aedificatoria* Alberti advises novice architects to thoroughly study all significant buildings and even to have them close by at all times in the form of models [Alberti 1966, pp. 96, 97]. And, even while indicating the use of orthogonal representations as the only rigorous design procedure the architect should have used, he referred to the wooden model as the surest guarantee for developing a design to its fullest extent. For Alberti, only the model could provide the definitive information about the position and layout, the thickness of the walls and vaults, or the cost of the building [Frommel 1994].
In *Palladio designer*, instead of using models and drawings as alternative systems, it was decided to use them as complementary illustrative techniques. Therefore, next to 3D prints of the digital models resulting from photogrammetric survey, all at the same scale (1:20) so that they could be compared (fig. 11), drawings with dimensions in feet and *once vicentine* (Vicenza ounces) were displayed, in 1:20 scale for the general views, and 1:2.5 for the details, that is, the same kind of output that Palladio proposes in *The Four Books* (fig. 12). Unlike the volume in which the details are reproduced in Book I, while the plans of private houses and mansions are found in Book II, in this case it was decided to display the general views and the details of each object side by side, thus favoring the comprehension of each object in a capillary manner.
The exhibition then focused on fireplaces, objects mostly disregarded by historiography except for their decorative apparatus [Attardi 2002], but of great interest because they are perfectly realized micro-architectures. In fact, they consist of the basic elements of a construction: two

Fig. 10. Analog maquettes of the fireplaces of Villa Garzoni in Pontecasale (Padova) displayed in the Palladio designer exhibition (photograph by S. Garagnani).

Fig. 11. Analog maquettes of fireplaces by Andrea Palladio and Vincenzo Scamozzi at the Doge's Palace in Venice displayed in the Palladio designer exhibition (photograph by G. Streliotto).

pillars supporting a lintel. However, these three elements are often interpreted in different ways. Fireplace mantels can replicate systems of entablature on pillars or corbels, or form a continuous motif around the fireplace.
In the fireplaces, the moldings, different for each of them, represent the artist's 'imprint' and are the expedient for shaping chiaroscuro in material form. Their study, focusing mainly on their two- and three-dimensional comparison, allows for a deeper investigation of the theme and links it to the sources of Palladio's history and design drawings, which may contain references to as yet unidentified mantels. Alongside this investigation, the analysis of proportions, dimensions, and the relationship between decoration and mantel, especially by comparison of the various fireplaces in the series, provides fundamental elements for trying to provide answers to the many still unresolved questions. Which fireplaces had Palladio actually designed? Were there recurring types or was each fireplace a source of autonomous design? What archetypes did they have? What was the formal, dimensional, and proportional relationship between one fireplace and another?
For this reason, the small analog models, all realized with a stereolithography photosensitive resin printer (MSLA), were not conceived as finished artifacts, but rather as mock-ups in three dimensions capable not so much of providing an image but, thanks to an abstract and simplified appearance given by a simple coat of matte white paint, of being fundamental tools for making formal comparisons and serial analyses.

Conclusions

Architectural analog models are distinguished by their essential connection to the physical reality of the object, generally of a building, which they envision. They are physically 'visible' and 'manipulable' artifacts, thus they are objects that multiply sensory perception. They are therefore representative systems central to 'architectural discourse'. Beginning with Alberti, this central position is intentional, including the (desired) flexibility that accompanies it. 'Exemplary' (indicating the model as an exemplary and singular archetype) and 'module' (indicating the model as authoritative and fundamental) are the terms by which he defines them, recognizing their ability to enable close cooperation between speculative-abstract and empirical-material approaches [Oechslin 2011, p. 131].

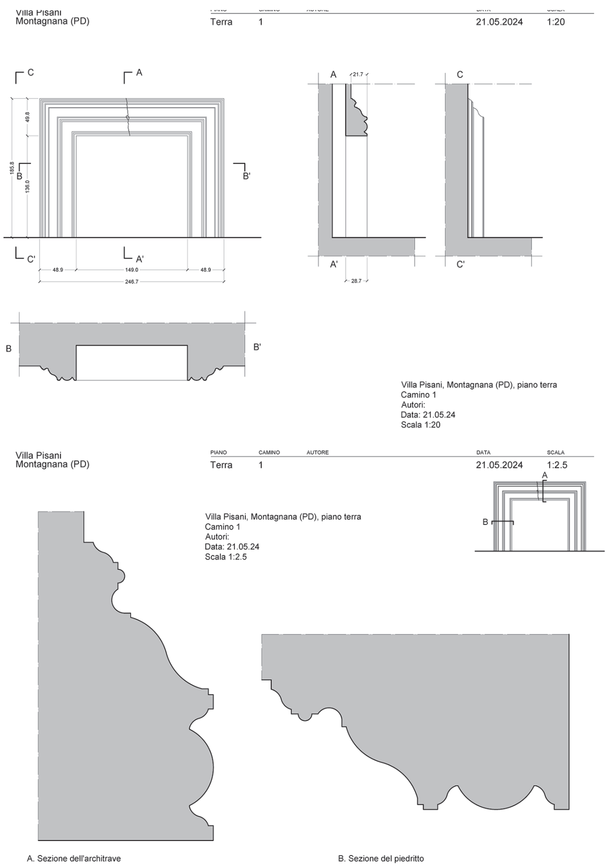


Fig. 12. General views and details of the mantel of a fireplace by Andrea Palladio at Villa Pisani in Montagnana (drawing by E. Angeletti).

This Albertian thought has guided theoretical observations and practical experiences described in this paper, simple episodes in a much more complex story, because in architecture the model has a special significance: it serves, like the drawing, as a simplified image from a representational or theoretical point of view that mediates between the abstract and reality, but with a far greater level of iconicity and with greater possibilities for manipulation than the graphic apparatus. Which is why the analog model will remain indispensable for a long time to come.

Notes

[1] Fabrizio Ivan Apollonio, Giovanni Bacci, Filippo Fantini, Simone Garagnani.

[2] Mendini, A., *Storielle di design (con morale). Lectio laurea ad honorem*, Politecnico di Milano, April 5, 2006. <http://www.ateliermendini.it/index.php?mact=News,cntnt01,print,0&cntnt01articleid=98&cntnt01showtemplate=false&cntnt01lang=en_US&cntnt01returnid=164> (accessed 10 June 2024).

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The Model of Cadiz: a Unique Prototype for the Representation of Spanish Cities at the End of the 18th Century

Nicolás Gutiérrez-Pérez, Isabel Artal-Sanz, Tomás Abad, Pilar Chías

Abstract

Once he assumed the Spanish throne after his reign in Naples, Charles III began an ambitious project for the elaboration of a set of models of the most important strongholds in Spain, in order to facilitate the comprehensive understanding of these cities and as a means to make proposals for improvement, mainly in their fortifications. The first project was developed in the city of Cadiz –the main commercial port of the Indies and strategic enclave of the country– between 1777 and 1779, under the direction of Francesco Sabatini, Royal architect, who appointed Alfonso Ximénez, military and model maker, to execute it in the city together with a large multidisciplinary team. As a result, they made a model larger than 100 m² of surface at ±1:250 scale, using noble materials, such as different types of wood, ivory, and silver, constituting an exception among the urban models that had been made so far, both for its size and richness, as well as for its level of abstraction. In this article we will approach this singular and unique exercise by contextualizing it in the European panorama of the time, as well as through its analysis and three-dimensional survey, which will offer new perspectives and will allow us to contrast its accuracy and relationship with historical cartographies, in order to finally value and vindicate the exceptional nature of this graphic contribution in the form of a model.

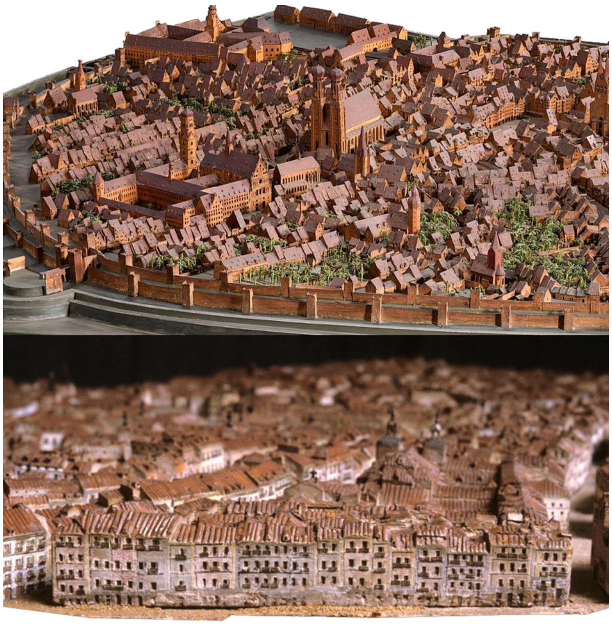
Keywords: model, Cádiz, prototype, Charles III, survey.

Introduction and precedents

The use of the model as a support for graphic expression is a fundamental practice in the discipline of architecture because it allows a three-dimensional and holistic view of the object represented. Likewise, its ability to visualize, check and experiment on the model makes it a particularly useful element for design and construction, in the same way, allows it to be understood in an accessible and intuitive way by the majority of publics and clients [Carazo Lefort 2018]. In this sense, the use of the model took on special relevance in the Renaissance, becoming a product especially requested by patrons of the arts as a means to obtain an image of the final state of their commission [Franco Taboada 2018]. In this period, stand out the wooden models produced in the city of Florence for the competition to design the façade of the cathedral or the model of Brunelleschi's dome which, in addition to being a visual approach, was a tool for understanding the construction process (fig. 1) [Millon 1994]. In the Spanish context, and with the same objectives, highlights the preserved project model of the current Prado Museum (originally the Natural Sciences Cabinet), made with different types of noble woods around 1786 and which allows to observe and understand its interiors by uncovering the roofs and disassembling all its elements [Maure Rubio 2021].
In addition, the use of the model also served as a means to objectify an element of reality in order to record its morphology to obtain a comprehensive –and at scale– vision and mastery of it, without any other purpose related to a

Fig. 1. Model for Brunelleschi's dome (1419-1436) and Giambologna's proposal for the façade of Florence Cathedral (1586-1589). Museo dell'Opera del Duomo, Florence.

Fig. 2. Top: Model of Munich (1570), Bayerische Nationalmuseum, Munich. Bottom: Model of Madrid (1830), Museo de Historia de Madrid, Madrid.



design process. As an example, in the 16th century a desire arose to represent cities volumetrically through models, both for strategic-military purposes, as well as for the eagerness of some monarchies to possess a scalar reproduction of their urban and territorial domains [Buisseret 1988]. In Europe, the models of the Bavarian capitals commissioned by the Duke of Bavaria stood out –among them the model of the fortified city of Munich made in 1570 (fig. 2), the oldest preserved– which as a whole were made of linden wood and, on this support, painted to differentiate the distinct types of elements represented: roofs, facades, terrain, etc. [Reuther 1974]. In the Spanish context, there is also evidence of a large collection of urban models of military character belonging to Philip II, which were kept in the Royal Alcazar of Madrid, during the second half of the 16th century [De la Torre Echávarri 2014].
At the end of the 17th century, the most notable collection of urban models in terms of volume was that of the French monarchy, which turned these objects into true elements of consultation that were indispensable for plotting any military strategy [Warmoes 2018]. In this case, models reproducing castles and fortified cities were promoted, including in them the territorial context as a means of recording the orography of the terrain, fundamental for the development of battles. The scale of representation used was 1:600, whose definition adequately met the objectives set, and they were made under the direction of topographers and geographers [Salerno 2019]. The material used to make these models was wood for the base, as well as cardboard, painted paper, metal and silk for the rest, which would give an ephemeral character to these representations, leaving open the possibility of making modifications later and also assuming a particularly realistic aesthetic in the graphic expression. Henceforth, the production of urban models with a realistic vocation of great quality and rigor would continue, for example, in the Spanish context with the model of Madrid by León Gil de Palacio made around 1830 (fig. 2) [Álvarez Barrientos 2016].
In short, and in general, we find two types of model representations during this stage: on one hand, those made with noble and solid materials –such as wood– which were mainly used for the presentation of buildings or certain parts of them prior to their construction, possessing a marked character of abstraction due to their dematerialization; and, on the other hand, those made with humble and ephemeral materials that were painted meticulously –hiding their true nature– and whose vocation was to

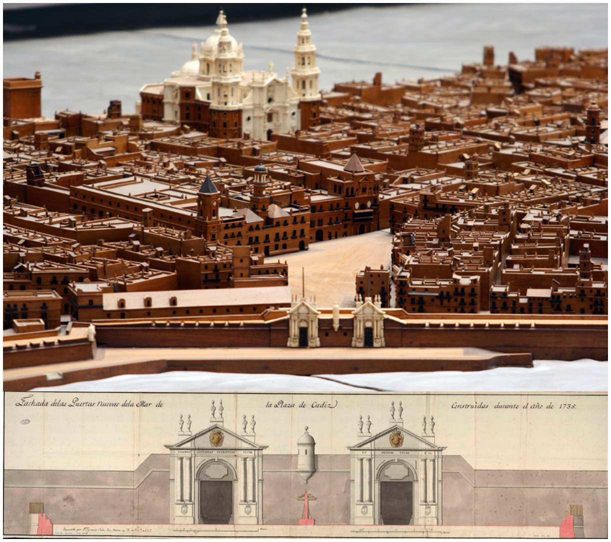
Fig. 3. General view of the model of Cadiz (Museo de las Cortes de Cádiz). Photo by the authors.

realistically convey the material and superficial qualities of the objects represented, which were essentially cities.
The project that concerns us, the model of Cadiz made between 1777 and 1779 (fig. 3), cannot be fully inscribed in the latter case, because although it is an urban model, its materiality resembles the building models of the architectural scale. That is, it represents an existing object and also assumes the abstraction or dematerialization prototypical of projection models. In fact, this model advances even further on the exposed archetypes, since it introduces materials of great richness, being a unique example in terms of its value and the abstract conjunction of materials, moving us to another typology of objects close to the sumptuary. Also, through the 3D survey of the model carried out, which offers us the possibility of viewing the floor plan of the model, we can compare the accuracy of the exercise according to the current morphology of the city and the historical cartographies of the time.

The first prototype for a Fortification Cabinet

The idea for the creation in Spain of a "Cabinet of Fortification" [1] during the Enlightenment was born in the Crown during the reign of Charles VII in Naples and, specifically, after accessing the collection of models that the Duke of Noja, Giovanni Carazza, presented to him in 1744. A set of 10 military representations of cities and fortifications of the kingdoms of Naples and Sicily made in wood, cork and painted plaster, most of which are preserved scattered in various Italian museums [Viganò 2007]. Later, once he assumed the Crown of Spain, this monarch –now, as Charles III– will find much utility in the models made by the infantry captain Alfonso Ximénez around 1774 of the Spanish fortifications in North Africa, that served as support for its defense during this period of great tension with Morocco [Muñoz Corbalán 1999]. After these events, the King promoted the construction of models of the main fortifications and strongholds of Spain as a means to understand, confront and improve the defense of these enclaves in anticipation of future enemy attacks.
The director of the project promoted by Charles III was the Count of Ricla, Minister of War, who proposed the architect and military engineer of the Royal House and responsible for the great urban and architectural reforms of Madrid, Francesco Sabatini, to be in charge of its execution [2]. After observing the last models mentioned, he appointed Ximénez himself as the person commissioned to create this collection of plan-reliefs of Spanish fortifications "such as all the Sovereigns of Europe already have" [3] and, after that, they selected the city of Cadiz to develop the first model and prototype due to its importance as the main commercial port of the Indies and strategic enclave of the country (fig. 4).
The work began in 1777 once Ximénez moved to Cadiz and selected the team of local masters –cabinetmakers, sculptors, measurement assistants, etc.–, although the project management considered the possibility of producing it directly in Madrid –the place where the model was to reside after its completion– and finally discarded it because of the higher economic cost [Martínez Montiel 1999]. This condition of mobility of the model was one of the most important and controversial factors when determining its scale, since initially the scale ±1:190 –"12 rods for every 3 fingers"– was considered and worked on, to finally adopt by agreement between Sabatini and Ximénez the scale ±1:250 –"7 rods per inch of Castile"– which would provide a smaller model [4]. In spite of this, the resulting model

Fig. 4. View of the model of Cadiz (Museo de las Cortes de Cádiz) with the Puertas del Mar (Sea Gates) in the foreground, next to the plan of its project in 1736. Photo by the authors and AGS, MPD, 53, 055.



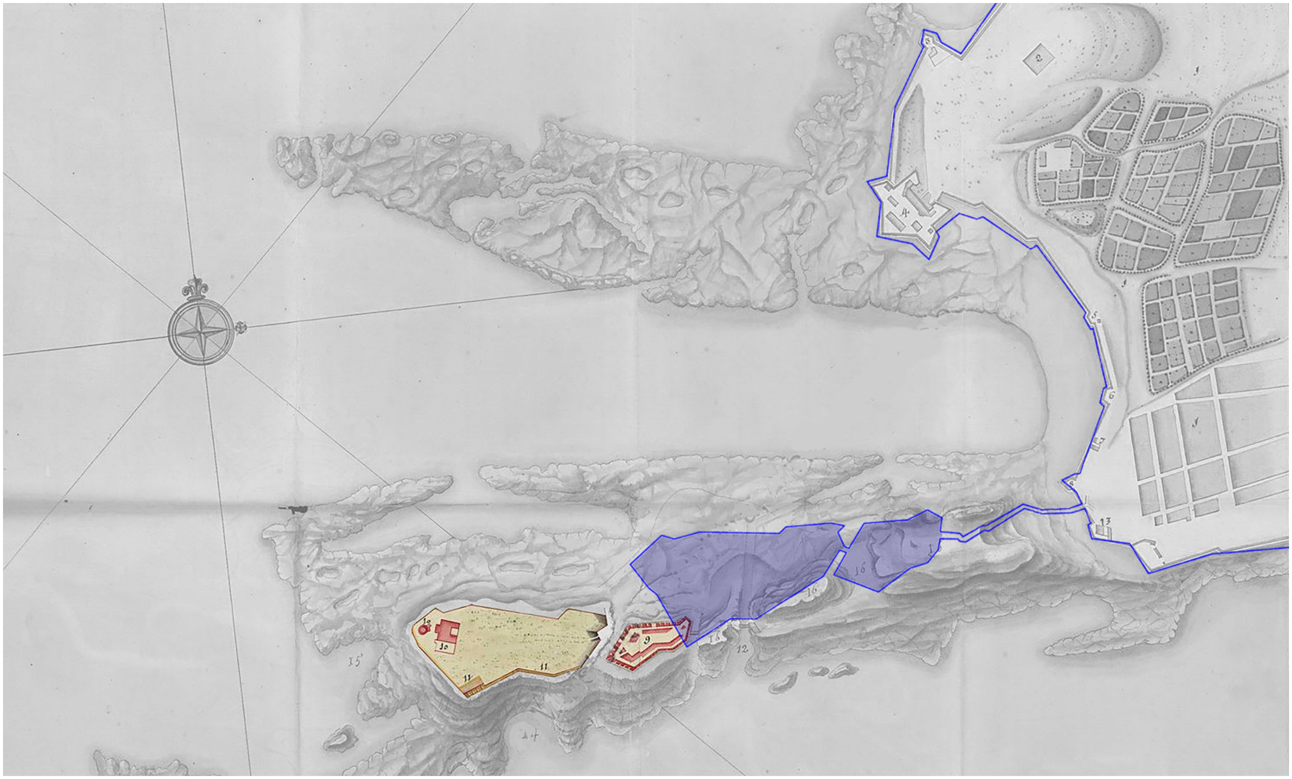


Fig. 5. Castle of San Sebastian in the model (in blue) with respect to its original position (in colors). Graphic elaboration by the authors over historical cartography of the 18th century (AGS, MPD, 18, 233).

would not respond effectively to this premise, since its final measurements were 13.4 x 7.5 m on surface, forming a vast area of just over 100 m² which, due to its dimensions, would cause numerous logistical and spatial problems. Likewise, this distance from the Court and from Sabatini's direct supervision offered Ximénez a freedom of action that, in effect, he would use to give shape to a prototype of the ideal model from the technical and artistic point of view, to the detriment of the premises of mobility and flexibility agreed upon during the commission.

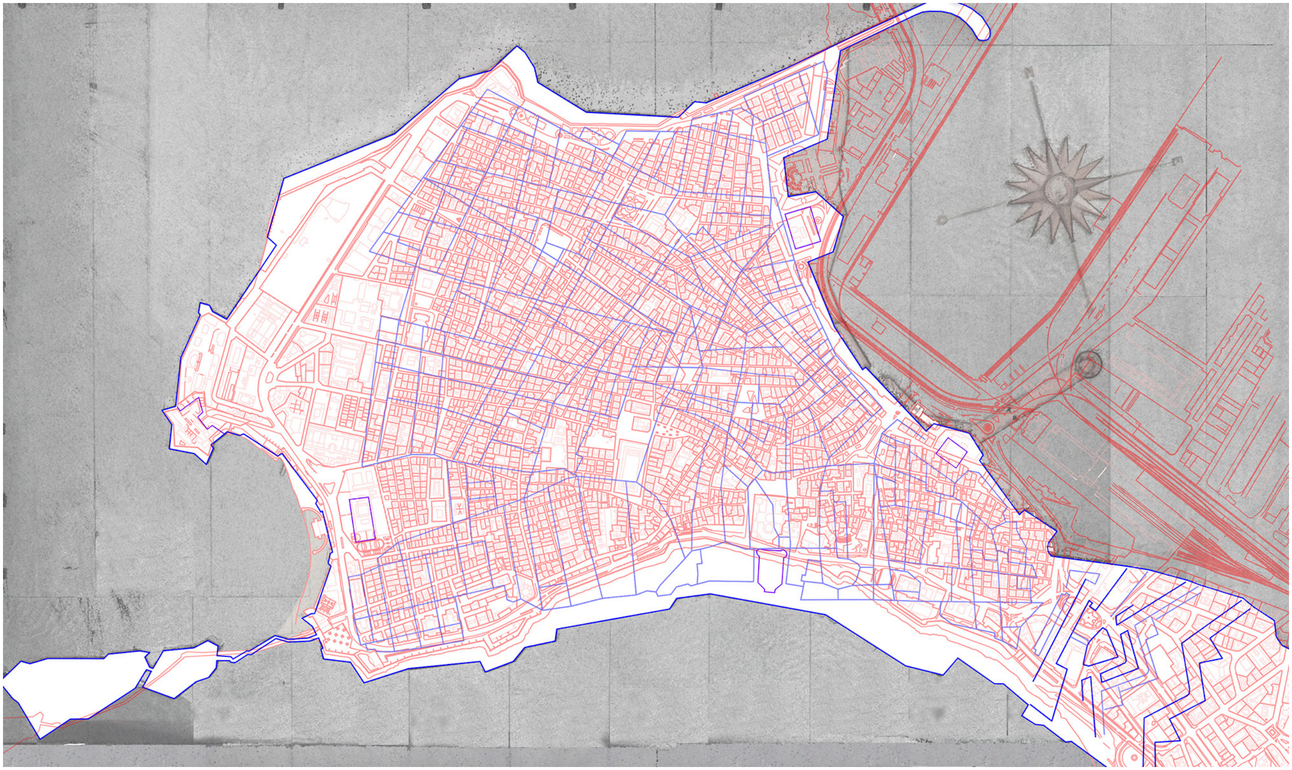
Finally, the model was finished in 1779 and moved during the month of May to Madrid, where it was installed in the distinguished Salón de Reinos of the Royal Palace of Buen Retiro [5]. There it was presented to the King and the Prince, who were fascinated by Ximénez's work: "H.M. with H.R.H. Prince Augusto spent an hour and a half filling me with incredible honors, until the King put his hand on my shoulder" [6]. However, the very high cost of the model –176,104 *reales de vellón*– [7], its practical immovability due to the complexity and the expense incurred for its displacement from Cadiz –both for its fragility and its dimensions and weight–, as well as the inability to introduce modifications on such static supports, led to the definitive conclusion of the project of the Cabinet of Fortification [8]. Finally, in 1889 the model returned to the city of Cadiz, where it is currently exhibited in the Museo de las Cortes.

Development and accuracy of the model

The work process developed by Ximénez began with the field work carried out by himself accompanied by two assistants for the survey plans and two masons who took the dimensions of the buildings and streets with specific measuring instruments for fortifications. Ximénez also had a camera obscura that he could place in the highest points of the city, in which there were numerous towers for the sighting of ships coming from overseas, as well as a field shelter to protect him from inclement weather while he made the drawings [9]. After carrying out the survey, he transferred the orders for their reproduction, personally supervising and correcting their development.

Likewise, there is no documentary evidence that Ximénez used the existing military cartography of the city, whose production was especially prolific during the 18th century due to the different fortification projects that were planned and developed at that time [Chías Navarro, Abad Balboa 2011]. On the contrary, and although they could serve as a reference, the author made new surveys of the fortifications: (on the ground) "I have continued cutting an infinity of profiles, and elevations and where these have not been sufficient, I have proceeded to the copy of the ground in wax that increases the perfection I desire"; (in the workshop) "immediately from the Maestranza to direct the cabinetmakers; either drawing the figures on the wood, or adjusting myself their plans, and thicknesses; and in such delicate matters; and small, I do not pass them the

Fig. 6. Superimposition of the scan of the model and its drawing (in blue) on the current cartography of Cadiz (in red). Graphic elaboration by the authors.



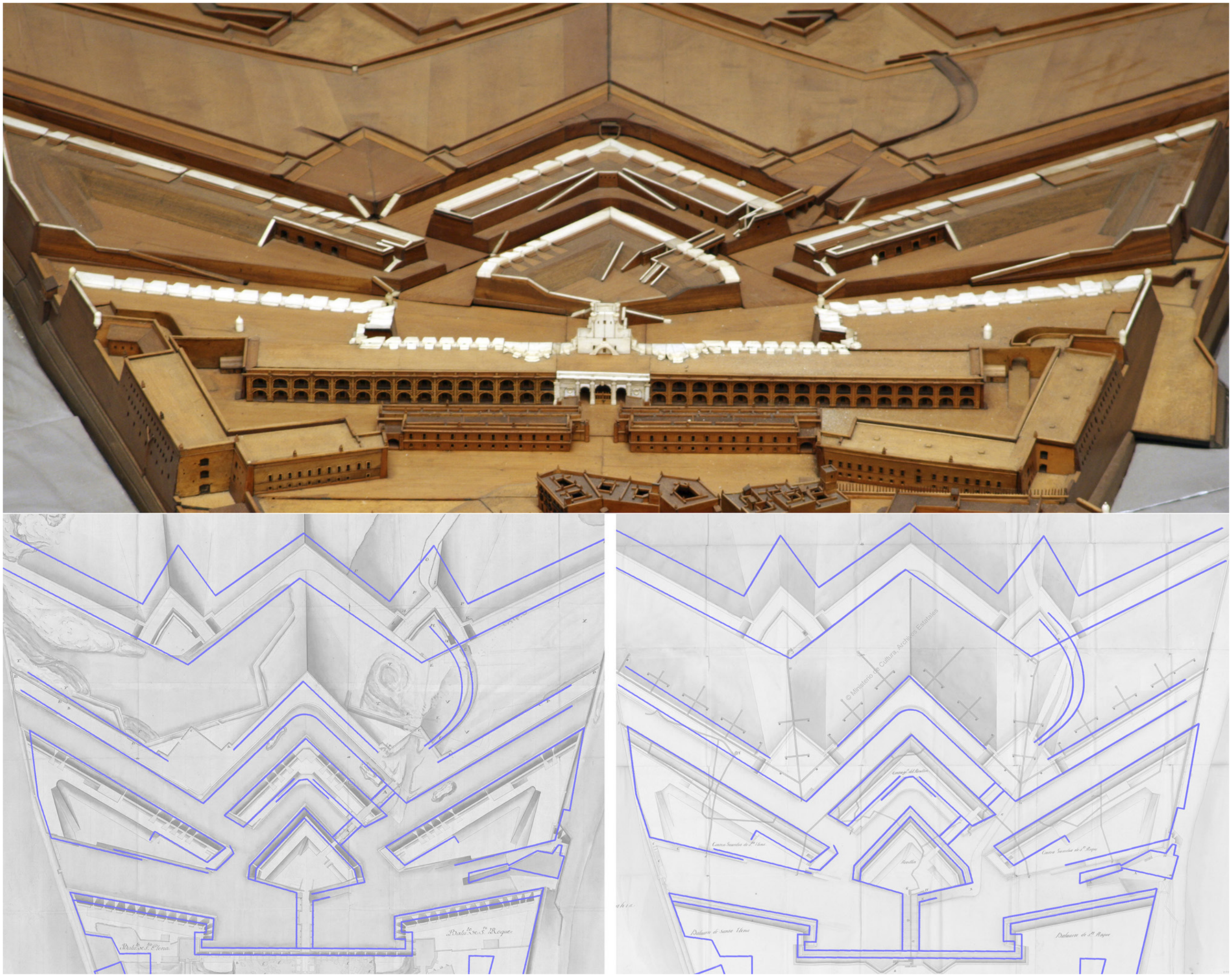


Fig. 7. Top: View of Puerta de Tierra (Land Gate) of the model of Cadiz (Museo de las Cortes de Cádiz). Bottom: Superimposition of the model survey (in blue) on the historical cartography of 1750 (left) and 1798 (right). Photo and graphic elaboration by the authors over AGS, MPD, 53, 034 and 57, 040.

most despicable"; (and, in short), "I do not hesitate a foot difference nor the smallest point of its original" [10].
The verification of the precision and accuracy of the model as a whole cannot be fully carried out today because it returned to Cadiz in very poor condition and was repaired –and transformed– intensively. In addition, it was again profoundly altered in the urban area and reduced in size to allow it to fit in the spaces intended for its musealization [Garófano Sánchez 2022; Granado Castro, Barrera, Aguilar Camacho, 2016]; therefore, the measurements of the current model are 10.80 x 6.45 m, 31% less than the original. One of the elements altered situationally is the Castle of San Sebastian, which approached the city during this reductive process (fig. 5).
During the research we have surveyed the model by laser scanner as a means to check its correlation with the plan of the present city and its fortifications [11] (fig. 6). In general, the plan corresponds quite accurately with the current maritime border –especially in the western, northern and eastern fronts– and, on the contrary, there is a significant mismatch with the sea line in its southern front, where the Cathedral is located. Likewise, the city's urban layout is precise and corresponds to the current urban grid –with some exceptions and slight mismatches– in the space delimited by the aforementioned coincident fronts; the greatest errors occurring in the space adjacent to the Cathedral, as well as to the great fortification of Tierra –located to the southeast of the city–. In any case, and taking into consideration the magnitude of the model, we can conclude that Ximénez's representation is highly coincident with reality and, from our point of view, it is possible to attribute these discrepancies to the transformations produced in the model after his return to Cadiz; due to the rigor with which the author developed all his work, as we point out below.

Fig. 8. Comparison between the 1775 project for the New Cathedral represented in the model of Cadiz (Museo de las Cortes de Cádiz). ETSAM Library, AG_0072-01 and photo by the authors.

Fig. 9. Details of different buildings and objects of the model of Cadiz (Museo de las Cortes de Cádiz). Photo by the authors.

On the other hand, and because of the demolition of some of the buildings recorded by Ximénez in the model, it is not possible to confront their accuracy with the current planimetry –specifically the case of the important walls of the front of the Puerta de Tierra, the only land connection with the Peninsula, and in which the author put special effort– and, therefore, we have resorted to the cartography of the time. Specifically, and due to the improvement actions to which it was subjected throughout the eighteenth century [Aguilar Camacho, Granado Castro, Lozano Martínez 2020], we have used the preceding military cartographies –done during the works– and later –concluded these–, yielding a result of maximum precision, especially with the last plan of 1798, which is a symptom of the exactitude of the model (fig. 7).
It should also be noted that Ximénez not only recorded the buildings in their current state, but also studied the projects and plans of the buildings that were being executed in the city, in order to reproduce the appearance that they would have once the works were completed. An example of this is the new Cathedral of Cadiz, which was under construction and whose original project had been replaced in 1775 by another that modified the facade, the towers and the dome that were being built [Navascues Palacio 1982; Marías Franco 2007]. In this sense, the model contributes to know what the cathedral would have looked like if this project had been executed, constituting a unique three-dimensional vision of this ephemeral proposal (fig. 8), since it was replaced by a more modest one in 1790.
In addition to this, the model has a significant group of buildings that are completely modeled inside, detailing the composition of their rooms, patios, walls, and arcades, as well as auxiliary elements such as stairs, pavements, etc., which could be observed by uncovering the roofs or extracting them from the model. These are civil and military buildings that belonged to the State –customs house, barracks, engineers' pavilion, etc. [Garófano Sánchez

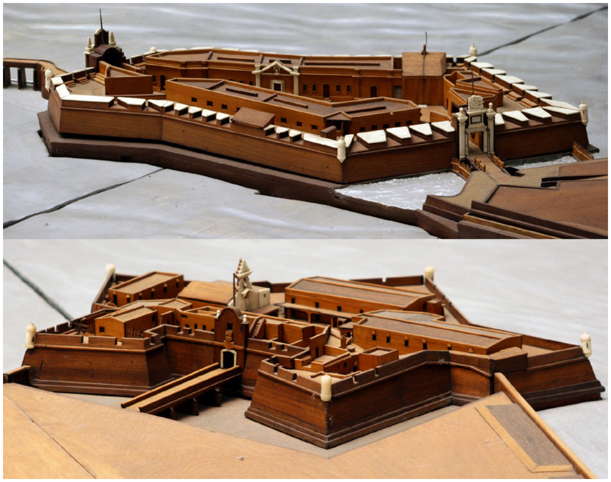
2022] – that Ximénez reproduced in order to create a holistic representation of the architectural structure that was at the service of the Government.
In short, the ambitious project undertaken by Ximénez not only faced the difficult task of making a 1:250 scale urban model, but did so with great rigor and accuracy, expanding the objectives of the same; and, ultimately, developing an ideal prototype for the government of a stronghold.

Materiality, abstraction and sumptuousness

As a whole, and in general, the model of Cadiz is made with only three types of materials –wood, ivory and silver– which were carefully selected and acquired by Ximénez during the process of study and execution in the city of Cadiz. In this sense, the author of the model requested samples of the different types of wood existing in Spain –including those from its overseas territories– and even from China, in order to determine their material qualities and their combinatory capacity [Martínez Montiel 1999].
The support is made up of 39 wooden boards that support the entire surface of the model. On top of these, there is a set of cedar panels carved in an undulating form that reproduces the sea that surrounds the city, and a framework of slats gives shape to the topography on which it sits; all of which is hidden from the viewer when the model is assembled.
The final result is dominated by the use of wood, which represents the entire land surface emerging from the ocean, as well as all the fortifications, streets and squares, and buildings that make it up. Specifically, there are numerous types of wood used in the model –mahogany, ebony, cedar, boxwood, acacia, guava, rosewood, orange, cherry, pine, etc.– [12] selected to fulfill a specific function in the model according to their nobility and hardness (fig. 9). For example, the lighter shades are arranged on the facades and in some of the city's public spaces, while the roofs are darker to offer a slight contrast with the support. Some of the most important religious buildings in the city have a delicate tonal nuance through the use of cherry, which allows them to be more easily identified. Finally, the black notes obtained with ebony are located in the window frames and balconies of the buildings. This combination of materials offers, through subtle chromatic differences, the possibility of differentiating and identifying

Fig. 10. Representation of the Cathedral in the model of Cadiz (Museo de las Cortes de Cádiz) with respect to the current reality. Photo by the authors.

Fig. 11. Detail of the meticulous work on the Castles of San Sebastián (top) and Santa Catalina (bottom) surrounded by ocean in the model of Cadiz (Museo de las Cortes de Cádiz). Photo by the authors.



the several depths of the plan-relief, to the detriment of a realistic representation of the materials.
The model is made up of about 350 detachable pieces that fit on the support structure and conform the buildings and military installations of the city. The blocks made up of several houses belonging to the hamlet are assembled to form a unit that facilitates assembly but which, in turn, allows the identification of the buildings that compose it through the courtyards and the parapets that make up the roofs through the crowning of its internal walls. The facades of the buildings are only represented in detail –doors, balconies, cornices, etc.– in those places where they can be observed and have an important role in the urban scenography of the city. That is, those facades facing the sea or the main squares of Cadiz, leaving the rest of the facades undetailed beyond their profile.
Ivory is reserved for the crowning of the great defensive elements –bastions, ravelins, castles, etc., as well as the numerous sentry boxes that dot the walls– which makes it easy to identify by contrast with the wood the location of the main lines of defense and lookout elements; and all of this, without there being a material relationship with the tectonic reality. Likewise, this material in combination with bone is used for the representation of the city gates with the same purpose although, in this case, two of them were made of white marble, showing a possible material or tonal analogy. A similar case is the representation of the Cathedral that, with resounding clarity, seeks the synthetic translation of the material duality that in effect this building possesses (fig. 10).
The solid silver formed by fine plates worked by a goldsmith silversmith of the city was spread over the undulating wooden support that forms the ocean [13]. Unfortunately, the disappearance of this material prevents us from understanding the impact that the brilliance and shine that this extensive silver surface would cause in any observer. In a recent restoration, it was decided to recover the appearance with silver leaf, which, although it resembles the primitive materiality, does not have the reflective capacity and purity of silver.
Finally, Ximénez also went so far as to design the figuration of the model by, for example, the making of 500 cannons that he placed in the loopholes of the walls and more than 200 ships to scale along the great mass of oceanic silver [14]. Likewise, the author conceived the model as a scenographical artifact that would allow the entertainment of royalty, for which he orchestrated a specific

Fig. 12. Model of the Church of the Holy Sepulchre, Jerusalem. It is possible to disassemble it to access the interior where there are other parts. Finch & Co Gallery. Photo by the authors.

assembly that would include an explanatory book, a stairway to observe the model from an elevated point of view, binoculars to observe all the details from a distance, large banners and damask fabrics that hid the internal structure of the support [15].
The use of only three materials gives the model a very high degree of abstraction (fig. 11) and distances it from the models of fortifications and fortresses that were being made in Europe at the time, characterized by their realistic representation of their finishes and landscapes. Moreover, the model omits the landscape and vegetal qualities of the context, in order to distance itself from any material simile with reality

–with the exception of the Cathedral–. In this case, the exercise of synthesis proposed by Ximénez confers another type of plastic and atmospheric qualities far removed from figuration and which are articulated through the different and rich tonalities of the wood, the delicate details of the ivory carvings, as well as the intense brightness projected by the great mantle of solid silver that surrounded the city. All of this gives it a unique character that moves away from traditional representations and is closer to the qualities of the most refined decorative arts of the time –even due to the training of its executors– and, specifically, to the furniture qualities of the objects acquired by the Spanish monarchy for the decoration of its architecture [Sanchez Casado 2021; López Castán 2005]. Likewise, we can relate the sumptuary character assumed by the model with other architectural representations to scale that, in this case, were created as objects of worship and veneration, and for which noble materials were used –mainly olive wood, mother-of-pearl and bone–, specifically highlighting the richness and fineness of their carving. We refer, for example, to the models of the Holy Sepulcher in Jerusalem that were made in this city during the 17th and 18th centuries for commercialization and export as a souvenir and testimony of this sacred space (fig. 12) [Williams et al. 2014].

Conclusions

Throughout this article, it has been shown how the model of Cadiz constitutes a unique and exceptional sample of graphic representation in the ideation of a scalar prototype to serve as an instrument of integral and accessible understanding for the government of a city. An ambitious proposal that made possible and facilitated immediate access to the conditions of a stronghold and, specifically, to the morphology of the defensive infrastructures, as well as to the civil and military buildings that were at the service of the State; all of which offered an enormously useful three-dimensional support for reflection. However, the scale chosen by Ximénez, who specifically preferred to increase the size of the model due to the difficulty of capturing his project at a smaller size –"an imponderable work due to the smallness of its parts"– [16], configured a prototype of disproportionate dimensions and difficult to handle, both for its size and its weight; all of which, added to its high cost, would lead to the halt of the Fortification Cabinet project.

The elements that through the 3D survey of the model we have been able to compare with reality or with contemporary cartography have revealed a great fidelity and precision in the survey and formalization of it, specifically regarding the defensive infrastructures. Likewise, and from the perspective of graphic expression, this prototype represents an advance with respect to the cartographies of the time by incorporating, for example, the morphological representation of the buildings that made up the city's hamlet, whose courtyards and internal walls are represented on the roofs of the blocks, thus facilitating a comprehensive understanding of the city; even anticipating the projects that were being developed at the same time as the model.

Finally, it should be noted that the model was conceived as an artistic and ornamental object that was to occupy a dominant place in the palace rooms –"the quality of the model will in no way detract from the decency and security of the site"– [17], as indeed came to be the case, and for which sumptuous materials typical of the discipline of the decorative arts were used. In short, we find ourselves before a prototype model that, added to the rigor of architecture, brings new concepts and approaches to the field of graphic and artistic expression of the time.

Acknowledgements

We thank the Museo de las Cortes de Cádiz for their facilities to scan the model. We would also like to thank the University of Alcalá for the Ayuda Margarita Salas granted to Nicolás Gutiérrez-Pérez, financed with Next Generations funds.

Notes

[1] AGS (Archivo General de Simancas), SGU (Secretaría de Guerra), File 3807, Sheet 577.

[2] "It would be very useful to have in the Secretary's Office of Your Excellency the Strongholds of the Kingdom worked in models of competent magnitude and exact measurements, not only for Your Excellency's government and prompt knowledge of any additions or repairs that may be projected or agreed to be made in any of them, but so that Your Maje-

sty, the Prince and Infantes, at all times, could understand with effective property the fortifications of each Strongholds and the defense of which it is capable". *Ibid.,* Sheets 32-36.

[3] *Ibid.*

[4] *Ibid.*

[5] AGP (Archivo General de Palacio), Box 804, Exp. 2, Sheet 48.

[6] AGS, SGU, File 3807, Sheet 577.

[7] *Ibid*., Economic report (June 16, 1779).

[8] *Ibid.,* Sheet 618.

[9] AGP Box 804, Exp. 3 and 18.

[10] AGS, SGU, File 3807, Sheet 145.

[11] The scanner model used is Leica BLK 360 and Cyclone Register processing software. During the survey, the main problems arose from the lack of space to locate the scanner, as the architecture around the model is very narrow. Also, the existence of a protective mesh in the upper gallery makes it impossible to take scans from elevated points, which would help considerably in capturing the interior of the different streets that make up the model, the main problem in this particular case. Therefore, during the survey campaign, different solutions were devised to locate the scanner at elevated points, by placing ephemeral elements to support it. In total, 8 scanning stations were set up, 4 on each side.

[12] AGS, SGU, File 3807. Record of October 1777 and September 1779.

[13] *Ibid.* Receipt for the work of the silversmith Antonio Lozano on the model.

[14] *Ibid.* Expenditure notes (May 1, 1779, and October 13, 1779).

[15] *Ibid.*

[16] *Ibid.* Record of September 1779.

[17] *Ibid.* Letter of May 5, 1779.

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The Mock-up as a Tool of Projecting. Innovation and Experimentation in the Nuova Rinascente by Albini and Helg (1961)

Lorenzo Renzullo, Margherita Maurea

Abstract

The construction details presented during the XII Milan Triennale in 1960 and at the Venice Architecture Biennale in 1968 suggest that Franco Albini and Franca Helg employed the mock-up as a tool to evaluate innovative solutions in the realization of the Nuova Rinascente in Piazza Fiume, Rome, inaugurated in 1961. Faced with regulatory constraints and contingent factors, the architects explored various project possibilities. It is noteworthy that the transition from an initial design (1957), characterized by steel portals and travertine walls, to the completed project (1961), featuring a steel frame and exterior closure in Silipol panels, is primarily attributed to an imposition by the Superintendency which required a 'Roman' character for the building. Consequently, the 'ostentatiously two-dimensional' front of the initial project had to change into a 'corrugated surface' of panels, leading the architects to conceive a prefabricated version of the traditional stone facade. By reconstructing the ideational process of the Nuova Rinascente project in Rome, this contribution aims to explore the architect-engineer's general inclination to experiment, through the mock-up, with an 'unconventional' approach to design, conceived as the potential radicalization of new spatial, formal, and material protocols that require the precision of work as an essential prerequisite for the quality of outcomes.

Keywords: Franco Albini, mock-up, design tool, facade.

Introduction

If during the Renaissance, with Alberti, the components of the building were designed directly on-site through the direct involvement of artisan craftsmen in the design and realization of detailed full-scale models, in the architectural and engineering culture of the second half of the 20th century, "the elements of the building are separated and articulated in order to respond to the structural and functional constraints imposed by the spatial program" [Venturi 2014, p. 46]. This period marked a crucial era, where prominent figures like Albini, Moretti, Nervi, Ponti, and others, aimed to reaffirm Italian architecture on the international scene. Their vision embraced a "reinvented modernity in which lives that Italian measure which is something unmistakable and intense […] a hybrid, metamorphic, and plural fact" [Purini 2008, p. 35]. Not surprisingly, these ideological affinities led to the exploration of the frontiers of *structural modeling*, a particular experimental technique that involved the creation of sophisticated 1:1 scale models. Working on a model was equivalent to working on reality: contact with physical matter pushed towards "a mental attitude of modest admiration in front of the mysterious and complex wisdom of things, a much more appropriate and profitable attitude than the simplistic certainty to which the formal absolutism of mathematical schematizations can lead" [Nervi 1947, pp. 4, 5]. This phase of renewal, especially in the field of compositional and constructive solutions, highlighted

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Fig. 1. Franco Albini and Franca Helg, The Rinascente department store in Rome (© Clementeste CC BY-SA 4.0).

the delicate balance between form and technique, structure and envelope. In these terms, there was an attempt to simulate not only the dimensions of the represented object but also its material and constructive principles [Mindrup 2019, p. 75]. Several contributions have already examined the scientific issues related to such experiments, often coming directly from the actors involved. However, this study aims to integrate the scientific contribution of such models, interpreted here as mock-up, to contextualize them in Franco Albini's design experience. Through a theoretical approach and a critical analysis of the Nuova rinascente project in 1961 in Rome, it aims to provide insights into the use of the mock-up and promote a deeper understanding of the possible implications and potentials in the field of design practice, as a design tool in the construction industry, and in academic research.

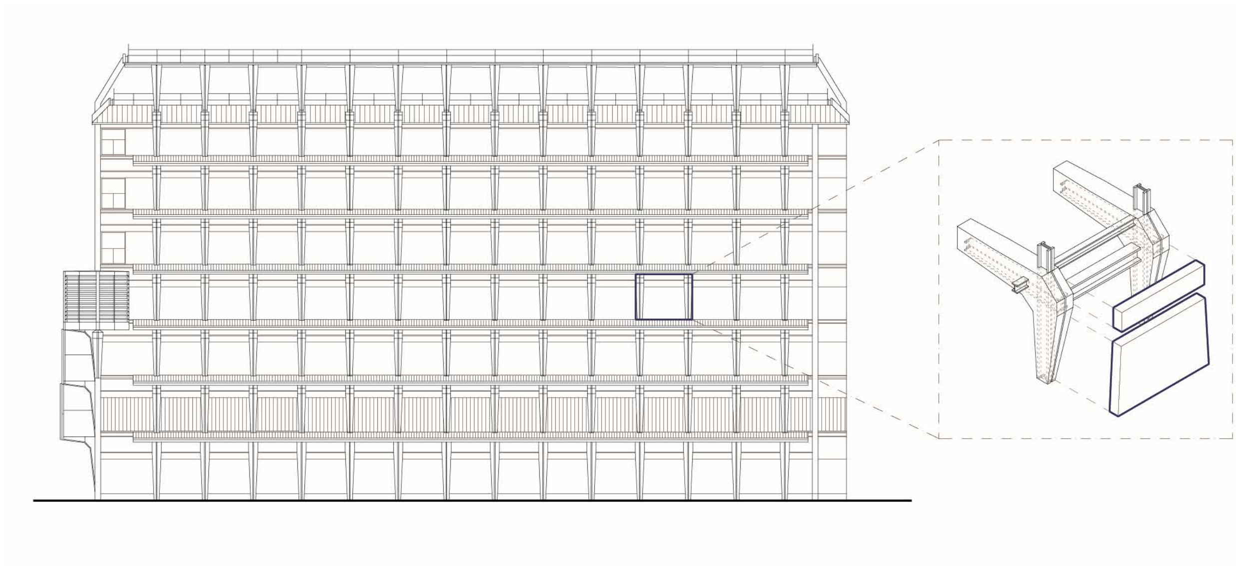
Mock-up in the history of architecture and Franco Albini's legacy

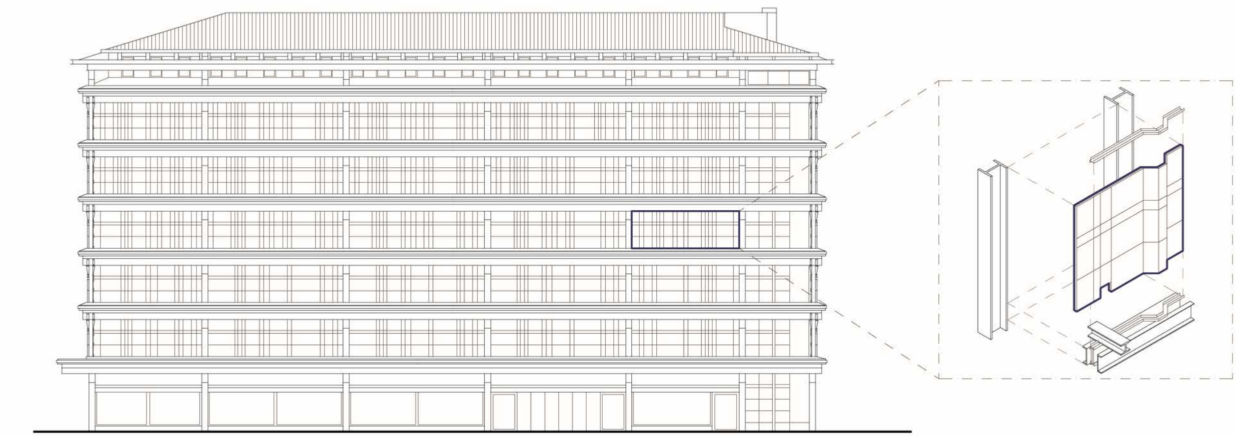
The use of mock-ups may not constitute an absolute novelty in the history of architecture. Already in 1770, Jacques François Blondel, in his *Cours d'architecture*, discussed the utility of this practice, emphasizing how the creation of models 'at the same scale' could ensure the excellence of work or persuade the client of the effectiveness of the forms or materials of a structure [Blondel 1773, pp. 160, 161]. He referred to the wooden model of the frame of Michelangelo's project for the Palazzo Farnese, which was placed on-site during construction, along with French models by Pierre Lescot, Claude Perrault, and François Mansart, to evaluate its effect from the ground. Even during the XVII century in Rome, scale models "carefully made to imitate the form and substance of the intended material" [Ackerman 2014, p. 72] continued to be used. Between the 1930s and 1970s, the attention to structural modeling favored experimentation with models that, "subjected to a series of agents" [Gargiani, Bologna 2016, p. 157], allowed the ideation of the structural form. Despite the differences between 'architectural' and 'structural' models, a solid point of contact between architecture and engineering can be found in the tangibility of the latter. These models serve as an intermediary tool that manages both structural and formal needs, allowing a reworking of the material beyond the capabilities of calculation or two-dimensional representation. Franco Albini's models [1] are part of a long tradition that spans through the history of construction, alongside other illustrious examples such as the wooden and clay models commissioned by Filippo Brunelleschi for the dome of Santa Maria del Fiore, those already mentioned by Antonio da Sangallo il Giovane and Michelangelo for St. Peter's, the models described by Leon Battista Alberti and Giorgio Vasari in their texts, the red wax and clay sculptures made by Francesco Borromini, Christopher Wren's models for St. Paul's Cathedral in London, Antoni Gaudí's funicular models, Pier Luigi Nervi's *capolavori in miniatura* [Neri 2014], and many others. In this context, Franco Albini was primarily recognized as a 'great craftsman' [Bucci, Irace 2006, p. 165]; his hands-on approach and attention to detail gave his works a unique human quality because "if ever a machine could perform those operations, the piece would not have the feverishness of the one executed by man" [De Seta 1980, p. 16]. He preferred to develop ideas through sketches and adopted "a method and a reverse process, from the particular to the general" [Bucci, Rossari 2006, p. 213], refusing to conceive a completed architectural project a priori. The physical model thus became a practical opportunity to verify insights and test solutions studied for specific contexts even on a different scale. In addition to their primary function of structural verification, Albini's models offer multiple interpretations that inform the project. Behind the formulas and technical nomenclature, themes and problems are revealed that touch on the process of design genesis.

The role of the mock-up between industrialization and craftsmanship: comparing experiences

In the context of the Nuova Rinascente project in Rome (fig. 1), the use of mock-ups takes on a primary role as a tool for research and experimentation. The ideation process stands out for the exploration of new spatial, formal, and material approaches, following "a continuous and rigorous verification of the coherence between proposed solutions and intrinsic and extrinsic data of the problem" [De Seta 1982, pp. 9-12]. The centrality of thematic and typological issues distinguishes the work of Franco Albini and Franca Helg from the project of Ferdinando Reggiori and Aldo Molteni in Milan. While the

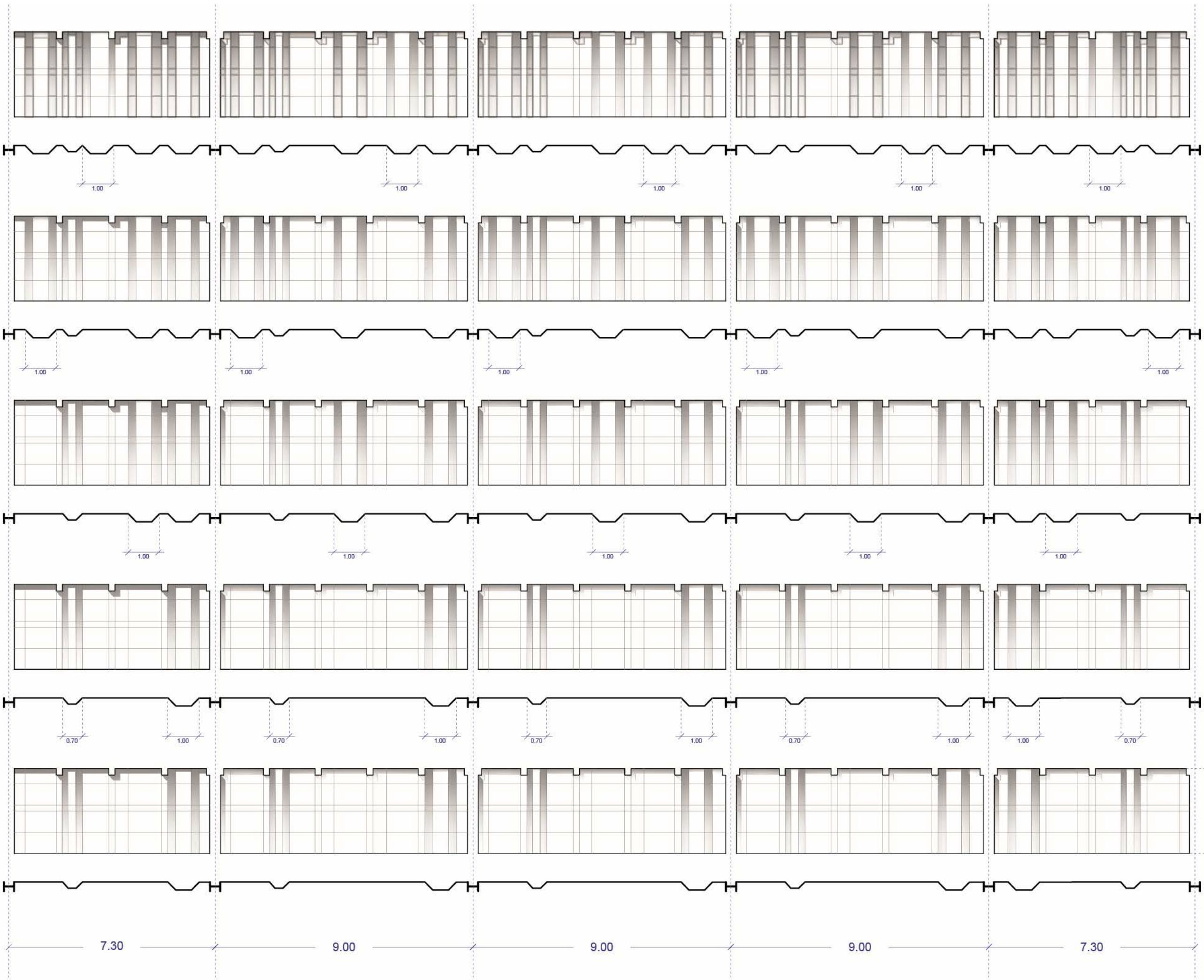
Fig. 2. Design proposal 1957. Axonometric view of the construction detail of the façade module (graphic elaboration by the authors).
Fig. 3. Final design 1961. Axonometric view of the construction detail of the façade module (graphic elaboration by the authors).





latter "did not pose the theme of the department store but only thought of a building suitable for the location" [Bucci 2009b, pp. 16-41], Albini and Helg faced specific challenges related to the commercial destination, urban planning regulations, and structural constraints. The Roman project, in fact, develops in response to a series of functional needs and regulatory contingencies that led to the adoption of an 'unconventional' approach. The department store had to meet destination constraints, which required large unpartitioned spaces with limited external windows –hence we witness the decentralization of stairs and service rooms– and constraints dictated by the master plan, which required a controlled facade symmetry. To these challenges were added the client's requests to create a building that was "anonymous and typical with one floor identical to the other" [Zevi 1978, p. 287], pushing towards the search for innovative solutions [Albini, Helg 1961]. Despite the perimeter, shape, and height being already fixed by the detailed plan, the first project presented to the Municipality of Rome in 1956 for the Nuova Rinascente reflected a clear influence from Giulio De Angelis's first Rinascente at Piazza Colonna. It is indeed likely that Albini's adoption of a metal load-bearing structure is in continuity with "that iron and cast iron skeleton" [Bucci, Irace 2006, p. 171] of De Angelis's project. Located between the emerging bulk of the Aurelian walls and late nineteenth-century residential buildings, the main front on Via Salaria, in this version, had a recessed ground floor that created a deep shaded recess, with "marked horizontal bedding of the facade strongly rhythmized by double T portals with variable section with an inter-axis of three meters" [Bucci, Irace 2006, p. 171]. This first project (fig. 2) demonstrates a particular interest in the degree of prefabrication of elements since it influenced the construction system, the arrangement of elements, and the methods of assembling facades [Wachsmann 1989]. This innovative vision is realized through the creation of instrumental mock-ups, representing a transition from the conceptual phase to a final solution. However, despite the travertine slabs covering the infill walls, giving the building fronts an "ostentatiously two-dimensional appearance" [Portoghesi 1962, p. 608], this initial solution underwent modifications. The requests of the Commissione Edilizia [Rogers 1961, p. 2] combined with the needs of distributing the air conditioning system led to modifying the 'flat head' to integrate them with the load-bearing structure and the floors of the building [De Seta 1980, pp. 23, 24]. Despite these interventions, the project was not approved by the client because "there was a lack of a functional stimulus in designing the facades" [Zevi 1978, p. 287]. The transition from the initial conception to the final solution in the project of the Nuova Rinascente in Rome is realized through the creation of an envelope that assumes two environmental roles: "one passive, as a barrier to prevent the passage of external climatic conditions or the loss of internal ones; and one active, as a distributor of air conditioning and environmental energy" [Banham 1978, p. 256]. In fact, the second solution (fig. 3) –the one actually implemented– features a structure consisting of four multiple frames, each composed of two spans of nine meters [Bucci, Irace 2006, p. 172]. These frames support a steel skeleton characterized by long longitudinal beams and transverse girders which, together with the vertical uprights, are fully readable on the facade. The use of this type of structure is motivated by design needs: "the deformations of steel in case of fire force to hide it inside behind cement thicknesses. Bringing the steel structure outside […] is the consequence of an architecture that derives its forms from structural realities" [Albini, Helg 1962, p. 6]. Another point of interest is provided by the walls that enclose the building inside the structure frames: they are moved in relief, revealing the passage of vertical air conditioning ducts to the outside [Albini, Helg 1962, p. 6]. This functional aspect has been transformed into an expressive element, highlighting Albini and Helg's ability to use technology as a design tool. The experimentation of new spatial, formal, and material protocols emerges through the use of full-scale mock-ups, allowing architects to test and verify the complexity of contingencies that influence construction, form, and the choice of materials for prefabricated panels. These panels, horizontally divided into four parts and edged by an ivory-colored middle band, represent a modern and prefabricated version of the traditional stone facade: "experimented for the first time, under the close supervision of architect Albini, by the FULGET company of the Capoferri Brothers of Bergamo, the Silipol cladding is a material used for exterior cladding" [Albini, Helg 1962, p. 17]. In this context, precision becomes the cornerstone upon which all creative ambitions rest, manifesting in the 'piece by piece' construction of 50,000 granite blocks [Piano 2006, p. 189] (fig. 4), following a

Fig. 4. Progression of the external facing in Silipol panels with plan sections of the elevation along Via Salaria (graphic elaboration by the authors).



serial design methodology that requires constant conceptual and constructive rigor [Jones 2020, p. 50]. The recognizability of each structural element and the mechanics of the device are further highlighted by the clear distinction of the string courses. These are composed of a C-edge beam mounted on a plane different from the pillars, leaving space for the passage of utility ducts in the protruding horizontal bands. This new arrangement of the facades alludes, through formal and proportional references, to the great Renaissance palaces and "with that protruding iron frame on the edge of the facade, it ironically seems to wink at the Michelangelesque cornice of Palazzo Farnese" [Piva, Prina 1998, p. 24]. Finally, the choice of materials was dictated not only by the indications of the Sovrintendenza ai Monumenti, which imposed a 'Roman' character in chromatic agreement with the Aurelian walls [Portoghesi 1962, p. 609], but also by economic considerations. In fact, in the transition from the first to the second solution designed by Albini and Helg, there was an increase of two floors, from four to six, in response to the different needs for the use of available volume. Ultimately, in the complex process of the Nuova Rinascente project, the synergistic interaction with construction companies and material producers was central. A concrete example is manifested with the F.lli Brambilla company, responsible for the realization of windows, doors, and venetian blinds in the Rinascente project, which was then commissioned to assemble at the *Venice Biennale* in 1968 (fig. 5) "the large true-to-scale model of a detail of the building" [Albini, Helg 1962, p. 14]. This partnership highlights the inherent potential in the collaboration between company, client,

Fig. 5. Mock-up design, Venice Architecture Biennale, 1968 (© Venice Biennale Historical Archives, ASAC, Photo: Ferruzzi).

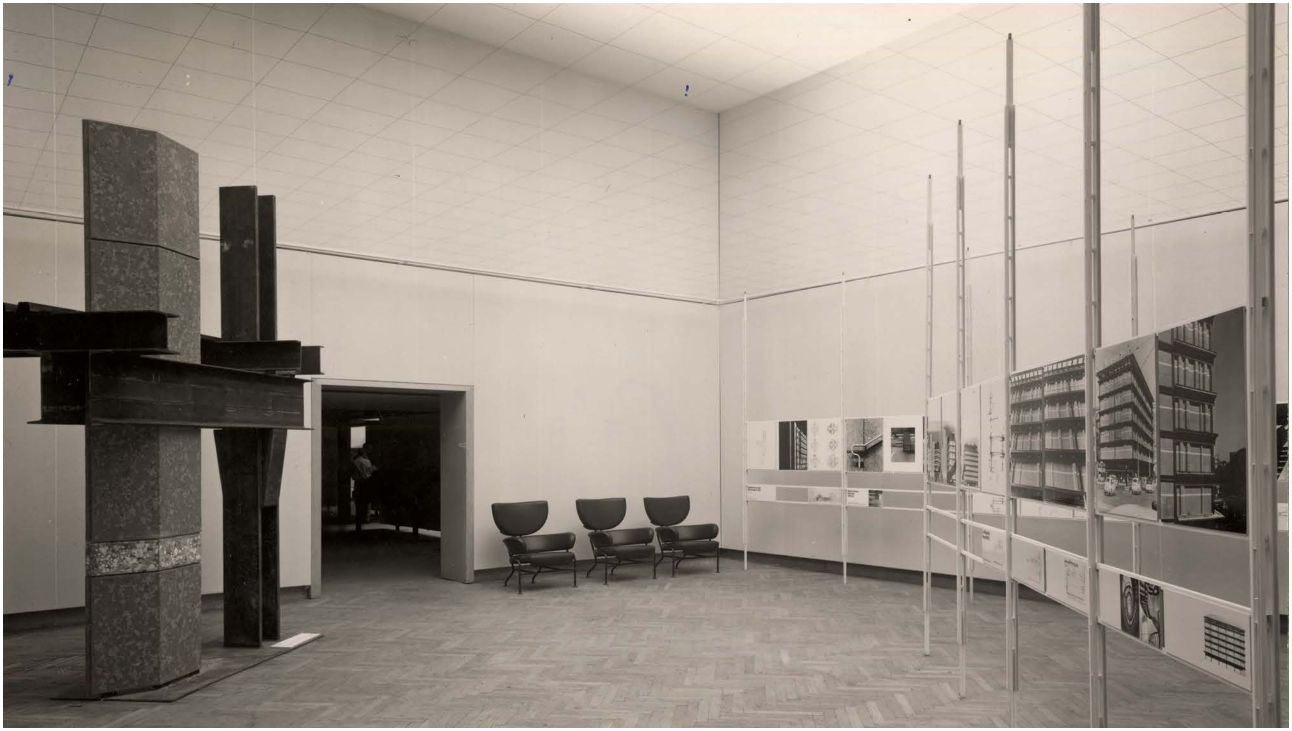


Fig. 6. Detail, XII Triennale, Solo exhibitions of architecture (© Archivio Fotografico Triennale Milano, Fondazione Triennale di Milano).

and designer. Through this synergy, the architect-engineer charts a new course in the design landscape, where the unconventional approach serves as a catalyst for the generation of innovative spaces, forms, and materials. The mock-up, therefore, assumes a primary role as a research laboratory, where the precision of work proves to be the indispensable foundation for the realization of architectural solutions of excellence.

The role of the mock-up between industrialization and craftsmanship: comparing experiences

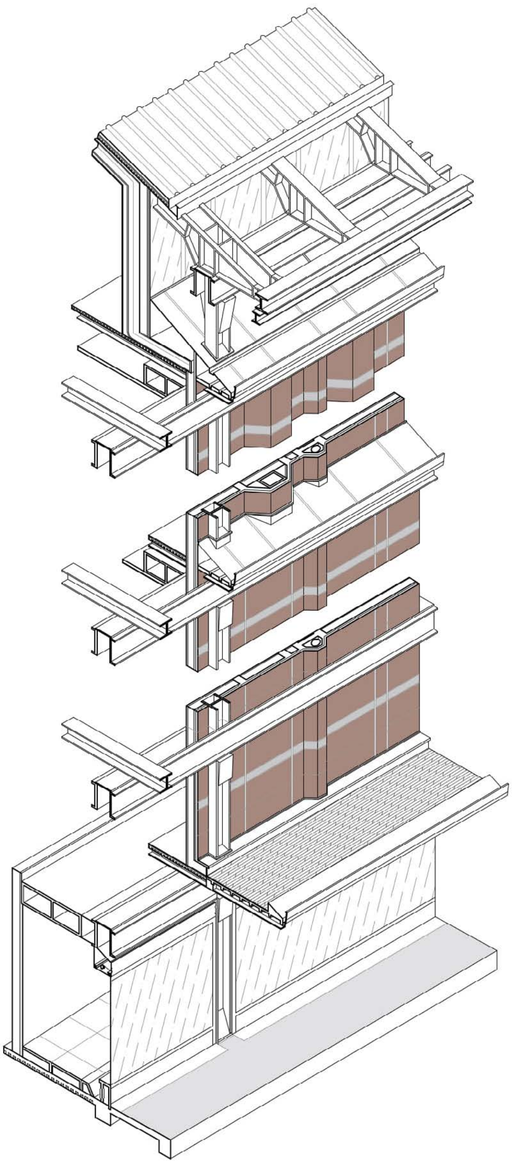
Franco Albini collaborated with a generation of architects who adeptly operated across the scales of furniture, interiors, architecture, and the city, acquiring skills in both craftsmanship and industrialization, especially during his tenure at the Ponti and Lancia studio. This professional-craft relationship with industrial production was not confined to the exclusive realm of design but directly involved the industrial and technological process, leading to a “direct confrontation with materials and their transformability” [Bucci, Irace 2006, p. 165]. This tension between idea and artifact, between production and craftsmanship, stimulated the experimentation of new design approaches and procedural innovations. Indeed, the production of experimental building elements was primarily facilitated by the necessary relationship with companies. For example, Giò Ponti, collaborating with the Saffa company in Milan, produced the *Populit* panel after the production of some prototypes [Griffini 1939, pp. 132, 133], while Bruno Morassutti experimented with new design methodologies applied to facade components, working with the Facep company in Mantua. Although industrialization, and thus mass production and automation processes, favored a broader diffusion of Italian design, Albini’s pioneering contribution seems to have been premature in fully embracing the changes induced by new industrial practices, as indicated by Vico Magistretti’s statement: “he was born too soon”. While it is possible to assume that Franco Albini employed the mock-up already in the project of the Palazzo del Lavoro for the Trade Fair of Milan in 1954 on parts of the facade, the structural system, and the interior furnishings, the subsequent experiments of some architects contemporaneous with him are equally notable. Starting from the project of the Palazzo dello Sport in Rome by Nervi (1956-1957), which led Nervi to create full-scale models to test the suspended roof and overcome imperfections [Gargiani, Bologna 2016, p. 315], to the prototypes of the Pirelli Skyscraper (1956-1960) in Milan by Giò Ponti used to test and verify facade solutions. Therefore, while the 'unmediated' approach of the architect can generate invention, the cultural predisposition of architecture as a discipline seems to have progressively abandoned craftsmanship, instead of investing in the possibility of radicalizing spatial, formal, and material protocols, which require the precision of work as a prerequisite for disciplinary advancement [Gelpi 2020, p. 24].

Twentieth-century exhibitions: 'sign' of new interpretations

Throughout the twentieth century, exhibitions in the fields of design and architecture have represented a fundamental ground for experimentation and innovation. In this context, Albini's early collaborations in interior design, during the 1930s with Persico, and from 1946 onwards with Giancarlo Palanti and Anna Castelli-Ferrieri, played a decisive role in his career up to the relaunch of the magazine known as *Costruzioni Casabella*. However, it was within the framework of the *Triennale exhibitions* in Milan and other Milanese galleries that Albini had the opportunity to explore new materials, construction techniques, and modes of assembly on a large scale (fig. 6). His transition from designer to architect emerged from the constant effort to control every aspect of the project and ensure "perfect execution through the instrument of design" [Prina, Piva 1998, p. 10]. Some elements, which in the executive project appeared as simple 'normality', became exceptions in the uniqueness of the detailed solution: "infinite sections of fixtures, joints, fittings, hinges, are investigated by scaling down to full-scale reproduction" [Prina, Piva 1998, p. 10]. This attention to detail, traceable to a logical-mental process of composition-decomposition for individual elements, extended to every scale of work, from the building to the furnishing elements, supported by the extensive use of scale models and full-scale prototypes [Cortesi 2019, p. 36]. Albini's participation in the Milan

Fig. 7. Detail 1:1, XII Triennale, Solo exhibitions of architecture (© Archivio Fotografico Triennale Milano, Fondazione Triennale di Milano).

Fig. 8. Exploded view of the building and plant system components in their entire elevation development, 1961 (re-elaboration by the authors).



Triennale exhibitions was guided by an interest in modern manufacturing methods and the desire to revive artisanal practices in architecture [Helg 1979, p. 552]. For the architect, the exhibition has an affinity with entertainment, and for its success, it is necessary to detach the visitor from external reality, introducing them into a particular atmosphere and sharpening their sensitivity without fatiguing them [Albini 2005, pp. 9-12]. After the three *Design Triennials* (IX, X, and XI), in the *XII Milan Triennale* of 1960, it was decided to abandon the criterion of organization by merchandise sectors, in order to invite the public to observe the different elements of the event in their contents and in the relationships between the exhibited objects. On this occasion, Albini was invited to exhibit in the section dedicated to 'personal exhibitions' and showcased the models of the first and second design solutions proposed for the project of the La Rinascente building in Piazza Fiume in Rome. He distinguished himself from his colleagues by presenting full-scale models and construction details of the external envelope (fig. 7), highlighting his ability to design and present objects in space: «the black metal frame, like the uprights of his installations, supports the panels covering the mechanical systems, as if these were paintings in an exhibition» [Bucci 2009a, p. 37]. Such aestheticization of the model changes its understanding and enhances its perceptual characteristics, previously ignored [Geiser 2021, pp. 69-80]. In this regard, it seemed that architectural models could have their own artistic or conceptual existence, relatively independent of the project they represented. Therefore, signals of new interpretations that enhance 'its artistic and communicative dimension' are advanced to the use of the mock-up as a design tool. The importance of the Roman project is such that it soon became a linguistic and typological reference model, so much so that it was presented at the *Venice Architecture Biennale* of 1968, where "the architect's autobiography was simply told by a full-scale piece of the Rinascente building" [Bucci 2009a, pp. 37, 38], as descriptive and narrative of the artistic and architectural process that distinguishes it. Generally, the production of such "highly exhibitionistic value elements" [Martín Díaz 2023, p.124] –which took place through construction companies– confines the mock-up as an architectural work in itself, a text to tell a design process [Eliasson 2009, pp. 9-12].

Conclusion: continuity and innovation

The innovation and experimentation of the Rinascente project have demonstrated how Albini employed the mock-up as a tool for research and experimentation to address specific challenges related to commercial destination, urban regulations, and structural constraints. The architect's journey throughout the 20th century, intertwined with that of his contemporaries, reflects a constant attempt to blend tradition and modernity, craftsmanship and industrialization, technical precision and artistic creativity. Through the study and realization of full-scale prototypes and mock-ups, an unprecedented integration between prototyping and industrial prefabrication has been achieved. Also noteworthy are the projects of the Milan Metro (1962-69), where a series of three panels (30, 40, 50 cm) in Silipol, supported by an iron framework, allowed for the possibility of disassembling the pieces for inspections of the installations in the perimeter cavity [Albini et al. 1966, pp. 42-48], and the project of the Snam office complex in San Donato Milanese (1969-1974), where the rose-granite cladding panels will reappear "although far from the surprising chromatic and three-dimensional corrugation of those prototypes of the Rinascente" [Bucci, Irace 2006, p. 176]. Therefore, each project "invited innovative solutions for modern work environments" [Jones 2020, p. 195], and this could be the lesson that a young Renzo Piano inherited from Franco Albini and that we will similarly find in the more renowned Pompidou Centre.

Nearly seventy years after its inauguration, the restoration and re-functionalization intervention of the Nuova Rinascente in Rome by Studio 2050+ testifies to a hypothesis of continuity and innovation. Through the targeted replacement of specific building components and the repair of Silipol panels, the aim was to preserve the integrity and identity of the original project, adapting it to the needs and challenges of a contemporary department store [2]. In this context, the moldings, which concealed the original installations (fig. 8), "have proven insufficient to support the functioning of the building due to changing climatic and regulatory conditions, showing how much the architects have thought about both what is seen and what is not seen" [Ricci 2023, p. ??]. In conclusion, the research aimed to demonstrate how, in various stages of the design process, the mock-up can be used as a true tool for controlling the conceptual and scale transition between the ideative and realizable scope as well as managing the complexity of the technological project.

Notes

[1] In the latter half of the last century, Giovanni Sacchi collaborated on industrial design projects with Franco Albini, Marcello Nizzoli, Marco Zanuso, Richard Sapper, Achille Castiglioni, and many others.

[2] In *2050+*, *La Rinascente – Piazza Fiume* <https://2050.plus/projects/la-rinascente-piazza-fiume/> (accessed on 17 February 2024).

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Small Glimpses. Photography and the Representation of Architectural Models

Nicolò Sardo

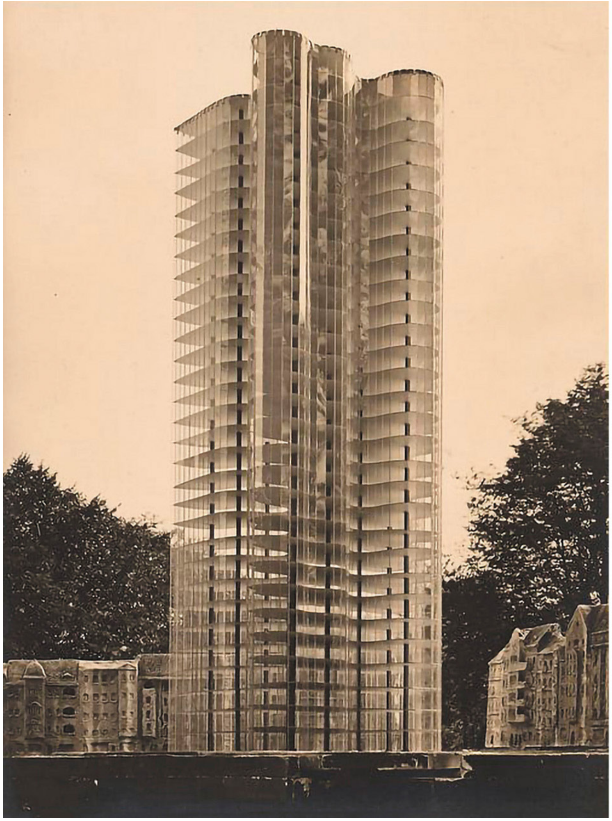
Abstract

This contribution highlights how the photography of architectural models was an important tool for representing architecture, often leading to emblematic images of a project. This study also presents a revealing series of artistic experiences in which the architectural model becomes a primary subject of photography. While traditional photography of architectural models often looked for realism that could anticipate the constructed building, this task has, for years now, often been assigned to digital representation. The model is therefore represented photographically in a decidedly more abstract manner, allowing it to enunciate particular aspects of the project. It is interesting to note how still today, important architects are particularly interested in taking photographs of project models, developing important collaborations with photographers. In recent decades, photography and some of its trends have often caused problems for its relationship to reality: by manipulating images, some authors completely detach themselves from any material nature, even producing entirely synthetic images. Instead, through the use of models, one still operates on a material plane, but implements a true artificial reality, and what is real becomes rebuilt through scale models with different degrees of realism or abstraction, presenting a virtual reality expressly conceived by the authors.

Keywords: photography, architectural models, representation, art and architecture.

Introduction

The photography of scale models has played a key role in the history of architecture, contributing to the representation and spread of projects and architectural concepts. Over the years, this *medium* has evolved significantly, shifting from a simple tool for documentation to a true artistic form and means of communication capable of conditioning perception and the understanding of the architecture itself. When taking photographs of architectural models, two devices of representation intersect and overlap to present the observer with a *mise en scène* of different realities.
Architectural models continue to play a fundamental role in representing architecture and, through a common thread that ties them to what was established in the Renaissance, they occasionally prove to be a tool used for previewing, communication, documentation, and assistance for the project. While "models are tools that allow us to explore the world" [Noë 2022, p. 178], photography as a 'device for seeing' allows us to select the point of view, making the investigation more specific. The history of architectural model photography overlaps chronologically with the history of photography itself. Two examples worth mentioning are the daguerrotype by an unknown photographer probably dating to 1850 showing a front view of a residential building [1], and the photograph –dating to about 1855– by Ludwig Belitski of the cork model of the Roman arch of Septimius Severus made by Carl May [2].



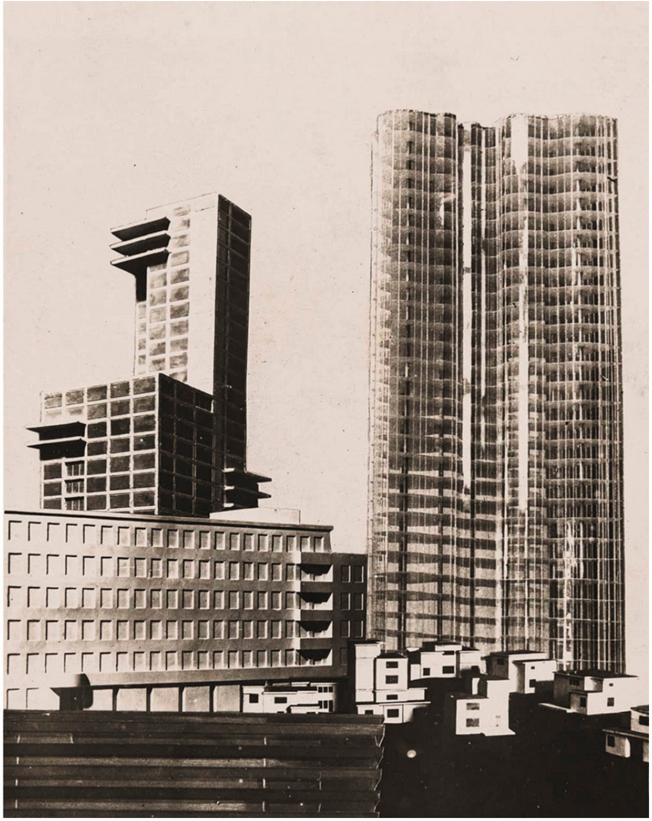


Fig. 1. a) L. Mies van der Rohe, Project model for the glass skyscraper, Berlin, 1922. Photograph by Curt Rehbein. <https://www.design-is-fine.org/post/152911811844/ludwig-mies-van-der-rohe-glass-skyscraper-model> (accessed 12 June 2024); b) L. Mies van der Rohe e W. Gropius, Models presented at the Bauhausausstellung held in Weimar in 1923, photomontage. <https://drawingmatter.org/mies-van-der-rohe/> (accessed 12 June 2024).

While traditional model photography often made skillful use of backgrounds, lighting, and a chosen point of view to look for realism that could anticipate the constructed building, this task has, for years now, often been assigned to digital representation. The model is therefore represented photographically in a decidedly more abstract manner, giving it the task of enunciating particular aspects of the project.
A photograph of a model often became the emblematic image of a project, especially if it was never realized, thus providing valuable historical evidence and contributing significantly to knowledge about the artistic avant-garde of the 1900s.
Some of the most interesting examples are the snapshots by Curt Rehbein of the model of the glass skyscraper (1922) designed by Ludwig Mies van der Rohe for Berlin (fig. 1a). The use of photomontage, in which images of the models are assembled in real contexts, was rather common for this German architect, who ultimately built a true 'city of models' together with Walter Gropius [3] (fig. 1b). Likewise important are the images from the series of *Arkhitekton* buildings that Kazimir Malevič developed in the 1920s.
In the most virtuous cases, the relationship between architect, model maker, and photographer lead to fundamental results for the development of the project, and these three spirits interact in a particularly fruitful way. An essential relationship also develops among the ways in which the model is photographed and graphical representations of the project.
A specific aspect of architectural model photography is its ability to spread knowledge about the specific products at a distance, as occurs more in general with constructed buildings. Likewise, the teaching aspects are of essential importance, and photography can also serve as a key tool for communication or to freeze the construction stage of a model.
The latter is a key element, traces of which are also found in some emblematic historical examples such as the images of the construction of the model for the constructivist tower dedicated to the Communist International designed by Vladimir Tatlin in 1920 [4] (fig. 2).
This aspect of photography as a means for spreading information about a model continues a tradition already present in centuries past, which was implemented through graphical depictions [see Sardo 2004, pp. 155-

Fig. 2. V. Tatlin (with I. A. Meerzon and T. M. Shapiro) during the construction of the model for the Monument to the Third International, Petrograd (now St. Petersburg, Russia), 1920. <https://www.cca.qc.ca/fr/recherche/details/collection/object/7584> (accessed 12 June 2024).

161]. Models used as objects to represent architecture were key in the watercolor by Joseph Michael Gandy (1818), which shows some projects by John Soane in one area of the architect's home-studio.
As already mentioned, photographs of architectural models also played a decisive role in presenting and spreading modern architecture. Photographs of architectural models were used to promote new projects, through both specialized journals and shows and public exhibitions contributing to familiarization with new formal approaches. Attention for these aspects also led some great photographers to deal with architectural models: Julius Shulman, Ezra Stoller, and the Hedrich-Blessing studio are just a few important examples of this interest.
What occurred in recent decades is the transformation of this representation into a means of artistic expression where the model acquires special strength because it is no longer an 'occasional' object, but is specifically arranged by the artist/photographer as a founding subject of the image.

Narratives

The creation of a model assumes, above all else, direct observation with an important 'interactive' relationship on behalf of the observer. Mediation by the photograph imposes a 'filter': the choice of specific points of view –if not even particular visual effects– transforms the model, as seen below, into an artificial reality.
The selection of the gaze through the photograph becomes a way to encourage understanding of the model, guiding the observer to pay attention to some particular aspects. In addition, it is important to underline how the photograph deconstructs the usual relationship between the observer and scale reproduction of the object [5]. Distance is established between the spectator and model, creating a disconnect that questions the relationships that normally exist in direct observation. Despite the realism underlying the image, the photographs ensure that many elements typical of direct observation of the model are absent –or nevertheless altered.
To photograph the models, the arrangement of photographic sets has particular features similar to photography of other objects: particular attention is placed on lighting [6] and background [7]. On the other hand, there are specific points of view that overcome the 'still life' tradition, instead simulating visions tied more to the tradition of architectural representation: bird's-eye and zenith views, simulation of 'axonometric views', even proposing realistic points of view using optical tools deriving from other disciplines [8]. Publications that address architectural photography also make room for photographs of models [9].
Photographs of architectural models was of fundamental importance in spreading the ideas developed by the avant-garde. At the Bauhaus, Lucia Moholy often depicted the results produced by students at the school.
While materials play a key role in various exhibitions, the publishing industry regularly welcomes images of materials as an essential opportunity to present new architecture. On the other hand, we can clearly distinguish László Moholy-Nagy's interest in models in the ample room dedicated to them in his publications [see Moholy-Nagy 1929, 1947]. In the short film *Things to Come* (1936) Moholy-Nagy also used models made of different materials, showing them dynamically through interactions with lighting effects and overlaps.
The use of model photographs in publishing, even with a teaching scope, is evident in the images of 'interior spaces' published by Luigi Moretti to accompany an important essay of his [si veda Moretti 1952-1953].
Photographs of models may help in defining the architectural project itself.
After moving to the United States, Mies van der Rohe used models as a vital tool to develop his his projects and he considered photographs of the models –taken by the Hendrich-Blessing studio– to be fundamental. Ideas for modifications to the project itself often arose precisely from the images [10].
Another great figure in modern architecture that assigned great value to conveying his projects through photographs of models was certainly Le Corbusier. Just think of the volumes in his *Œuvre complète* or his many publications, which the Swiss architect always saw to in the finest detail [11]. Lucien Hervé, the photographer whom Le Corbusier developed an important collaboration with starting in the 1950s and lasting to his death, often photographed models of his most important works from that period [12] (fig. 3).
Even authors that reconsidered the principles of modern architecture and developed a utopian vision of the

city between the late 1950s and early 1970s made intense use of models and their communication through photographs with the goal of clearly conveying unusual project ideas [13].
For Peter Eisenman, photography allowed him to select the 'correct' view for observing the 'axonometric' model of House X, made specifically through deformation, leading to the isometric projection: "Usually a photograph of a building is a narrative record of a fact –a *representation* of reality. Here the photograph is the reality of the model because it is the view which reveals its *conceptual essence* as an axonometric drawing. But while the conceptual essence of the model is a drawing, that of the photograph is not. For it is not a photograph of a drawing but of a model… Yet the black and white photograph depicted in this catalogue and the drawing are one and the same. Here the circle is closed, and the true reality of the house remains suspended. The model serves as the final heuristic approximation, the last act of what I call a process of decomposition. The model exists as one reality and simultaneously another" [Eisenman, in Frampton, Kolbowski 1981, pp. 82, 83].
Enric Miralles used photography to analyse the model for the project of the Pabellón de meditación in Unazuki (1991), and, playing with light and projected shadows, he followed a procedure that seemed to derive from historical avant-garde experimentation [see Esquinas Dessy, Zaragoza de Pedro 2016, p. 118].
It is interesting to note how still today, important architects are particularly interested in taking photographs of project models. One particular instance is the collaboration between Thomas Ruff and the architects Herzog & de Meuron. In addition to depicting the completed works, the German photographer is also interested in models made by the Swiss firm [see Riley 1991].
In the collaboration between German photographer Thomas Demand and the British architectural firm Caruso St John, the project The Triple Folly (2022) is particularly emblematic. Here, the photographer starts with an 'extemporaneous model' and suggests the shape of the pavilion built in Ebeltoft in Denmark [14].

Simulations

Through photography, the scaled relationship between the object and observer is thrown into crisis:

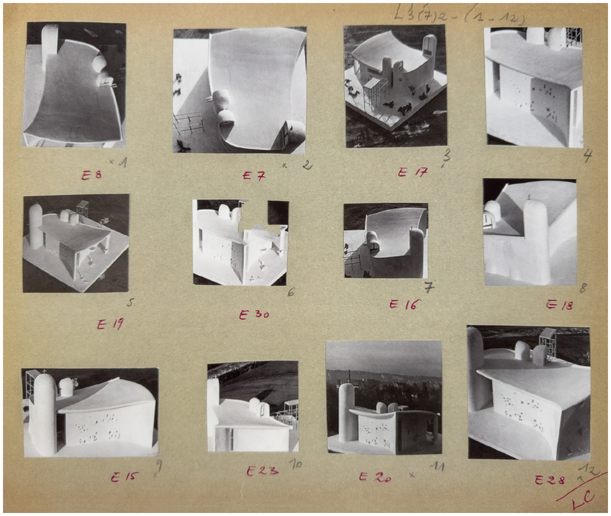


Fig. 3. L. Hervé, Study model for the church in Ronchamp, contact sheets, 1950. From: Sbriglio 2011, p. 89.

the 'distance' and point of view of the snapshot simulate a possible reality.
The model is conditioned by the photographic requirements. "Paraphrasing Walter Benjamin, we could say that to an ever greater degree the architectural model reproduced became the architectural model designed for reproducibility" [Deriu 2012, p. 175].
The use of models for experimentation, especially with respect to structural tests to analyse deformations, was often used in the past by important structural engineers in the 1900s [15]. Even in this respect, the use of photography as a means to 'record' the results seems advantageous. But the use of photographic documentation by Franz Max Osswald (fig. 5), a Swiss engineer, seems even more original. In the acoustics laboratory at ETH Zürich in the 1930s, he experimented with the use of photographic snapshots to analyse acoustic models [16].
Before the development of digital visualization systems, one of the objectives of models was to create a vision that could in some way anticipate real points of view of the future building. Even the large wooden model for St Peter's by Antonio da Sangallo was made and

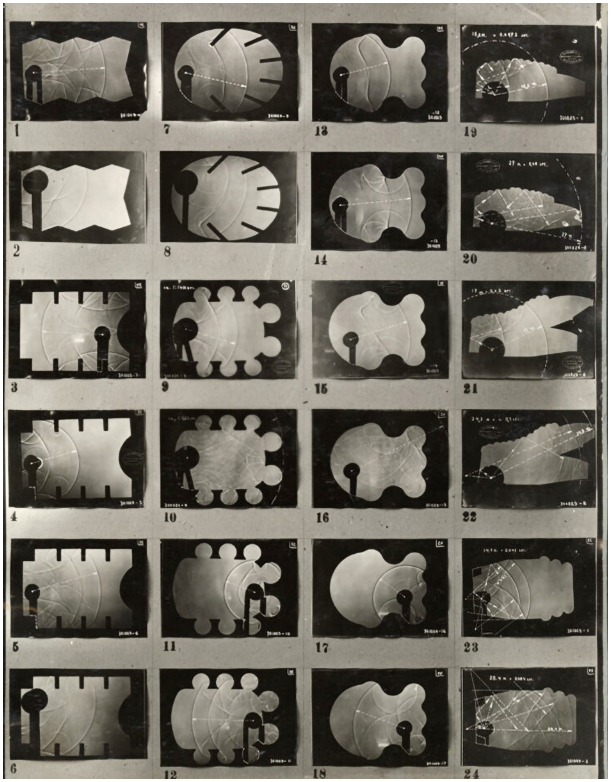


Fig. 4. F. Max Osswald, Photographic studies of sound propagation in different rooms using models, 1930. ETH-Bibliothek Zürich. <https://soundandscience.net/collections/max-osswald-photographs/> (accessed 12 June 2024).

arranged to create a realistic view of the interior of the basilica. Precisely to meet this need, models are often photographed to obtain previews that anticipate the reality of the completed building. For this purpose particular tools were developed, such as the 'upside down periscope' used by Gaston Bardet for the 1937 Exposition in Paris or the *maquettoscope*, developed by the architect Robert Auzelle in the 1950s [Pacot 2020, pp. 60-61]. The *relatoscope*, originally designed for medical purposes, was adapted by the German architect Martin Schulz Van Treeck in the late 1970s to take photographs of models [17].

If the end goal is a vision that simulates reality, the use of mirrors is not uncommon. In the model for *Supersuperficie* (1972) by Superstudio, the limited space of the reproduction is expanded visually through reflection. Marcel Lods, on the other hand, integrated three mirrors into one of his models to simulate the insertion of the project in the real setting [see Pacot 2020, p. 62].
Close-up views of the model simulating real points of view were also used in the photographs accompanying the project by Bernard Tschumi for the competition for the National Library of France (1989), where the rather detailed and structurally accurate model was shown as a preview of the finished building.

Model and architect

An interesting photographic tradition also regards models photographed together with the project authors: Frank Lloyd Wright, Mies van der Rohe, and Le Corbusier are just some architects that were photographed together with models of their works.
Undoubtedly, the image of an architect posing next to a model of a building he or she designed is a common theme. Portraits of the architects are made with models of their projects rather than with the real buildings, following a practice that is deeply rooted in the iconographic tradition of donating the models.
The choice of the model is motivated not only by its greater visual strength compared to a drawing, but also compared to the building itself: the reduced size situates the product in a position of full control and authority. Models reflect the architects' design activity in their studies and during construction; however, architects are often presented with gestures that go beyond simple exhibition, assuming a role that is nearly paternal (or maternal) with respect to the work itself [18].
In addition to the more common images of architects 'posing' –as with the photographs of Mies van der Rohe taken by Irving Penn (fig. 6)– one particularly fascinating thread is stories showing the designers working on their models –as in the series with Eero Saarinen and the large model for the TWA Terminal (fig. 7)– or even in the action of photographing a model as in the series that shows Charles and Ray Eames studying the set-up for an exhibition (fig. 8).

The Hand of God
A topos present in architectural model photography is the *mise en scène* of the hands, symbolic evidence of the architect as a 'creator'. The hands point, support, and sometimes work, changing the shape of the model itself.
In one of the photographs of the model for the Unité d'habitation in Marseilles, the principle of the organism as a *casier à bouteilles* (bottle holder) is shown through the image of a hand inserting a small housing unit within the structure (fig. 9).
In the documentary *L'architecture d'aujourd'hui* (1930) by Pierre Chenal [19], –from which some well-known photos were taken– Le Corbusier's hands work and move over the model of the Plan Voisin for Paris (fig. 10).
In recent years, photographs of models by MVRDV [20] or Herzog & De Meuron [21] often show the hands working on the models.
Alberto Campo Baeza turns this iconography into an original design idea, suggesting –both to his students, but also to himself– to "build a model so small that it fits in the palm of your hand" [Campo Baeza 2013].

Fig. 5. I. Penn, Portrait of Ludwig Mies van der Rohe (with Philip Johnson in the background) with the model for the Seagram Building, New York, 1955. <https://www.cca.qc.ca/en/search/details/collection/object/11189> (accessed 12 June 2024).

Other realities

In recent decades, photography and some of its trends have frequently caused problems for its relationship to reality: by manipulating images, some authors completely detach themselves from any material nature, even producing entirely synthetic images.
Instead, through the use of models, one still operates on a material plane, but implements a true artificial reality, and what is real becomes rebuilt through 'simulacra': actual scale models with different degrees of realism or abstraction, presenting a virtual reality expressly conceived by the authors. In these results, however, the model is no longer presented as a preview of a possible future reality, but is itself manifest as 'reality'. In this process, the evidentiary value of the image is not questioned [22], but it is the subject itself –abandoning its traditional worth as documentation– that questions the conventions of what was traditionally covered by photography. 'The photograph abandons its traditional documentary value as a tool used to capture the decisive moment, and introduces doubt about what one is seeing and naively accepts as being real' [Pemjean 2014, p. 35]. Thus, it is the 'original' that is redefined, and the model takes centre stage. 'The false truth of the copy forms a simulacrum that simulates the being itself, even replacing it (in the case of illusionism)' [Wunenburger 1999, p. 139]. The model, the replica, becomes the main feature: "*Today abstraction is no longer that of the map, of the double, of the mirror or of the concept. Simulation is no longer that of a territory, of a referential being, of a substance. It is the generation by models of a real without origin or reality: the hyperreal*" [Baudrillard 1981, p. 10] [23].
One of the most important authors working along these lines is undoubtedly Thomas Demand. The German photographer uses paper and cardboard to create actual 'scenes' rich in detail, often drawing inspiration from real places and environments related to specific historical events (fig. 11a). His nearly obsessive reconstructions tend to simulate and deceive. His images

Fig. 6. B. Korab, Eero Saarinen and the model for the TWA Terminal, 1955 ca. <https://www.hermanmiller.com/stories/why-magazine/myth-maker/> (accessed 12 June 2024).

thus become a critique of the photographic representation of reality. What is depicted is just a simulation; and the models, after being rigorously photographed, are destroyed, further marking their creation solely for the purposes of taking pictures [see Bonami, Durand, Quintin 2000; Demand 2011].
James Casebere also addresses the particular realism of models, making characteristic use of colours while also embedding precise clues as to the 'scale'. The presence of water, which further increases the sense of disorientation in his depictions is also unique (fig. 11b). The activities of this American photographer began in the 1970s when he made cardboard models of domestic scenes that he shot in black and white. In the following years, his conceptual approach grew clearer and the reconstructed scenes become more complex: light became a fundamental element and highlighted greater realism, which was also combined with the use of mixed materials. Between 1998 and 2003, he began to photograph models depicting 'flooded' environments. He then began to concentrate on reconstructions of peripheral urban contexts, with images taken from an aerial point of view [see Casebere 2016; Enwezor 2011].
The work by Emilio Pemjean is also particularly original. The Spanish artist and architect identifies spaces extracted from uncompleted (or no longer existent) paintings or architectural works and makes laconic models of them (fig. 12). These simulacra also show undefined or hidden aspects of the original works. The neutrality and conciseness of the surfaces of the models guides a perception of the essence of the spaces being represented. Even light, as a vital element of his structures, becomes a device used to characterize the environments reproduced in his models. In addition to taking snapshots, he also often makes videos that show how the spaces change as the lighting changes, thereby creating a true visual experience for the observer [24]. His project *Palimpsesto* "in a transmutation of languages ranging from architecture to painting to sculpture to photography […] is a path through architectural works that no longer exist –destroyed or radically transformed– but which are still a point of reference and collective legend, perfectly identifiable due to some masterpiece paintings". These works are reconstructed in the form of models, even "completing and reinterpreting the spaces partly hidden by objects that the painter used for the scene" [Pemjean 2014, p. 34].
Oliver Boberg questions the act of representing reality through photography, building realistic models of common buildings and public spaces in a hypothetical urban periphery. The careful lighting helps to further increase the visual deception that makes the observer believe that they are actual buildings. The anonymity of the constructions evoked by Boberg's models somehow makes the simulation even more credible, which in the photograph tends conceptually towards 'objectivity'

borrowed from the results of Bernd and Hilla Becher [see Berg, Engler 2004].
In addition to the experiences examined here, in relevant series of experiences shows how models are configured as vital subjects of photography.
In 1973, the American photographer Duane Michals presented *Things are Queer*. In it, he uses a series of nine photographs and a space of the miniature house to move the observer through contradictory representations underlined by continuous jumps in scale [Michals 2023].
Luigi Ghirri often turned his gaze to 'reduced' realities. One important project from this point of view is the one dedicated to the park *Italia in Miniatura*, located near Rimini. The scale reproduction of the Italian landscape and monuments served as an opportunity for Ghirri to once again critically question the relationship between vision and reality in the work allusively entitled *In scala* [25].
One of the most interesting recent examples was developed by Lori Nix. The American photographer arranges models that underline extreme realism, which is also characterized by the rich details. The dioramas she creates and the photographs of them represent special situations of completed constructions, presenting an apocalyptic vision where the buildings are shown as abandoned ruins in which nature seems to want to take over the spaces [see Nix 2013].
With regard to experiences in art, once could mention results such as those by the photographer David LaChapelle, who, between 2012 and 2014 developed two projects –*Gas Stations* and *Refineries*– containing pictures of specifically made models of petrol stations and refineries. The models appear particularly realistic and are always photographed in their natural environments [see LaChapelle 2013].
In Italy, two important artists/photographers use specifically made models for their projects, although starting with different assumptions and goals: Paolo Ventura and Silvia Camporesi. Ventura's models serve as an essential background for his 'sets' in which he himself is the protagonist, playing different characters. Thus he creates particularly fascinating scenes with reconstructions that evoke cities such as Milan, Rome, and Venice [see Guadagnini 2020].
Camporesi has also often used models in her projects to reconstruct scenes that are then photographed, simulating apparently real situations. In *Le città del pensiero* (2015), she made models to recreate urban glimpses of some metaphysical paintings by De Chirico and then took pictures of them [26]. In *Il paese sommerso* (2019), she rebuilt the abandoned village Fabbriche di Careggine in 1:20 scale. Since 1941 the town has lain within a dam, and she photographed it immersed in a basin of water, simulating real underground photos.

Fig. 7. C. and R. Eames with the study model for the exhibition Mathematica: A World of Numbers… and Beyond, California Museum of Science and Industry in Los Angeles, 1960. < https://westernartandarchitecture.com/april-may-2019/the-eames-legacy> (accessed 12 June 2024).

It seems clear how this trend has developed, particularly in recent years, and artists/photographers have increasingly and meticulously designed and built models as real three-dimensional sculptures with the purpose of taking two-dimensional photographs [27].
It is also unique how other artists simulate them precisely to maintain an ambiguity that evokes images of the models. In addition to building some models, Gordon Matta-Clark presents photomontages of real spaces presented as models.
Olivo Barbieri instead overturns this idea: it is no longer a *mise en scène* in which the model is used to

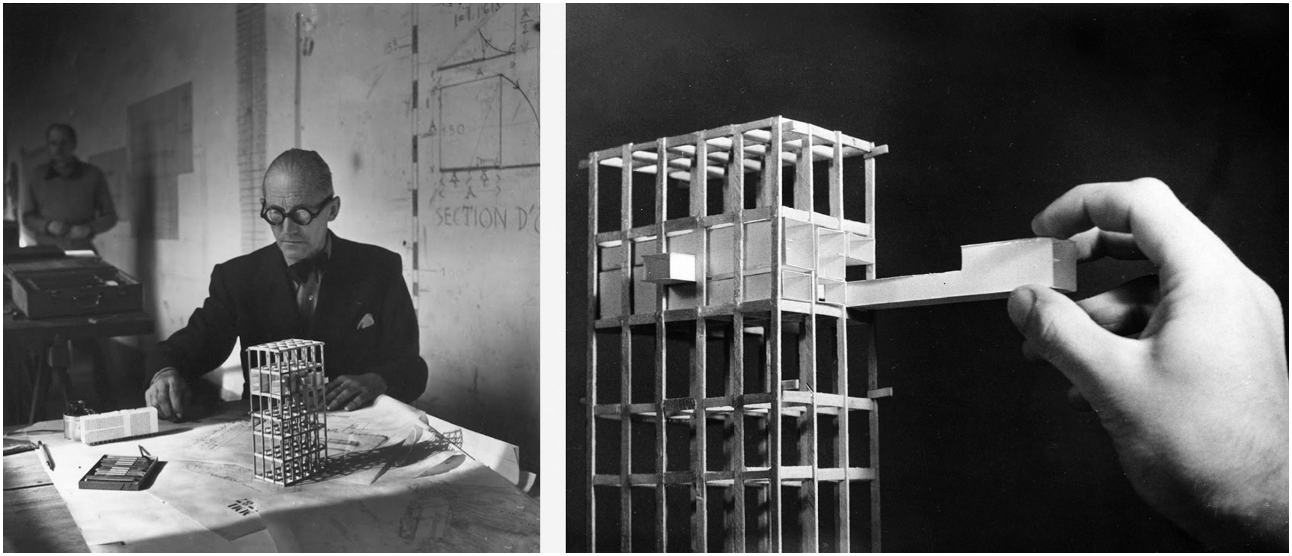


Fig. 8. N. Leen, Le Corbusier with the study model for the Unité d'Habitation in Marseille, 1946. <https://monoskop.org/Le_Corbusier>; <https://www.mandua.com.py/estudio-sobre-le-corbusier-eleva-a-la-maqueta-arquitectonica-a-arte-plastico-n352> (accessed 12 June 2024).

simulate an artificial 'reality', but reality that is exhibited as a 'model'. By selectively defocusing the image by tilting the objective lens of the camera, the aerial views of the city lead to disorienting images that show apparent artificial urban constructions [see Tognon 2001, pp. 182-187].

Conclusion

The photography of scale models has played a crucial role in the history of architecture, contributing to the representation and spread of architectural projects and concepts.
The importance of this specific form of representation remains fundamental, even in the digital era, continuing to play an essential role in promoting and spreading contemporary architecture.
Over the years, this medium has evolved significantly, shifting from a tool for documentation to an independent artistic form and means of communication capable of influencing perception and the understanding

Fig. 9. Le Corbusier illustrates the project for the Plan Voisin. Photogram from the documentary L'architecture d'aujourd'hui, directed by P. Chenal, France 1930.

Fig. 10. a) T. Demand, Diving Board (Sprungturm), 1994. <https://artblart.com/tag/thomas-demand-brennerautobahn/> (accessed 12 June 2024); b) James Casebere, Pink Staircase #2, 2000. <https://www.jamescasebere.com/> (accessed 12 June 2024).

Fig. 11. E. Pemjean, Palimpsesto I, 2013. The model reconstructs Diego Velázquez's studio; the view is the same as in the painting Las Meninas, 1656 ca. <https://www.emiliopemjean.com/projects/Palimpsesto> (accessed 12 June 2024).

of the architecture itself. Photographs of architectural models continue to be essential today, serving as a tool for previewing, communication, and documentation, while shifting towards a more abstract representation, increasingly entrusting digital representation with the capacity to anticipate the completed building. The interaction between these two devices generates new and original visual codes. This analysis highlighted how model and photograph, in their increasingly particular relationship, provide a narrative that is always special from the point of view of representation and description of the architectural space.
The hands of architects, artists, and photographers come together in a creative process that goes beyond mere documentation, giving rise to simulacra that challenge conventions and redefine reality itself. This artistic approach to photographing models presents a new perspective of architecture, creating images that go beyond mere representation to explore complex concepts and narratives. In addition, photographs of architectural models continue to be fundamental for spreading modern architecture, providing historical evidence and promoting new formal approaches. Finally, the artificiality of the model thus becomes an expedient that allows the photographer's creativity to maintain a strong relationship with the material reality without limiting it.

Notes

[1] The daguerrotype is stored at the Canadian Centre for Architecture, Montreal. See https://www.cca.qc.ca/fr/recherche/details/collection/object/6896 (accessed 14 February 2024). For more on the topic of model photography see also: Bergera 2016; Higgott-Wrany 2012; Moon 2005; Pacot 2020; Sachsse 2012; Stierli 2018; Wagner-Kajewski 2020.

[2] The image –salt print on glass with wet collodion– is part of the collection of Istitut Minutoli Liegnitz (now Legnica, Poland); see Sachsse 2012, p. 23.

[3] The photomontage was presented at the Internationalen Bauhaus Ausstellung in Weimar in 1923. Gropius's model for the Chicago Tribune competition can be seen; see Beitin, Eiermann, Franzen 2017, pp. 92-95.

[4] See Quilici, V. (1991). *Il Costruttivismo*. Roma-Bari: Laterza, pp. 91-99. See also the reconstruction of the tower in the place where it should have risen in Petrograd (today's Saint Petersburg) in the brief video made by the Japanese Takehiko Nagakura, instructor and researcher at MIT.

[5] For more information on this aspect, see Deriu 2021.

[6] The lighting, which can be natural or artificial, can be augmented by the use of reflecting panels.

[7] The backgrounds may be neutral or present photographs of real settings. But the models are commonly photographed outdoors.

[8] On the use of endoscopes, see below.

[9] For the most significant cases, see Shulman 2000, pp. 84-87.

[10] For more information, see Çoker Bilici 2020, pp. 79-85.

[11] Among the most emblematic photographs of Le Corbusier's models closely tied visually to the project are certainly the ones of the 'Citrohan' house (1922), Plan Voisin for Paris (1925), Centrosoyuz (1929), Soviet Palace in Moscow (1931), and the plan for Algiers (1930). See also Cova Morillo Velarde 2019.

[12] On the relationship between Hervé and Le Corbusier, see Sbriglio, J. (2011). *Le Corbusier & Lucien Hervé. The Architect & the Photographer: a Dialogue*. London: Thames & Hudson. The photographic reports focusing on models that can be seen in the books include: Notre-Dame du Haut (1950) p. 89, Secretariat in Chandigarh (1952) p. 169, Palace of Assembly in Chandigarh (1955) p. 189, and La Tourette (1953) p. 247.

[13] On models of this type, see Sardo 2021.

[14] For more information, see Demand, Caruso St John 2023. On the use of model photography within the studio see Engel 2013.

[15] The most important include Richard Buckminster Fuller, Frei Otto, Robert Le Ricolais, Eduardo Torroja, David Georges Emmerich, and Felix Candela; see Sardo 2004, pp. 175-179, Fabricius 2017.

[16] For more information, see von Fischer 2017.

[17] See Cornot, J. (2019). *Martin Schulz van Treeck (1928-1999). Architecture espace ou objet?* Paris: ENSAPB, pp. 39-63. In the early 1960s, the London-based company Optec marketed the *ModelScope*, an optical device with 18 miniature lenses, a sort of periscope that afforded a realistic vision of the interior of the models and used an adaptor to allow for photography. See also Deriu 2021, p. 100 and Pacot 2020, p. 62.

[18] For information on the iconography, see Frémy 2002 and Sardo 2014, pp. 185-187.

[19] The scenery of the documentary (about 18 minutes long) is by Chenal and Le Corbusier. The tests are by Le Corbusier himself and music (now lost) composed by his brother Albert Jeanneret was originally added to the film.

[20] Among others, see the studio models for the Leidschenveen Town Center (1997).

[21] One of the models for the De Young Memorial Museum (1999) is particularly interesting.

[22] This refers to Roland Barthes's concept "that the thing was there": see Barthes 2003 p. 78.

[23] «*Aujourd'hui l'abstraction n'est plus celle de la carte, du double, du miroir ou du concept. La simulation n'est plus celle d'un territoire, d'un être référentiel, d'une substance. Elle est la génération par les modèles d'un réel sans origine ni réalité: hyperréel*» (English translation by the author).

[24] See Pemjean 2014; 2016. See also the artist's website: <https://www.emiliopemjean.com/> (accessed 12 June 2024).

[25] Ghirri would photograph the park multiple times between the late 1970s and mid-1980s. An initial series of images was presented for the photography project *In scala* (1977-1978). The photographs dedicated to *Italia in Miniatura* were the subject of a recent exhibition held in Reggio Emilia in 2022 and 2023, entitled *In scala diversa. Luigi Ghirri, Italia in Miniatura e nuove prospettive*.

[26] See Camporesi 2018, pp. 82-85. In the 2011 project *La terza Venezia*, Camporesi mixes snapshots of the actual Venice with those taken of the scale reproduction at *Italia in Miniatura* in Rimini; see Camporesi 2018, pp. 56-61.

[27] Other artists following this trend include the Swiss Bernard Voïta and Dutchman Edwin Zwakman. See Zwakman 2008.

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Micro-Architecture Survey and Modeling: the Archetype of Messina's Ancient Municipal City Hall

Alessio Altadonna, Adriana Arena

Abstract

The subject of this paper concerns the wooden model of the ancient municipal building of the city of Messina. The building, embedded within the eighteenth-century Palazzata, was demolished due to the damages caused by the 1908 earthquake. The only iconographic documentation that has come available to us, despite the vintage photos, refers to the surveys made by J.I. Hittorff in 1823 and to this artifact, realized in a scale of 1:38 and dating back to 1810, currently kept at the Regional Interdisciplinary Museum 'Maria Accascina' in Messina. A sort of inverse operation will be carried out: a physical model of a work that no longer exists will be surveyed and overlapped and compared with the survey drawings mentioned; after verifying any discrepancies on the compositional, geometric and dimensional features, an attempt will be made to evaluate the aesthetic and functional qualities. The model survey will be carried out both with photogrammetry across the alignment of a series of images taken on the object and the creation of the sparse and dense cloud (Agisoft Metashape) or by point cloud acquisition from laser scanner. Once this investigation phase is over, with the current 3D printing methods, a new model conforming to the original, but in a smaller scale, could be assembled, constituting an effective tool for the usability of a visually impaired audience as well.

Keywords: instrumental survey, modelling, archetype, ancient municipal hall of Messina.

«È il modello prima e principal fatica di tutta l'opera, essendo che in essa guastando e raccomodando, arriva l'Artefice al più bello ed al più perfetto. Serve agli Architetti per istabilire le lunghezze, larghezze, altezze e grossezze, il numero, l'ampiezza, la specie e la qualità di tutte le cose, come debbano essere, acciò la fabbrica sia perfetta: ed ancora per deliberare sopra le maestranze diverse, delle quali si dee valere nel condurre l'edificio siccome per ritrovare la spesa che debba farsi in esso»
[Baldinucci 1809, pp. 341, 342].

Introduction

Generally considered the final product of surveying operations or a tool for verification and control, prior to the building process and the economic evaluation of the structure, the architectural model has, over the centuries, represented the most direct and effective evidence of the realized construction, both in its design and execution phases. Subsequently, the prefiguration of an architecture that is to come, but also the conceptual interpretation of it that is expressed by its ability to highlight the main peculiarities in linguistic terms. Furthermore, the architectural model, in some cases, can be considered an autonomous expressive form with aesthetic values such as to assume the significance of a work of art. Even today, in professional practice, the model, represents a way to govern the three-dimensional complexity of the object by investigating the relationships between its parts and the entire form and such with the context. At the same time, with special arrangements, a physical model can become an important aid to support the enjoyment of an expanded user base. The objective of this contribution will be to provide, through appropriate tools, original elements of knowledge regarding the archetype of the ancient municipal headquarters of Messina, destroyed by the earthquake

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of 1908. As a nineteenth-century building, the artifact is chronologically placed in an intermediate phase between the building design and its construction, confirming the strategic value of this type of aid for the control of the outcome. The only elements of comparison between the realized edifice and the model remain the surveys of the building carried out by J.I. Hittorff, still under construction, which establish the object of comparison with the results obtained through the digital survey of the artifact. The final goal of the research, once the knowledge phase is exhausted, could involve the creation, through 3D printing, of a reduced-scale model to be used in a museum context as a valid tool for the usability even by a visually impaired audience.

Fig. 1. Ancient municipal hall of Messina. Above: elevation facing the sea; below: elevation on Ferdinanda street (authors' private collection).

Messina's ancient municipal hall

The issue of the present analysis is based on the model of the ancient municipal building of Messina. Crafted in walnut wood, in 1810, by cabinetmaker Giuseppe Papalia, deriving reference from the design drawings of the actual work made by Giacomo Minutoli, Antonio Tardì and Giovan Francesco Arena. The building was located within the 18th-century Palazzata, which characterized the entire waterfront of the city, replacing the previous structure collapsed after the earthquake of 1783. The original project of the imposing construction, completed around 1840, envisaged two elevations with the ground floor characterized by arcades and projecting bodies; the two floors were articulated, starting from the lower one, by Doric and Ionic colonnades. The original design of the imposing building, whose construction was completed around 1840, envisioned two elevations with the ground floor characterized by arcades and advanced bodies; the two floors were punctuated, starting with the lower one, by Doric and Ionic colonnades. The crowning of the building was marked by a long balustrade. To demonstrate the enthusiasm generated among the city authorities, a first archetype was prepared to be sent to King Ferdinand of Bourbon for the customary approval [Pennisi 1913, p. 22]. Afterwards, the choice of the arcades was criticized from various quarters, valued risky, which would have compromised the stability of the building due to the seismic terrain characteristics. Instead, according to Francesco Basile, it would have been Minutoli himself who rethought a different solution, wanting "probably to avoid, with an entirely perforated first floor, the spatial laceration, the rupture of proportions, which a compact building corpulence might create in the urban fabric" [Basile 1960, p. 31]. Afterwards, it would have been the same "supervisory magistrates" that requested "the reduction and night closure for the city-harbor connections" [Basile 1960, p. 33]. The arcade would then be replaced by a succession of entrances surmounted by round arches punctuated, also in this new version, by Doric and Ionic half-columns and the base characterized by a robust ashlar [1].

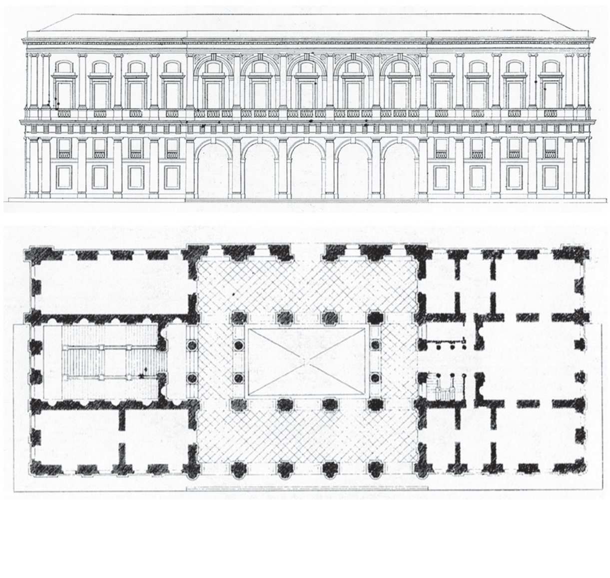
Presumably at the center of this imposing architectural system, developing for about a kilometer and a half, between two of the 36 city gates (Neptune and St. Camillus), was inserted the municipal hall or senatorial palace. The construction, which began in 1803 and lasted until 1828, so it is very likely that the wooden model, the subject of

this contribution, was commissioned during the manufacturing to have greater awareness of what the result would be, when once the edifice was completed. The building was arranged on a rectangular plan subdivided into three modules, the two lateral ones destined for offices while the central one housed a courtyard with an ambulatory, surrounded by "sixteenth-century arches" [Basile 1960, p. 35] that echoed the rhythm of the main elevation and by a double order of Doric and Ionic columns on the short sides; its location allowed the crossing of the building in order to reach the square behind. In the left wing an imposing stairwell led to the Council Chamber.
The two elevations, facing the sea and the one on Ferdinanda street, differed in their compositional arrangement: more magniloquent in its form was the first one with a giant order affecting about two-thirds of the elevation development; on the ground floor an ashlar basement supported the long balcony of the first floor affecting the entire elevation and on which opened a succession of rectangular apertures; coinciding with these, on the next floor, other openings of equal size with related small balconies. At the top a tympanum, bearing the inscription *Municipio*, i.e. City Hall, concluded the central module of the building, slightly advanced respect to the side bodies. On the other facade, the giant order was not reproduced, but a superimposition was used of Doric orders at the ground and first floor and Ionic at the second and third. Even on this elevation the two side modules were slightly set back respect to the central part, distinguished by the insertion in every one of the five bays by round-arched closures. This facade was entirely adorned also by a balustrade with rectangular openings topped by smaller windows. Following the 1908 earthquake, the building underwent considerable damage, especially in its interior, and in 1913 its demolition was decreed, carried out with dynamite charges (fig. 1).

The survey drawings by J. I. Hittorff and L. Zanth

Between the 10th and 20th of September 1823, the architects Jacob Ignaz Hittorff and Ludwig Zanth carried out a series of surveys of the city's most significant monuments in Messina; such outcomes afterwards contributed to the volume on the *Architecture Moderne de la Sicile* published in Paris in 1835. This iconographic apparatus is particularly important considering that the drawings cover both the buildings that were reconstructed after the 1783 earthquake and those that were recently built, forming the new identity of the city [Lo Curzio 2017]. The drawings published in the layout plates of this volume, which were elaborated by skilled engravers under the guidance of Hittorff himself, represent a very small fraction compared to those executed in site, and comparing them, appears clear the different purposes for which they were performed: the former for illustrative purposes, the latter for reasons related to the specific study interests of their executors. The first ones are impeccable in formal terms, rich in alphanumeric annotations, and mostly executed in pencil. The recent publication of these latter drawings [Kiene 2013] has provided scholars with the opportunity to appreciate the refined graphical meticulousness of the author in describing even the smallest details "that wants to leave little or nothing to subjective interpretation" [Manganaro 2017, p. 165]. Within a closer examination, his highly analytical approach for the fabric structure and design activity, Hittorff anticipates the current concept of surveying as "an integral part of the documentary process aiming to provide a useful knowledge in the design development" [Merlo, Lavoratti, Lazzari 2023, p. 8].

Fig. 2. J. I. Hittorff. Plan of the first floor and elevation on Ferdinanda street of the ancient municipal hall of Messina (Hittorff 1835, planche 17).



Regarding the *Maison de Ville in Messina*, in describing the plates to which he refers, Hittorff begins by stating that, as frequently happens in smaller cities, the construction internally housed ambiences for collateral functions in addition to the administrative spaces, and precisely for commercial activities: "*localités propres à recevoir les negocians pour y traiter des affaires du commerce*" [Hittorff 1835, p. 35]. This peculiarity, as well as providing an undisputed economic advantage, offered the rationale for very spacious rooms thus giving an imposing appearance to the building complex that distinguished itself from the adjacent private residences. Then he dwells on the compositional arrangement of the main façade (on Ferdinanda street), emphasizing its *concordance de proportions*, specifying that the height of the central forepart stood in a 2:3 to its length, while the backmost bodies formed two perfect squares. He contrasted the criticisms made about the two rows of windows along the two backward bodies by arguing how difficult it was to solve an equal division of holes when inside corresponded rooms of different sizes. Less lenient was the judgment on the Doric order that characterized the first level: the presence of grooves in these columns only in the lower and upper parts of the shaft aligned them to those in ancient monuments that remained unfinished [2]. Regarding the internal courtyard, he appreciates the contextual use of the colonnade and arches, which, regardless of the observer's position, produced suggestive perspective effects. Hittorff continues further on stating that, at the time of his studies, the building wasn't completed and that the drawings on which his surveys were founded were given to him by Giacomo Minutoli, adding that he could not graphically render the decorative apparatus of the grand staircase if not by referring to a model: "*nous n'avons pu donner la décoration de l'escalier que d'aprés un modéle*" [Hittorff 1835, p. 36]; it is not unlikely that this is indeed the object of our analysis!

Fig. 3. J. I. Hittorff. Longitudinal section of the ancient municipal hall of Messina: in the red box the legend we have referred to [Lo Curzio 2017, fig. 30, p. 134].

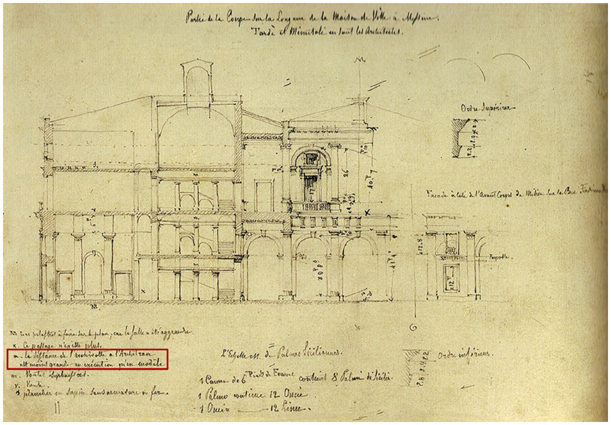
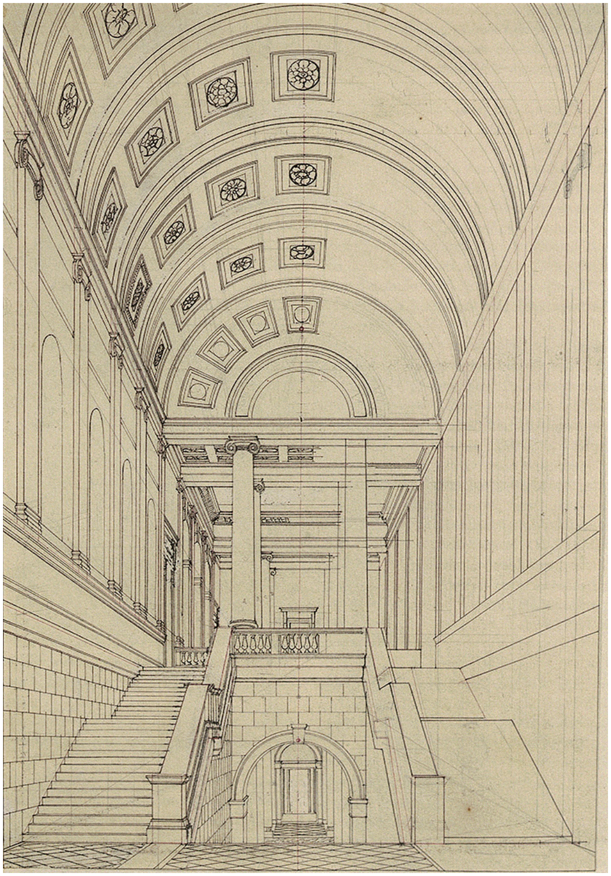


Fig. 4. J. I. Hittorff. Perspective section on the grand staircase of the ancient municipal hall of Messina [Lo Curzio 2017, fig. 31, p. 135].



Hittorff, in completing his studies, carried out, within an editorial format a ground floor plan [3], the elevation on Ferdinanda street (fig. 2), a longitudinal section passing through the courtyard, and a perspective view of the grand staircase. By examining the preparatory sketches, in the two sections in particular, a variety of information comes out regarding, for example, the dimensions of both the principal elements and some of the decorative details. Another clue, which leads us to believe that Hittorff had the opportunity to examine the archetypal building, is found in one of these two drawings: in the legend at the lower left of the longitudinal section, at the letter 'a', the architect describes the detail of the archivolt above the staircase space, which turns out to be less larger than in the model ("*la distance de l'archivolte à l'Architrave est moins grande en éxecution qu'en modèle*") [Lo Curzio 2017, p. 134] (fig. 3). The frontal perspective of the main staircase, executed on the penultimate level of the building, in its geometric construction with the choice of a very low viewpoint and at the exact center of the composition, tends to enhance the monumentality of the space, graphically restoring it in its grandeur both in compositional and decorative terms. The choice of defining in detail, only one half of the drawing, is typical in the graphic production prior to the twentieth century and is also found in other types of drawings depicting elements with a central axis of symmetry (fig. 4).

The archetype survey of Messina's ancient municipal hall

Within the design field, having ideas but not knowing how to explain them ultimately translates into not owning them. Consequently, the creation of a model, whether physical or digital (in current times), has always proven to be the most effective method for conveying one's intentions, its ideational path, for sharing with the employees but also with a larger community what will be the final layout of the building. This does not preclude, of course, the possibility of reconsiderations during the process construction, whether due to the designer's evolving ideas, economic factors, or site conditions, etc. As Manuela Piscitelli asserts: "The representational function of the model has a dual value, the crystallization of an idea and pre-vision of the constructive reality, focusing the artist's formal attention on the judgment of the senses" [Piscitelli 2009, pp. 106, 107].

Observing the models produced in the past and comparing them with the final construction, accompanied with document analyses, can become an opportunity to investigate the project evolution, finding where necessary the differences between the two objects. In Sicilian context, the use of wooden models is evidenced by a significant production dating back to the 16th century. The uniqueness of these artifacts consisted mainly, in addition to the reasons mentioned earlier, in their ability to "facilitate the understanding or evaluation of complex solutions even for a non-expert public and in accelerating the subsequent stages of approval of a contract in which the model assumes a role of guarantee for the contractors" [Sutera 2010, p. 161]. In addition, their creation made it possible in some cases to settle issues related to complex designs or the identification of any structural or compositional problem.

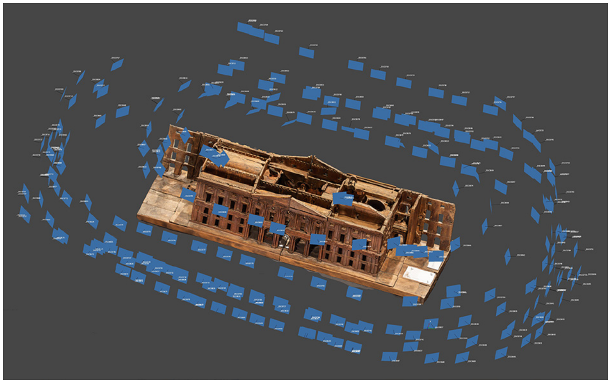
Fig. 5. Views of the wooden model of the ancient municipal hall of Messina (photo by the authors).

As already mentioned, the archetype in question was made of walnut wood in 1811 by a local cabinetmaker and, until 1908, it was kept at the Messina Civic Museum housed inside the former monastery of San Gregorio. After the earthquake, along with other works of art, the model remained, until 1911, in the premises of the University [La Corte Cailler 2002] before finally being placed in the storage of the new museum at the SS. Salvatore dei Greci. Currently, after appropriate cleaning interventions, the artifact is exhibited at the Regional Interdisciplinary Museum 'Maria Accascina' of Messina as part of the permanent exhibition titled *1908 CittàMuseoCittà* (fig. 5).

Fig. 6. Wooden model of the ancient municipal hall of Messina. Detail of the coffered ceiling and aediculae (photo by the authors).

The model (whose dimensions are 3.10 x 0.74 x 0.70 m) is the result of the assemblage of eight parts (each of which is clamped on a board about 7 cm thick and about 1.55 x 0.25 m in size equipped with carrying handles) held together by pins and screwed joints (now largely missing), which hold wires and prevent warping or loosening. To confirm the concept of the model as an instrument of design control, the two city gates and the attachment to the adjacent buildings were added to the waterfront elevation on both sides: almost a kind of verification to emphasize the integration of the building respect to the architectural continuum of which it would have been part of. Unfortunately, its precarious condition allows only limited internal inspection, which could have fully revealed the decorative solutions prepared with a level of detail that could facilitate the execution of the works by craftsmen such as plasterers, marble workers, stonemasons etc.: at the grand staircase it is possible to catch a glimpse of the coffered ceiling and niches that distinguish the environment (fig. 6). Over time, various elements of the decorative apparatus have been lost; partially missing are capitals, shafts, columns, bases, architraves, and even a section of ashlar work. A first cognitive approach to this artifact consisted in comparing it with Hittorff's drawings and the finished work through the consultation of vintage photographic documentation.
A first observation of the elevation on Ferdinanda street clearly shows the absence of the tympanum hypothesized in one of the first stages of the project in the central

Fig. 7. View of the model in Metashape showing the distribution of the photographic shots (graphic elaboration by the authors).



module and a different arrangement of the door-window system in the upper floor: in the model, in fact, it is reproduced the almost final configuration, while in the drawings it is proposed a solution in which the window rests directly on the architrave of the below opening. Continuing further in the comparison, one notices in the model the absence of the balcony that runs along the entire front. It could be presumed that, as moreover Hittorff himself states, since, in 1823 the building appears to be still under construction, his surveys were based on the designer's original drawings ("*l'abbé Giacomo Minutolo, architecte, qui en donna les dessins*" [Hittorff 1835, p. 36]) and thus prior to the creation of the model. Other discrepancies include the presence of circular oculi within the lunette above the five openings of the central partition at the first floor, which will later be replaced by rectangular apertures, and the short ramp of steps preceding the entrance, which isn't introduced in the final solution. The distinctive grooves at the top and base of the ground floor columns are shown with equal accuracy in both Hittorff's model and drawing. As for the seaside elevation, since no drawings are available, it is possible to carry out the comparison only between the model and the finished work: again, neither the long balcony on the 1st floor nor the individual small balconies on the second floor are reproduced; instead, the Ionic capitals of the giant order and the rustication of the basement are reconstructed with extreme meticulousness.
The survey of the wooden model was carried out using the digital analytical photogrammetric technique SFM (*Structure-from-Motion*), assembling 249 photographs with the use of *Agisoft Metashape Pro software* (1.8.3), which automatically solves the camera's positioning and orientation problem (fig. 7). The images were taken with a NIKON D5600 which, for reasons of greater model definition, have various focal lengths (164 with 50mm focal length, 25 with 26mm focal length, 45 with 24 mm focal length, 15 with 18 mm focal length). All images were saved in RAW format with a resolution of 6000x4000 px, edited in post-production with the same parameters, and saved in .jpg format. The model control in Metashape was also achieved through the recognition of the four markers arranged on the archetype. The images were imported and organized into several chunks based on focal length, and then used to create a sparse point cloud. This sparse point cloud was further processed to generate a dense point cloud, from which a mesh was created, and a texture applied (figs. 8, 9). In parallel, a laser scanner

Fig. 8. Side elevations from a texture model in Metashape (graphic elaboration by the authors).

Fig. 9. Waterfront elevation and elevation on Ferdinanda street from a Metashape texture model (graphic elaboration by the authors).

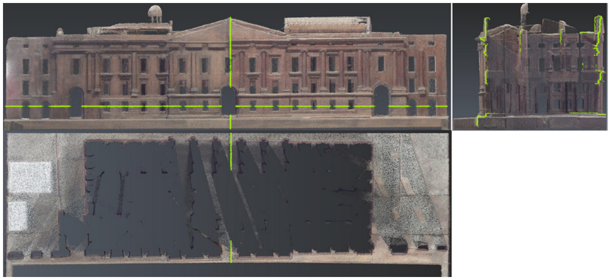
survey was carried out with Leica BLK 360 by making 8 stations. The individual point clouds obtained from each station were registered together using Cyclone Register 360 software, and then imported into Cyclone 3dr for cleaning and meshing operations of the 3D model.
The two models are extremely similar in size and document with different specificity the current state of the archetype (figs. 10, 11).

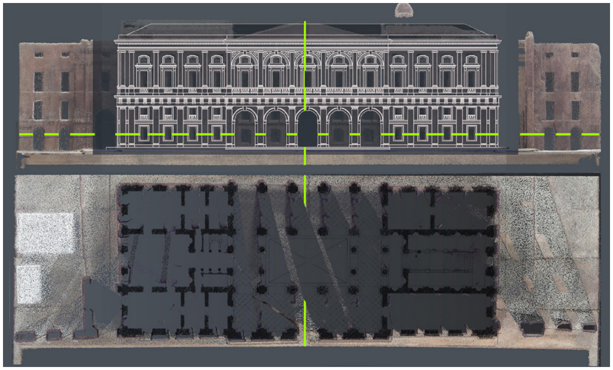
Conclusions

The results achieved, obtained through the combined use of 3D digital acquisition techniques (photogrammetry and laser scanner survey), demonstrated the effectiveness of this methodology in graphically representing an object, in this case little known and which, at present, is in a rather precarious condition from a conservation point of view. The survey operation allowed an in-depth study of the geometric and formal aspects, reaffirming once again the indispensable role of Drawing in the process of documenting the existing historical heritage. Specifically, since this is a model of a building that no longer exists, the creation of a digital twin makes it possible to interpret correctly the object's qualities, but also in rapport to the real architecture of whose forms it reproduced. In addition, the comparison of the data acquired by instrumental surveying with the graphical elaborations produced by Hittorff at the beginning of the 19th century made it possible to draw some reflections on the evolution of surveying procedures, which today, compared with the past, give more reliable and extremely accurate results. In conclusion, the work presented here could be configured as a starting point for a twofold operation: first, thanks to the documentary corpus produced by the three-dimensional survey that highlighted the morphology of the model and its fragilities, this could be useful for an eventual drafting concerning a restoration project; then a second stage regards, with appropriate arrangements, the 3D printing of the digital model, generating another model, in a smaller scale, within a museum context and intended for employment also by a user with visual disabilities [Empler, Fusinetti 2021].

Fig. 10. Plan, elevation on Ferdinanda street and vertical section from a point cloud model (graphic elaboration by the authors).

Fig. 11. Plan and elevation on Ferdinanda street from a point cloud model with overlapping Hittorff surveys on white (graphic elaboration by the authors).





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The authors thank the Director of the Regional Interdisciplinary Museum 'Maria Accascina' of Messina, architect Orazio Micali, for the opportunity granted to perform the surveys of the wooden model displayed in the exhibition. They also thank architect Alessia Chillemi who took the photographic shots and edited the processing of the model with Metashape.

Credits

Despite the unity of the contribution, the paragraphs: *Messina's ancient municipal hall* and *The survey drawings by J.I. Hittorff and L. Zanth* are attributed to Adriana Arena; to Alessio Altadonna the paragraphs: *The archetype survey of Messina's ancient municipal hall* and the *Conclusions*; *Introduction* is to be considered shared.

Notes

[1] For a reconstruction of the events linked to the eighteenth-century Palazzata project, see: Passalacqua 2008, pp. 168-199.

[2] In this regard Hittorff refers to what he observed and transcribed in his previously published works entitled *Architecture antique de la Sicile* (1827) and *Antiquités inédites de l'Attique* (1832).

[3] Among the preliminary sketches there is a previous version of the plan in which, evidently, certain decorative elements have not yet been defined such as, for example, the niches that characterize the walls of the main staircase.

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Models at Different Scales. A Study on the Inference in the Perception of the Relationship between Space, Body, and Object

Daniel Martin-Fuentes, Javier Martin

Abstract

The debate of the predominance between drawing and model as design tools is as old as Architecture itself. Up to our days, we cannot deny the centralism of drawings in the process of ideation, configuration, and communication of architecture, but the use of models has never disappeared because both elements result to be complementary.
Is widely known how drawings change in concretion depending on the scale. There is no research if the same thing occurs with models. Basing the study on the works done by students along four courses in an Interior Architecture Degree, this paper delves into the mechanisms of perception behind scale inference in architectural models and discusses their implications for design practice.

Keywords: model, mock-up, scale, perception.

Introduction

The architectural project as an ideation process, although it has incipient examples in the Gothic, emerged definitively during the Renaissance [Muñoz Cosme 2008]. In this period the use of drawings began to spread, but up to this date scale models were almost the exclusive method of architectural conception and expression, and they were considered sufficient for the definition and construction of the building. Even when drawings had started to being massively used, models kept great value as a tool of communication and definition, and the drawing-model debate, as the main means of definition and representation of the project, was far from being overcome [Muñoz Cosme 2008].
When drawing, there is a process of abstraction or concretion that adapts the work to the scale of the physical printing or digital representation. The adaption stands for a better understanding of the results presented and there is a consensus of the line-weight, detail, and quantity of information that an architecture plan must include depending on the scale. But when it comes to models there is no research done in this issue and some questions, already answered for drawings, arise in this realm.
In [Carazo Lefort 2011], The author lists multiple sources in which the history of three-dimensional models has been extensively studied (the same author has published numerous times on this topic). Anyway, he recognizes, talking about research on models, that their objectiveness and playful nature has not facilitated a rigorously treated place in the history of architectural representation [Carazo Lefort 2018].

Fig. 1. The Ribbon. Models at two scales and final mock-up.

What is the proper level of detail that a model must have? At what scale models represent volumes vs spaces? What would be a good scale to represent interior spaces or constructive details?
Beginning with research on the scale of models and the psychological mechanisms of scale perception, the previous questions are the starting point of a study based on the works done by students along five courses in an Interior Architecture Degree. To design a small pavilion, drawings and models are used at three different stages of the design process:

- Preliminary designs, with the use of rough models;
- Final ideation, along with more detailed models;
- Real configuration, finishing the subject building a model, or mock-up, at 1:1 scale.

The use of different techniques, materials, and solutions, according to the scale and degree of development of the design will allow to analyze, compare, and contrast to achieve conclusions on the matter (fig. 1).

Models for thinking

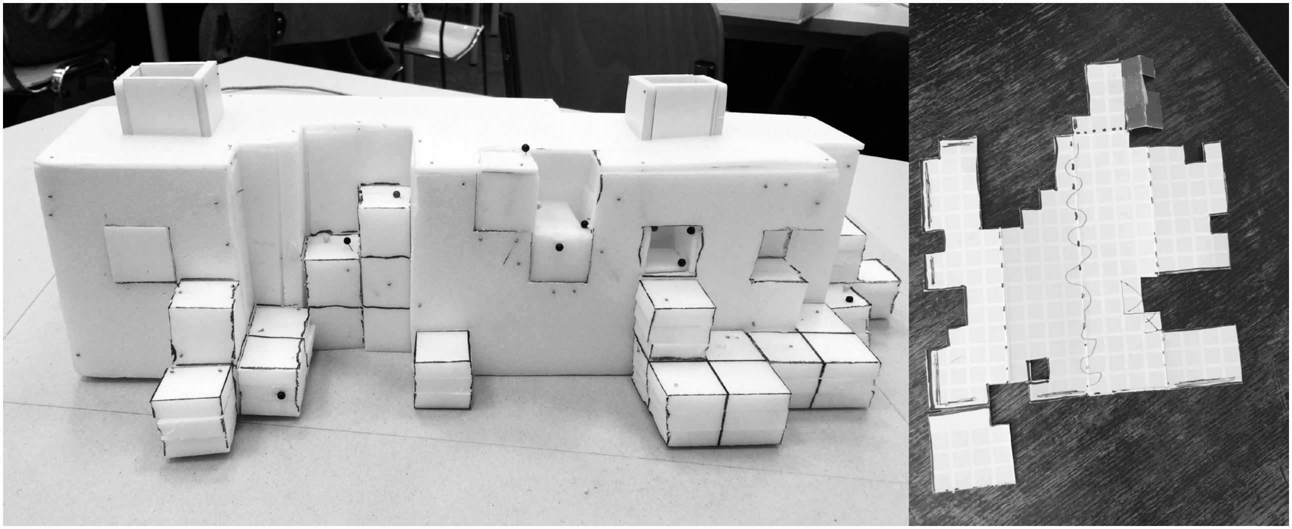
Models play a double role in the architectural process: ideation and communication. An idea already included in Alberti's *De Re Aedificatoria* and clearly exposed by Vincenzo Scamozzi in his treatise *L'Idea dell'Architettura universale*, written in 1615 [Yanguas Álvarez de Toledo 2019]. While these two purposes may seem closely intertwined, they serve distinct roles. Models for thinking are conceptual frameworks that aid architects in conceptualizing, exploring, and refining their design ideas. On the other hand, models for communicating are representations of these ideas, crafted to convey architectural concepts and intentions to clients, stakeholders, and collaborators.
It is known that models developed for thinking may evolve into communication tools as the design progresses, undergoing iterative refinements and enhancements to improve clarity and coherence. But, as the works we are going to study have been developed by students, we will focus exclusively on models for thinking and the role they have in the design process in which they have the condition of a dispositive, a tool, to conceptualize and articulate design ideas.
David Kirsh's work on external representations and cognitive artifacts sheds light on how physical models function as cognitive tools that support architects' problem-solving and decision-making processes [Kirsh 2013]. He states that physical models serve as external scaffolds for architects' thinking, aiding them in organizing their thoughts, visualizing spatial relationships, and testing design hypotheses. Physical models allow architects to externalize and manipulate design ideas in three-dimensional space, facilitating a deeper understanding of form and proportion.
In all this process, scale plays a key role because it impacts not only the physical dimensions of the model but also its visual appearance, tactile qualities, and spatial relationships [Mills 2019].

Scale perception

The perception of scale in architectural models is influenced mainly by two psychological mechanisms, both interrelated. The first one is size constancy, which refers to the perceptual phenomenon wherein individuals maintain a consistent perception of an object's size despite changes in its distance or angle of observation [Gogel 1965]. In architectural models, size constancy allows viewers to infer scale based on familiar objects or spatial relationships within the model. With this comes the other mechanism that is relative size, in which viewers compare the size of elements within the model to each other or to familiar reference points [Palmer 1999]. For instance, the perceived height of doors or windows relative to the overall structure can provide cues about the scale of the entire building. Contextual cues also play a significant role in scale inference by providing visual anchors for comparison [Cornell 1993]. Surrounding buildings, human figures, or other objects within the model serve as contextual indications that help viewers gauge scale accurately.
There are several studies investigating the perception of scale in models that have provided insights that can be used to deepen the knowledge in the area. [Jiang et al. 2019] conducted a study in which participants estimated the size of architectural models under various viewing conditions. The results revealed that viewers relied on both absolute and relative size cues but being the contextual cues the ones that most significantly influence scale perception. Similar research done by [Stamps et al. 2000] explored the effectiveness of different scale

Fig. 2. Vertebrae. Model and final mock-up.

Fig. 3. CUBUS. Rough models in the design process. Design with compact enclosure.



indicators in architectural models. They concluded that human figures were the most reliable scale indicators, but other contextual elements, such as furniture or vegetation, could also aid in scale inference, particularly in the absence of human figures.
These relations stand on the perception of volumes, shapes, and sizes. But, in models, another important factor is materiality and all the sub-factors that depend on it. In the case of an architectural model, its condition as an object, that has necessarily to be concretized having materiality, counterbalances the abstraction that every scalar operation entails, in which the reduction in size implies an inevitable simplification of reality [De la Cova 2016].
Other studies, clarify that materiality has also a wide impact in scale perception. The texture and surface detail of materials influence viewers' perceptions of scale; fine-grained materials may suggest smaller scales, while coarse textures may imply larger scales [Bodmer 2010]. The weight and density affect how viewers interpret the solidity and massiveness of depicted structures. Heavier materials may convey a larger scale, whereas lighter materials may suggest a smaller scale [Ruddle 2007]. Transparency or opacity can influence spatial depth perception making transparent materials enhance the perception of scale by revealing spatial relationships between elements [Jiang et al. 2019]. Regarding reflectivity, materials that reflect light strongly may highlight surface details, enhancing the sense of scale [Dove 2000]. Colour and hue choices in materials can evoke associations with certain scales or environments. Familiar colour palettes may ground the model in a specific context, influencing viewers' perceptions [Stamps et al. 2000]. Familiarity with materials influences viewers' preconceived notions and expectations of scale. Cultural and contextual associations with materials guide viewers' interpretations of scale within architectural models [Holl 1996].
During the preparation for the study, we decided to reduce as much as possible the dispersion of results eliminating some variables by fixing their 'value'. So, aiming materiality not to influence the results, students were asked to only use white materials that had no connection with any real materials when making their different models. Even in the construction of the mock-ups, possible materialities were eliminated using an industrialised system of plasterboards painted in white to formalise the designs.

Defining the students work

The study was developed in a subject of the Interior Architecture Degree of the Berlin International University of Applied Sciences called Interior Construction 1 held during the second semester. Along the four courses that the study lasted, from course 2018-2019 to course 2021-2022, the assignment given to students, even changing the design topic, was basically the same and aimed at the design of a medium-sized pavilion that had to be circumscribed in a rectangle of 2,5 × 3,5 meters, using the drywall construction systems. Its height was free with a maximum of 2,5 meters in the highest point due to the place where the final mock-ups were to be built. There were two deliverable works that had to include mandatory information. On one side a printed booklet including specified drawings at stated scales, sketches, perspectives, and photos of models. On the other side a digital presentation in which the students would present their work with a 5 minute projection including all the mandatory information, always specifying that the presentation should include model pictures. It was also specified that models had to be done in the exploration of the design ideas and then in the presentation of the definitive design, but there was not given a specified scale, letting the students decide on the go.

Fig. 4. Flora. Rough models in the design process. Design in smaller independent part.

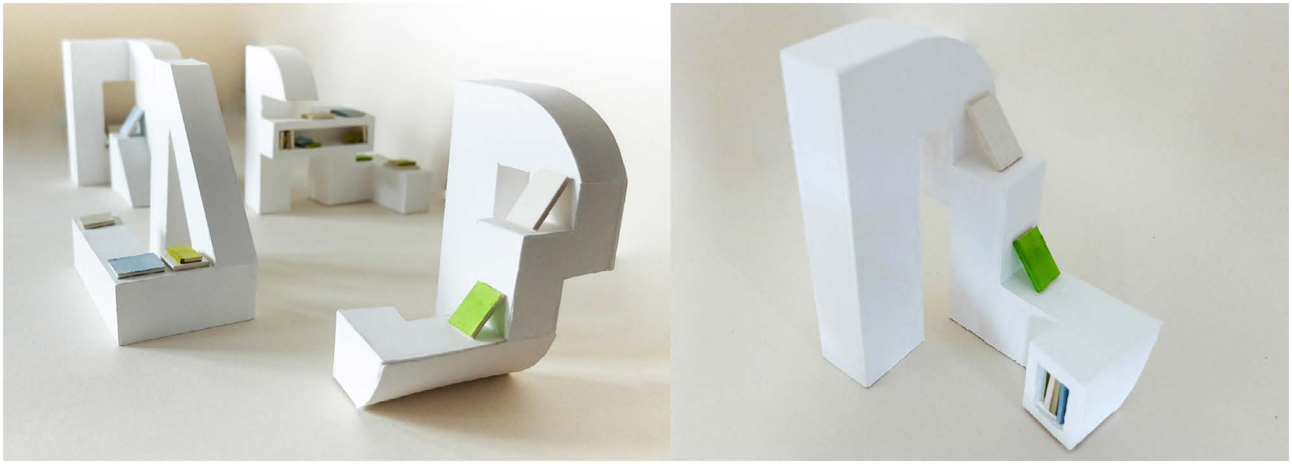
The subject would end with the students helping, together with a professional worker, in the construction of a mock-up of the pavilion at real scale and testing the construction details of the drywall systems studied. In this final phase having to engage in physical manipulation and observation, made them develop a deeper understanding of architectural concepts and processes and offered them the opportunity to experience the spatial qualities of their designs.
This hands-on approach encourages iterative design thinking, cultivating a mindset of inquiry and experimentation. But 1:1 scale prototypes are not generally feasible and this desirable learning by doing technique has to relay on more affordable, in terms of money and time, processes such as the ones that occur in model making.

Models as objects

When starting a design process there is an exploration that often prioritizes overall form and proportions over details [Ching 2014], focusing on developing the fundamental concept and vision for a project. Models created at this stage are mainly used for the exploration of form, massing, and spatial relationships rather than detailed interior layouts [Schwartz 2009].

When in the development of the courses, students were asked to start modelling, we observed that they created, crafted, models that could be easily manipulated with their own hands. Visual analysis of the designs came more from moving the object rather than moving the observer, i.e. the point of view. So, in this situation, it seemed that the key factor was size independently of scale.
Some designs started from a compact enclosure occupying the whole area as preliminary concept and others were made of smaller independent parts that could be linked or added (figs. 3, 4). Therefore, the first ones were generally modelled at smaller scales than the second ones resulting in objects of very similar sizes. Something that fits perfectly at the heart of Campo Baeza's essay *Una idea cabe en la palma de una mano* [Campo Baeza 2014, p. 47]: "That little scale model […] prompts serious reflection on the project itself, the kind of reflection that is characterized by research and at times can prove difficult for non-architects to understand. […] that tiny model is an extremely efficient tool of project research".
In his words lies the notion that architectural ideas, despite their grandeur or complexity, can be distilled to their essence and encapsulated within a small physical form, but for that they must be dimensionally encompassable at human hand scale. Understanding this perceptual dynamic at play is essential for comprehending why, at this

Fig. 5. READ. Photos from an 'axonometric' approach.



scales, models are perceived as objects rather than representations of interior spaces [Vrachliotis 2016] knowing that observing this small objects generates 'axonometric' approaches [Carazo 2011], a representation system that can be said to be exclusively used for volumetric drawings and that tends to insist on the interrelation between the parts and on a vision of the building as an artifact [Moneo 2017].
In our case, having to build a pavilion of bigger plan size of 3,5 meters, most of the models measured between 15 and 20 centimetres approximately. Which resulted in scales ranging from 1:23 to 1:17. In the example of a medium-sized pavilion a scale of 1:20 could be appropriate for design thinking, but in houses or buildings it jumps out of the hand scope. Anyway, in some cases it still allows to perceive the designs as objects as Le Corbusier stated in the *Volume 1* of the *Oeuvre Complète*: "*Plusieurs maquettes en plâtre sont exposées à l'échelle de 5 cm pour mètre; c'est une échelle qui permet vraiment de voir ce qu'on fait*" [Boesiger 1999, p. 59].
At this scale models yet allow to 'truly seeing what is being done' because there is the possibility of observing them together, one in front of the other, as if it were a series [De la Cova Morillo Velarde 2016].

Models as spaces

As we have seen smaller-scale models that create small sized objects may focus primarily on volumes and spatial relationships. Some authors say that larger-scale models afford architects the opportunity to incorporate interior details such as furniture layouts, circulation patterns, and spatial organization [Ching 2014]. And this may seem that

Fig. 6. Escherism. Mock-up. Pavilion as an interior space.

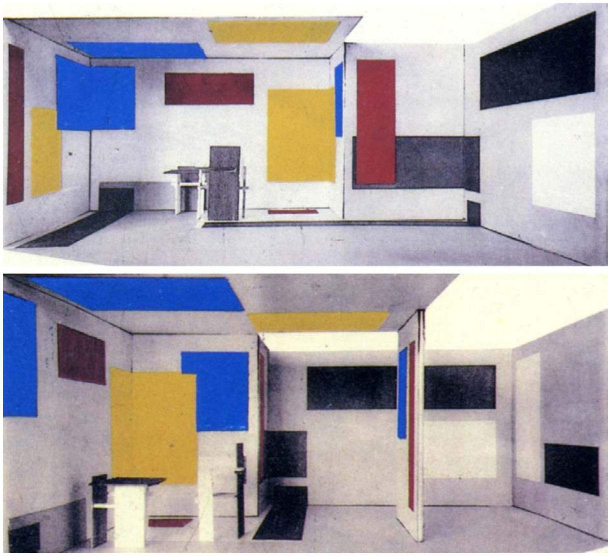


Fig. 7. Original model. Raumlosung. Juryfreie Kunstschau Berlin. 1923. Huszár and Rietveld (Troy 1983).

the specific threshold at which interior representation becomes feasible varies depending on an intended level of detail of the model. But in our study, details, along with materiality, have been consciously erased from the formula and when models start to become bigger, students represent them with photos that get closer to an emulation of real eye-height perspectives but never arriving to a normal person height.
This fact makes us think that the camera size and its field of view impact directly in how the model can be represented and therefore perceived through images. Same thing would happen in real perception, but human face size and possible eye position would be the key factors then. Again, the perception of a model as a representation of spaces that serve as an envelope for human activities depends on size, or relative scale between the model and the viewer, embodied in a camera or in a real person. So, when trying to take a photo of an interior space, the medium eye-height at the scale has to be bigger than the smartphone or the camera dimensions or even larger than the face dimensions in order to allow a realistic position of the point of view.

Actually, in our study, none of the photos is really at an eye-height level, they are taken from higher probably because the camera was too big to place it properly. But when it comes closer to a position that would seem reasonable in the real world, then models are perceived as built realities that surround us.
In his thesis, De la Cova [2016], explains how the Nederland's architects, in the De Stijl exhibition held in 1923 in the Lénce Rosenberg Gallerie expose models that incorporate the idea of space in the three-dimensional model (fig. 7). Through photographs we can deduce that their scale and position admitted placing the eye for observation at a very similar distance that it would be in a real scale construction. He also underlines the contrast that these models had with the plaster massiveness of Le Corbusier models that where compact volumes without holes in the windows or possibility of seeing inside them. A few months later, Le Corbusier's atelier made the first model with an interior –at least known– for Kevin La Roche. The windows were real holes, and to one of the two models done the roof could be removed, in the same way as opening the lid of a box and being able to see inside [De la Cova Morillo Velarde 2016].

Conclusions

Architectural models, need, as happens with drawings, an abstraction that every scalar operation entails and therefore implies an inevitable simplification of reality. They run between multiple scales, it is their condition, but the same can be said about architecture itself. At the end this condition shared by models and real constructions leaves them halfway between object, representation and plastic work [De la Cova 2016].
Following our study, it can be concluded that the key factor that seems to influence the perception of models is size regarding the person that builds or views the model. That is deeply linked to scale, that depending on the real size of the building may vary to adjust to particular dimensions that make the model be perceived differently. On some occasions as an object focusing the attention on its corporeity, in other occasions to the space it embodies.
When the designs were finally built at real scale students said to have those two complementary perceptions, that differentiate so well in models, altogether in the mock-ups. They realized that the process of designing using models had allowed them to better understand the real dimensions that

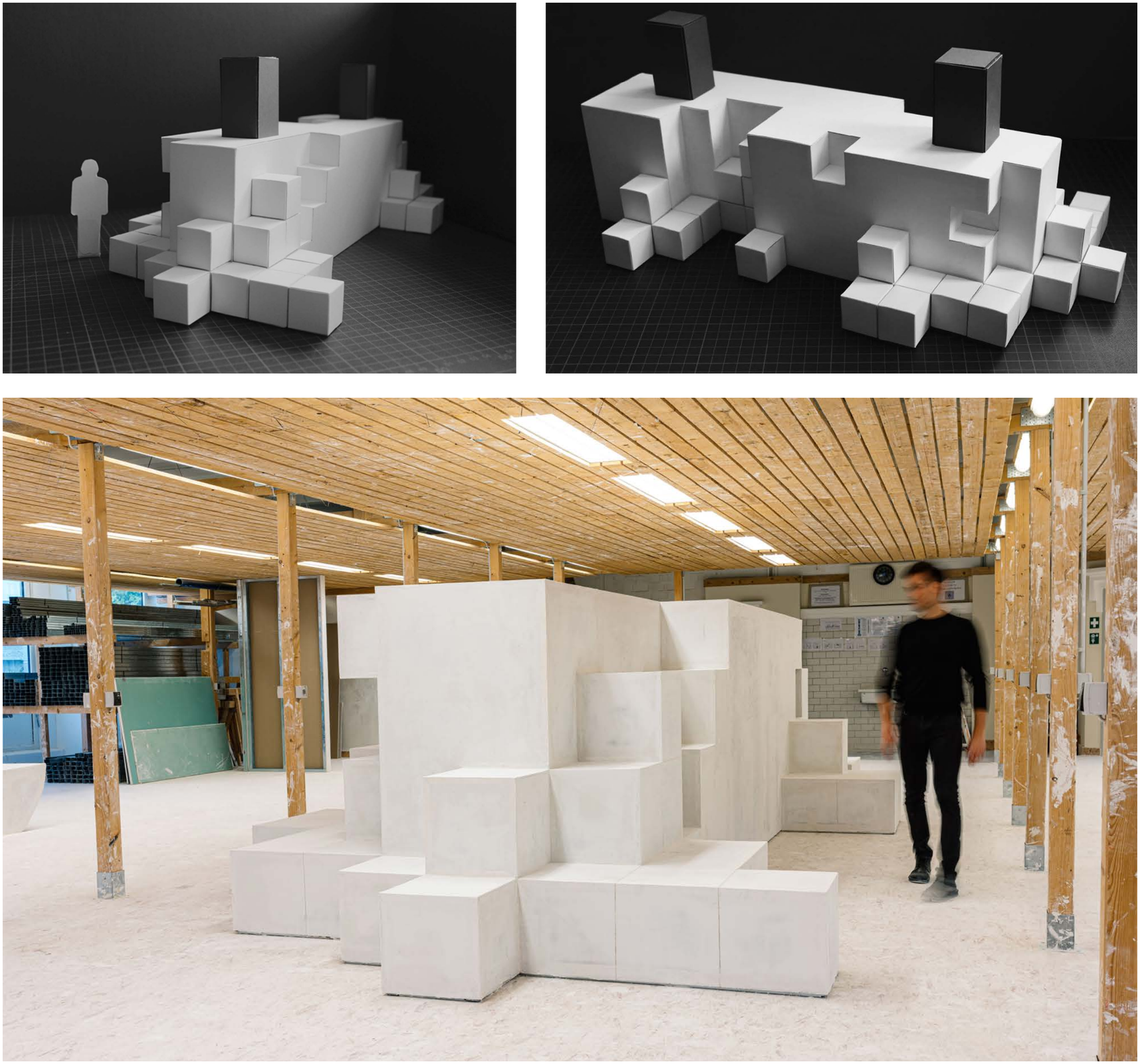
the pavilion was going to have. Some of them had to adjust the measurements as it already happened to Le Corbusier in the design of the Governor's Palace in Chandigarh. He admitted that the scale of the Palace had become excessive, having built on the scale of giants [Le Corbusier 1955], something that became obvious when building the model at scale.

In conclusion, our research paper has highlighted the diverse roles and potentials of architectural models in shaping architectural thinking and practice. From their function as tools for conceptualization and exploration to their embodiment as objects of aesthetic and experiential value, models play a central role in the design process, facilitating creativity.

Fig. 8. Flora. Final design models and mock-up.

Fig. 9. A-MAZE. Final design models and mock-up.

Fig. 10. CUBUS. Final design models and mock-up.



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New Materials for New Technologies

Model Materials: Uses and Materials in the Construction of Scale Models

Eduardo Carazo, Álvaro Moral

Abstract

Scale models have been an integral part of architectural activity from its origins and continue to be so today, despite significant advancements in digital graphics. There are several reasons for the enduring presence of these small architectural objects, which have adapted to various conditions of creation and different historical moments.
Despite the rapid advancements in infographic media and even virtual reality related to architecture, the model remains an object of interest in major architectural offices around the world. Thus, models continue to captivate the public with their unique magic and characteristics in architecture exhibitions, whether related to contemporary architects [1] or ancient ones [2].
The intention now is to consider the factor of the material with which they are built, a crucial issue from various aspects inherent to the model: the scale relationship, the reference to the real or projected object, the artisanal relationship with other trades, the presumed formal or sculptural autonomy, and ultimately, the very spirit of the times or Zeitgeist in which each model is framed.

Keywords: architectural model, scale model, celoplasty, model materials.

Introduction

At the end of the astonishing neorealist film about the tumultuous life of Michelangelo Buonarroti [3], a disquieting scene is presented in which the brilliant artist walks among cypress trees as he flees from Florence to Rome seeking the protection of Pope Leo X, who had summoned him to lead the construction of Saint Peter's Basilica. For all his luggage, Michelangelo carries in his hands a wooden model of his centralized design for the great basilica of Christendom (fig. 1). A wooden model [4] that is certainly not comfortable to carry during a long journey on foot.
Is it possible to claim that the wooden model became the essential element of his project? What interactions did the model present, as a substitute for the architecture itself, compared to convenient and unequivocal paper plans?

In some previous research, we have highlighted various issues about these small architectural objects, especially their capacity for adaptation and transformation to survive as an effective method of support for the architectural project in its multiple facets [Carazo 2011], including naturally the learning and teaching of architecture itself [Carazo, Galván 2014; Campo Baeza 2013]. We have also explained how their inherent playful component [Carazo 2018b] has, in many cases, prevented them from receiving due attention in the theory and historiography of both ancient and modern architecture, having finally attracted the interest of some specialized publications in the final decades of the 20th century and up to the present [Carazo 2018a].

The consideration of their material quality now leads us from the idea of the model as a true built essay of the future building to the well-known mechanical tests of the inverted catenaries by Antonio Gaudí. But it will also allow us to recognize the wooden models of the sculptural tradition of the Renaissance [Millon, Lampugnani 1994], or the models of Le Corbusier for the church of Notre Dame du Haut in Ronchamp, related respectively to the representation of form and space, having for this a plaster model and another of wire and paper –in the manner of model aircraft– and which we know through the photographs taken by Lucien Hervé [5] (fig. 2).
From a historical perspective, models have accompanied architecture since immemorial time, with well-known models found in Egyptian tombs, not always considered architectural objects but rather understood as mere symbolic elements. However, for an object to become a symbol, it must first have been of everyday use, then become a paradigm and be sacralised [Gentil Baldrich 1998, pp. 15, 16]. But from the point of view of architectural theory, these curious architectural objects have never been given the importance they deserve, although since the last decades of the 20th century, more rigorous studies on the matter have intensified [Mindrup 2019].
Addressing them from their multiple facets, one by one, can help gradually frame the problem and ultimately establish their true relevance in the history of architecture, not only from an instrumental viewpoint.

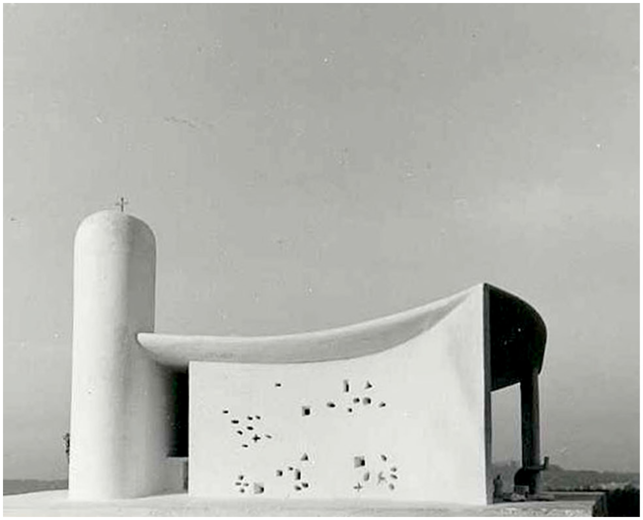
Fig. 1. Final scene of the movie "Il Peccato" (2019) by Andrei Konchalovsky. Alberto Testone (Michelangelo) with the model of St. Peter's Basilica on his way to Rome.

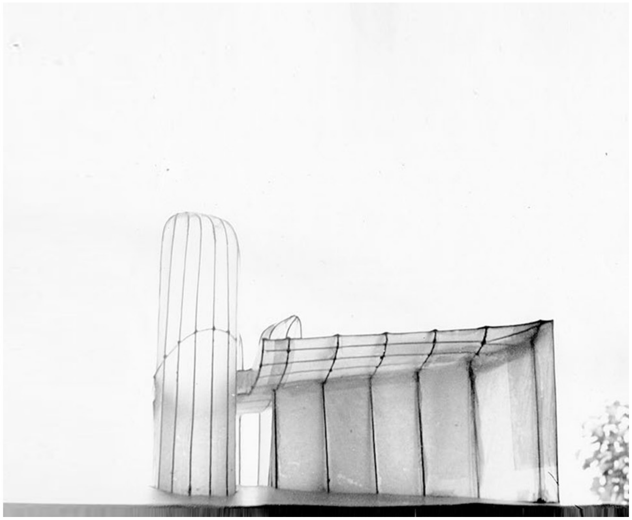
Discussion

The methodological approach we propose here aims to address one of the characteristics that define any three-dimensional physical object made by human hands, namely the physical matter of which it is composed: The material of the model.
As we will try to demonstrate, the material is not merely a casual physical support chosen for simple reasons of proximity or craft tradition; it sometimes acquires the quality of a medium [Seelow 2017], in which ideas can be combined with icons, ideas that convey proposals, concepts, or ideologies to various recipients, among whom the client –models as propaganda and final product– and the architect himself –models as sketches, as a means of ideation– stand out.
In any case, one of the difficulties in following the history and theory of architecture through the model is precisely its material quality, and consequently, its fragility. If we add to this the difficulty of its conservation due to its size, and the playful component that invites touching and handling, we understand the scarce number of models that have reached us relative to the infinite number of them that could have been produced over time.
The initial materials of architectural models were related to the familiarity that the model maker –perhaps also in his capacity as an architect– had with their use, always under their mechanical capabilities that influenced their relationship with the architectural reality they represented; as demonstrated, for example, by the small Egyptian limestone capitals for a model that would later be built in sandstone in the royal temple [Mindrup 2019, p. 79].
Although the Egyptian models preserved in tombs as ritual objects were made of polychrome wood, a material close to the craftsmen –not architects– who made them [6], we have also received an architectural model from antiquity constructed of stone, representing the base of a Phoenician temple and today preserved in the Beirut Museum in Lebanon (fig. 3) and called the Model of Niha [7] [Franco Taboada 2018]. The model is carved in the same stone as the temple; it probably represented as a project, a material quite unsuitable for such a small-scale model due to its difficulty of carving. Nevertheless, this stony quality is probably the reason why this valuable testimony of antiquity has reached us.
However, this naive relationship between the material of the model and that of the future building it represents

does not seem to be a constant until the Renaissance, when many models ignored this biunivocal relationship.
In the grand exhibition of Renaissance models that I had the opportunity to visit at Palazzo Grassi in Venice in 1994 [8] [Millon, Lampugnani 1994], the models made to conceive and construct the great Italian Renaissance buildings from Brunelleschi to Michelangelo were displayed. All the models in that exhibition, without intending to, were characterized by a double material homogeneity; they were all made of wood, and their manufacture is attributed to the workshop of the architect who authored the building in each case (fig. 4).
This dual condition, being made of a material different from the one it represents and with its authorship from the very conception of the project, highlights how, in this case, the wooden material constituted itself as a malleable mechanism but very precise in its details of concrete definition of the projected architecture. Here, the model, by virtue of its faithful representation, is constituted as a rehearsal of reality and at the same time as propaganda to the client and patron, who would undoubtedly be captivated by its capacity to transmit the future coveted building.
These types of models stem from the principles stated by Leon Battista Alberti, in which models should be characterized by their simplicity and their unique capacity to convey the volumetric idea of the projected building [Alberti 1991, book 1, chapters 3-9], and also by another Renaissance theorist, Vincenzo Scamozzi [9] [Gentil Baldrich 2021, pp. 1671-1673]. This approach also ties back to the well-known controversy over Renaissance drawing implicit in the so-called Letter to Leo X [Gentil Baldrich 1993], which ended up attributing the drawing to the architect and the model to the sculptor, thus defining a new intellectual status of the former over the latter. In the tradition of the workshops of Spanish architects of the time, they were called, not coincidentally, 'modelos de bulto' (volume models), thus indicating their massiveness and simplicity.
Among the Baroque architects, the work of Borromini stands out, whose dual role as architect and sculptor distances him from those intellectual controversies and leads him to materialize his architectural ideas in the same way he did with his sculptures, that is, through volume models carved in soft materials, of which the 'red wax', already used by his predecessors as Vasari recounts

Fig. 2. Plaster model and wire model of the Chapel of N. D. de Ronchamp. Le Corbusier Foundation. Photographs by Lucien Hervé.





[Vasari 1945], is noteworthy. This type of soft and perishable materials –there is also talk of turnips as raw material– implies in turn a change in the function of the model, more linked to the sketch or the creative phase of the project than to a final idea of a finished building to present to the builder or the client.
Despite these controversies, many architects continued working with models thereafter, although their use extended to other areas, such as the representation of the territory and the city. In this sense, it is worth highlighting the grand commission by King Charles III of Spain to create a set of models of all the fortified cities of the kingdom. Although this ambitious project only materialized in the 1799 model of the strategic city of Cadiz, at the southern edge of Spain, it is noteworthy for the rich materials with which it was made [Granado, Barrera, Aguilar 2016], including silver sheets in the representation of the sea surface surrounding the city. These types of models no longer have a creative or architectural function, in fact becoming known as 'relief maps' and acquiring an essentially military function [10]; that is, they are models that represent an already existing reality, not an idea or project, and moreover, due to their material richness, they are also an object of contemplation and luxury.
The model (fig. 5), which represents the city and its maritime and terrestrial surroundings, was made under the auspices of the royal architect Francisco Sabatini, but was specifically commissioned to a particularly skilled military engineer. The execution was carried out by a large team of craftsmen, using top-quality and expensive materials, among which holly wood stands out for the facades and cedar for the rooftops and the sea, with ivory being used for ornaments. However, in a final whim of its creator, the sea was ultimately covered with a thin layer of silver sheets, which were later removed for their monetary value and have now been restored. The model ended up functioning like the construction of a real building, with costs so burdensome for the Crown that the project ended where it began: exclusively in the model of Cádiz. This is a clear example of how the material can ruin the enterprise.
During the 18th century, the model adapted to a new use, which in turn led to a new choice of materials for their construction: within the new artistic tradition of the Grand Tour, which awakened in the European art academies in relation to the admiration for classical antiquities, the fashion of fetishist collecting of models of Greek and Roman buildings emerged as a souvenir and desire for

Fig. 3. Stone model of the Phoenician temple of Niha in the National Museum of Archaeology in Beirut (Lebanon) and the current state of the same temple.

possession, just as it still happens today with modern tourists and models of the Tower of Pisa, the Eiffel Tower, or Le Mont Saint Michel, in resin, metal, etc. In several European countries, these collections were then treasured, which in turn led to the appearance of various workshops of significant professional model makers who manufactured them [Kockel 1998].
One of the examples was undoubtedly the collection of Sir John Soane in his London house, today the Soane Museum, where we can find the two characteristic types of models of the time: models that used cork –Phelloplastica [11]– to simulate ancient ruins in their realistic state of breakage and fragmentation, and, on the contrary, perfectly polished and finished plaster models that represented classical buildings in their ideal state, in the same way that pensioners at the academies in Rome drew the admired antiquities.
In both cases, the models are no longer architectural project objects *per se*, but rather collector's souvenirs, manufactured in various specialized workshops as consumer products, and then purchased and transported to collections in emerging museums. The cork models were, in particular, especially easy to transport due to their low weight and their resistance and flexibility.
The Soane Museum in London has two models that represent the same building, the Temple of Vesta in Tivoli, constructed respectively in two different materials with their corresponding versions, of ruin and ideal model. The first one of cork, finished with artistic colorations painted to give it a dramatic realism that represented very well the deterioration of time on stone, made in Naples in the well-known workshop of the artisan Giovanni Altieri (active between 1766 and 1790) [12]; and the second one executed in clean and white plaster that represented the temple in its ideal state, newly built, white and exquisitely polished. Its realization is based on a certain system of 'reinforced talc' as it contains a substructure of metal rods that gives resistance and stiffness to the model against the vicissitudes of long-distance transport from the Paris workshop to the various clients' destinations around the world (fig. 6) [13].
However, although the production of these models at the end of the 18th century was encouraged by the high tourist demand from the cultured travellers of the Grand Tour, in the case of Soane, their use as teaching material is also documented. As a professor of Architecture at the Royal Academy from 1806 to 1837, Soane used these models to teach his students the scientific and artistic principles of construction from classical Antiquity and used the models to illustrate the history of architectural development in a tangible and especially visual manner. The ambivalence of these pairs of cork and plaster models, with their different perceptual effects, served, based on their specific material qualities, to illustrate the passage of time on the great buildings in the history of architecture.
Despite the decline in the use of models among architects in the 19th century, motivated by the great development of perspective drawing in European and American academies, the advent of the Avant-Garde in the 20th century heralds a resurgence of the model as a mechanism for architectural

Fig. 4. Painted wooden model for the Church of Santa Maria della Consolazione in Todi. Todi, Municipal Museum.

creation. The *tabula rasa* that modern architects sought in all areas also reached architectural representation, and axonometry largely replaced conical perspective, thereby valuing the model again, whose visualization is closer to axonometry given its small size and its propensity to be viewed from above.
On the other hand, the modern era takes up the model "as a prototype to shape new ideas, but above all, to re-establish the physical, material, manual, and artisanal relationship of artistic creation; with concepts as relevant as the new objectivity –*Neue Sachlichkeit*–, the total work of art –*Gesamtkunstwerk*– and, in short, the artistic trends returning to craftsmanship, which contradicted that intellectual status conquered by the architect in previous centuries. And the model again dirties the hands of the new artist-artisan-architect with plaster and clay" [Carazo 2018b, pp. 825]. It is in this context that

Fig. 5. Model of the city of Cádiz, 1799. Museum of the Cortes of Cádiz.

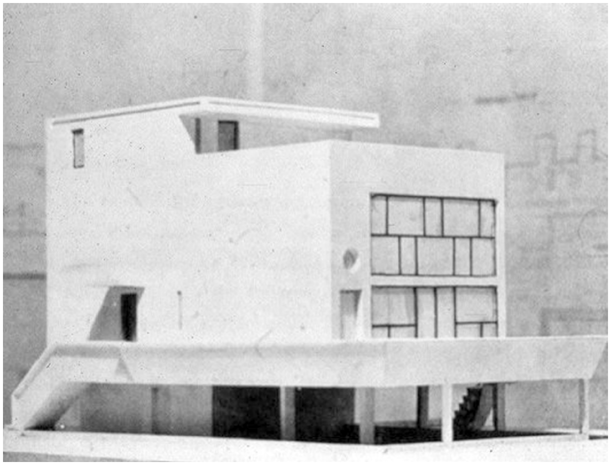
Fig. 6. Models of the Temple of Vesta in Tivoli, made of painted cork (Photo: © Sir John Soane's Museum, London) and in reinforced plaster (talc) (National Heritage of Spain Inventory number 10011717).

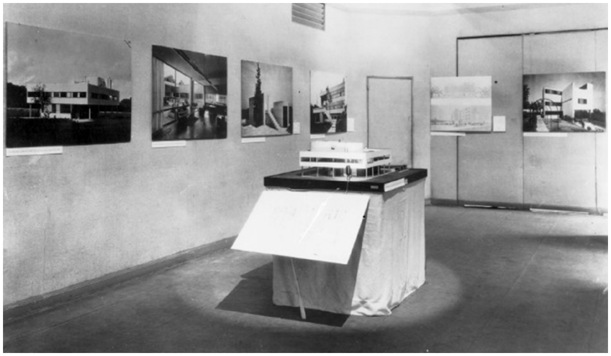
Le Corbusier presents the models of his revolutionary houses at the Autumn Salons in the innovative Paris of the 1920s (fig. 7) [De la Cova Morillo-Velarde 2016].
In De Stijl, the use of model-objects was reinaugurated, constructed with wood panels painted in primary colours, as seen in the preliminary model of the Rietveld's Schröder House. However, in these uses, the persistence of the idea of massive volume can still be perceived against the bold neoplastic proposal of architecture of plane and colour. The year before, Rietveld had used thin, flat cardboard to build architectural models for the *Maison Particulière* (Private House) of Vilmos Huszár and Theo van Doesburg, thus demonstrating his full knowledge of the material and its utility for modelling a volume [Mindrup 2019, p. 164].
From that moment on, the avant-gardes unleashed all their propagandistic potential through the intense use of models of their innovative architectural proposals. Here, the model was more capable of anticipating the new architecture than its future construction, which was still nascent for a building industry without sufficient development and for a society very reluctant to such radical changes.
Exhibitions were the main medium for this expansion and propaganda in the first half of the 20th century, especially in the interwar period. It should be considered that architecture exhibitions have a peculiarity: in other arts, such as painting or sculpture, the works exhibited are precisely paintings and sculptures, but it is not possible to 'bring' real buildings to an exhibition [14]. Therefore, in addition to plans and drawings, the most expressive and popular medium for an architecture exhibition is precisely the model [Montes Serrano, Carazo 2018].
Among those made in that period, the one organized by Philip Johnson and Henry-Russell Hitchcock at the Museum of Modern Art in New York in 1932 stands out as paradigmatic, where ten models by the ten European and American architects most involved with the avant-gardes were exhibited, commissioning each one a model made expressly for the exhibition (fig. 8). The first aim was to unify scales and sizes of the models to be exhibited and to achieve greater didactics in the public, specific instructions were given about their construction materials: "the models will be constructed in celon, wood, *papier-mâché*, glass, chrome, steel, and marble. Special care will be taken to provide each model with an attractive environment, with trees, grass, people,

and cars. As far as possible, the interior planning should be visible from the outside" [Montes Serrano, Alonso Rodríguez 2018].
The matter of models as the main subject of architectural exhibitions has become established worldwide, with the previously mentioned example of the Soane Museum in London and its model room. In some cases, these are temporary exhibitions that host original models from the time the projects or buildings were created, such as the one mentioned in Venice in 1994 [Millon, Lampugnani 1994], or monographic exhibitions of an architect [15]. However, some of these collections have also become established as architecture museums, like the German Architecture Museum (DAM) in Frankfurt, which uses models as the main content of its permanent collection and temporary exhibitions [Elser et al., 2012; Miller 2013].
However, the great boom in architectural models came in the second half of the 20th century, precisely through new industrially manufactured materials, and the emergence, primarily in the United States of America, of significant model-making workshops amid the development of American architecture in big cities [Jacobs 1958]. With the reference to the lost model of a skyscraper project by Mies for Berlin in 1922 [Mindrup 2019, p. 187, fig. 5.14], American architects in the 1950s fostered a large industry of models built with industrial materials, such as plastic and metal, which required for their manipulation and perfect assembly highly equipped industrial workshops with specialized staff and machinery. As Jane Jacobs points out, these models were not intended to captivate the public, but rather, to verify before construction the various effects of transparency and light reflection of the large curtain walls that would form the surface of the buildings, and even to check for possible errors in the model prior to actual construction.
The model workshop of Theodore Conrad (1910-1994), the most distinguished and prolific architectural modeler of the 20th century, whose private archive has been recently discovered, is perhaps the best example of this industrial production of architectural models, with scale reproductions of emblematic buildings of New York City from the Rockefeller Center to the Lever House (fig. 9) and the Seagram Building. These models competed with their almost fetishist realism with the finished buildings through photography –an essential medium of their dissemination, not covered in this work–, using materials

Fig. 7. Model of the Maison Citröhan, Le Corbusier, 1922, Salon d'Automne, Paris.

Fig. 8. Photographs and model of the Villa Savoye at the Modern Architecture Exhibition at the MoMA in 1932, Le Corbusier.





almost identical to the constructed reality and with a technical perfection characteristic of this new industry. Never were material and construction so parallel in the real world and in the world of models [Fankhänel 2021]. These realistic and professional models, however, open a new field within the study of architectural modeling, as they are made almost in competition with the work of the architect themselves, or at least we could say in parallel to it, not being a product of the architect's own studio understood as a focus of architectural creation. Although we have seen this precedent in the Italian or Parisian workshops of the Alteris or the Fouquets in 18th century Europe, the industrial models of the 20th century already denote a singular intensity in the use of industrial materials and production.
The technical perfection and the use of new materials, characteristic of the architecture of the 'machine age', also encompass certain episodes of the post-avant-gardes of the 20th century, such as the models produced with plastics and metals by the Dutch group known as the 'Situationists', led by the artist Constant Nieuwenhuys [García Ríos 2023]. In the complex development of the utopian city of New Babylon and because of his training as a visual artist, the means of representation were drawings and models. And for this reason, the models were not formalized as architectural representations, but as autonomous artistic objects, with an intrinsic aesthetic value, a quality that is also inherent to models (fig. 10).
In contrast to these products of technical perfection or almost autonomous artistic overvaluation, we still find the use of other synthetic but malleable materials, such as the extreme case of the clay models made by the German architect Gottfried Böhm [Architekturmuseum

Fig. 9. Similar views of two different models of Lever House, 1949. Metal and plexiglass models by Theodore Conrad.

2006], who, following the tradition of the sculptor-architects of the Baroque, carries out 'soft' modelling to capture volumetric ideas that, due to the malleable quality of the clay, are susceptible to modification and constant corrections on the initial design, thus using the three-dimensional volumetric model as a sketch (fig. 11).
One last issue regarding the material as the essence of the model, and the different uses it implies in relation to the various functions it can adopt, which has allowed it to adapt to each moment and survive in the digital age, would be the models produced by three-dimensional printing through computer programs for the virtual construction of three-dimensional objects (fig.12). This issue, deserving its own development beyond the scope of this work, brings us closer to the question of the material of the model from within, being the limit case in which the material –plastics, synthetic powders, etc.– constitutes the model itself, forming from a numerical digital system into a physical and tangible volume in the world of things. Current architecture reflects, for the first time in history, on the real possibility of becoming, through this 3D mechanism, a representation of a model itself.

Fig. 11. Clay model by Gottfried Böhm for Ausstelllungs- und Tagungszentrum, Hannover, 1986. Courtesy of Deutsches Architekturmuseum.

Fig. 12. 3D printed model from the Renzo Piano Building Workshop (RPBW).

Fig. 10. Model for √2-Omgang, 1965, New Babylon, Constant Nieuwenhuys. Constant Fundation.

Conclusions

The creation of architectural models is a complex and deeply reflective process, where the choice of material is far from arbitrary and is intensely influenced by various factors. These range from the existing intention behind the model to the physical limitations of the materials used to construct it. The material then becomes one of the fundamental aspects to consider when determining the purpose of the model, so much so that it can even act as a symbolic object that encapsulates the essence of the project.
In addition, the ability of the material to adapt to the scale of the model and its limits of strength and modelling are crucial. A material may be ideal for representing certain details at a particular scale, but unsuitable at another, requiring careful deliberation by the creator of the model, whether it is the architect conceiving the project himself or a specialist or craftsman from outside the project. It is also essential to consider how the materials reflect or dialogue with the prevailing artistic and architectural currents of the time, as this can add an additional layer of meaning or critique to the work.
The evolution in the use of materials for scale models parallels the advance of contemporary industry, with modern industrial production capacity enabling the creation of exact replicas of architectural projects. This development has facilitated the incorporation of industrial production techniques in the creation of models, expanding the possibilities for precision, detail and technical perfection.
However, despite the rise of digital tools in architecture, physical models retain their prominent place in both large architectural offices and small studios around the world. They remain a vital medium for creative experimentation, where changing materials can reveal new dimensions of the project or idea. The physical manipulation of materials and direct interaction with form allow architects to explore design alternatives in a more intuitive and tangible way than digital media allow.

Notes

[1] https://arquitecturaviva.com/articulos/las-maquetas-de-peter-zumthor-en-la-werkraum-haus (accessed 19 November 2023).

[2] https://prensa.fundacionlacaixa.org/es/2009/10/06/palladio-el-arquitecto-1508-1580/ (accessed 19 November 2023).

[3] *Il peccato: Il furore di Michelangelo*, Andrei Konchalovsky, Italy 2019.

[4] The term we will primarily use in this work will be 'model', as opposed to the also common 'mock-up'. Although these terminological nuances are very important, and we have already given them due attention, we do not intend to distract here with a debate on them [Carazo 2011].

[5] https://www.fondationlecorbusier.fr/ Photo library, Contacts L3-3-1001.jpg and L3-2-11001.TIF (accessed 19 November 2023).

[6] It' important to distinguish between models that represented parts or scenes of daily life, like those found in Deir el-Bahari (West Thebes) inside the tomb of the chief steward and royal seal bearer, Maketra, from the Middle Kingdom aedeweb (accessed 22 february 2024), and the so-called 'soul houses', terracotta pieces with house models for offerings. https://es.wikipedia.org/wiki/Casa_del_alma (accessed 22 February 2024).

[7] http://tochoocho.blogspot.com/2019/01/ (accessed 17 February 2024). This is about the only architectural model from antiquity still preserved, of a temple located in Niha, near Baalbeck, similar to the Temple of Bacchus in this city from the Roman-imperial era. The steps contain words and measurements in Greek that reveal the discussions between the temple's commissioner and the architect regarding the suitability and size of the steps, with requests for changes recorded on the model itself.

[8] http://efaidnbmnnnibpcajpcglclefindmkaj/https://archivio.unita.news/assets/main/1994/03/31/page_030.pdf. In *L'Unità newspaper,* 03/31/1994 (accessed 18 February 2024).

[9] As cited by Mindrup [Mindrup 2019], Scamozzi notes that architectural models can be made of "various materials, such as wood, stucco, and cardboard or similar, according to each one's mind or fantasy", though "for Scamozzi, however, a model must 'show the value and esteem of what it represents', and for this purpose, he warned against using a 'flimsy material' like cardboard, because 'such thinness' cannot properly represent the thickness of the walls".

[10] The issue of collections of scale models of fortified cities in Europe was developed in various nations, according to: Granado, Barrera, Aguilar 2016, note 3.

[11] The art of modelling with cork is also called feloplasty (from the Greek *φελλός* phellos, cork). Its tradition originates in Naples, as an art to recreate the Nativity scenes that still endure in the family tradition of southern Italy and the whole Spain. https://en.wikipedia.org/wiki/Architectural_model (accessed 17 February 2024).

[12] *Ibid*.

[13] These plaster models, of which there are also other examples in different European collections, come from the well-known workshop of the Fouquet family, Jean-Pierre Fouquet (1752-1829), François Fouquet (1787-1872), and Emile-Françoise Fouquet (1817-1879), father, son, and grandson respectively, established in Paris. A collection of these models can be seen in the Royal Collections of National Heritage, at the Royal Palace of Madrid, which has an exceptional series of ten architectural models from the Fouquet workshop. [Navascués et al. 2017]. https://www.juaneloturriano.com/noticias/2017/07/06/pieza-destacada-modelos-de-arquitectura-de-fouquet-en-el-palacio-real-de-madrid (accessed 10 February 2024).

[14] Except for exhibitions of pavilions or prototypes, such as the one by Mies at Pavilion II of the German Building Exhibition of 1931 in Berlin (Deutsche Bauausstellung in Berlin 1931) [Carazo, Moral 2020].

[15] Like the one held at Caixa Forum Madrid in 2009 titled *Palladio, the Architect (1508-1580)* with models of his villas at the same scale and constructed in lime and beech woods: or various exhibitions on the monographic work of contemporary architects, Herzog & De Meuron, Peter Zumthor: https://www.metalocus.es/en/news/architecture-born-craftsmanship-architectural-models-atelier-peter-zumthor (accessed 10 February 2024), Zaha Hadid, etc., in which models and their materials are protagonists.

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Inverse Models. Analog as Verification of the Digital

Fabio Bianconi, Marco Filippucci, Giulia Pelliccia

Abstract

The importance of representation as a space for model building has always been central to architectural practice. These models have served as a means of verifying ideas, according to a design approach that can be defined as "form-checking". With the digital transition, this relationship is reversed and models are increasingly identified by parameters and information providing analysis, forecasts and identifying solutions, in an approach that thus becomes "form-finding". If, however, the idea and form were initially "drawn" in the mind and on paper, today the idea and the figure remain in the mind, while the digital drawing finds the form according to the desired performance. The research presented here analyzes three case studies in which models stigmatize the relationships between ideation, verification and implementation. The first case study concerns the construction of the Ames room, an iconic theme of perception, created as a temporary pavilion, generated through generative algorithms, BIM models and digital fabrication. The second case study presents the creation of a test room, a model built to monitor in real-time and compare actual performance with data simulated by multi-objective algorithms. The third case study concerns experimental research on 3D printed wooden hygroscopic architectural elements, similar models that show the role of representation in the relationship between design, manufacturing and responsiveness.

Keywords: generative design, Ames room, digital fabrication, wooden pavilions, wood 3D printing.

In Catilinam

Representation as a field of research hyperbolically reflects the transformations activated by the digital transition [Hensel et al. 2006; Schumacher 2009] in the centrality of models [Bedoni et al. 1989; Migliari 2000; 2003], conquest of modern thought [Baudrillard 1981] as a theoretical construction, because, as Vasari writes, "the drawing is an apparent expression and declaration of the concept that one has in his soul, and of what has been imagined in the mind of others and fabricated in the idea" [Vasari 1568, p. 111]. Representing means fueling that necessary and continuous reference between reality and virtuality which is the basis of the model, a dynamic and continuous process where the materiality of analogue models has always played a fundamental role in refuting doubts and implicit 'allegations of falsity' attributed to the drawing, ascribed to the class of images. Analogue models have always had the task of 'verifying' the consequences of the loss of an inherent dimension in the drawing, due to the need to experience space, always understood as doubt and as conquest. Digital has emphasized distrust and distrust towards images, but the current role of Analogue models finds a new status in data-driven design [Bianconi et al. 2019b] and the centrality of performance [Oxman 2009; Hensel 2010].
With the digital transition, the selection and recomposition processes necessary for the knowledge process [Maturana et al. 1987; Popper 2002] converge in the representation of form, which presents itself as an effective

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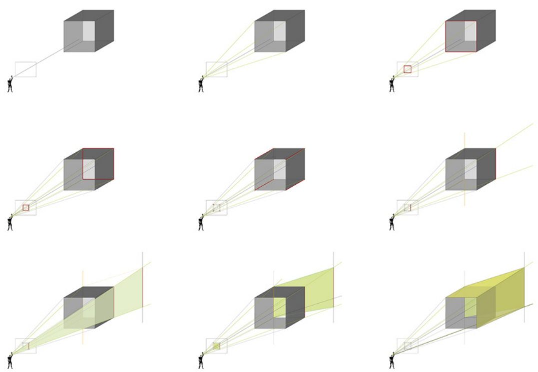
support for orientation [Passini 1981; Sancar 1986; Meng et al. 2012; Bianconi et al. 2022] and memorization of information [Oxman et al. 2014], tool for visualizing logical connections [Jabi et al. 2013; Bianconi et al. 2019a] and the hierarchical relationships established between them [Bettetini et al. 1999, p. 75]. Representation thus becomes the field of existence of information [Mitchell 1995; Kolarevic 2001], due to the need for transdisciplinarity that this language offers for integrated planning [Labaco 2013], which feeds on the centrality of the connections that it brings to the current 'fifth industrial revolution', where the protagonism of artificial intelligence in information management is establishing itself [Bianconi, Filippucci 2019].
These concretizations reflect the canonical approach to the project, linked to the identification of design solutions aimed at generating forms, which are first verified through a series of criteria that weigh their performance. It is therefore a 'form-checking', which becomes more complex in the inclusion of the various project information, which must be specifically examined. Design increasingly becomes integrated, a condition that is enhanced by digital, always capable of including and connecting, with the form that lends itself to guaranteeing the existence of heterogeneous intertwining of entities, relationships and logics, identified by parameters and information, which can be interrogated from different disciplinary perspectives through calculations to offer analysis. In the variation of the possibilities of the parameters that are inherent in the model, the form can be read as one of the results, a process that can be seen as a substantial transformation of the design morphogenesis, however having the same statutory purpose of finding the best solutions. Digital is capable of making increasingly efficient calculations and it is thus possible to seek 'for the best' solutions aimed at optimizing even unthinkable performances [Menges 2009], not by deconstructing according to a single aspect [Jones 2009], but by combining in the organic and integrated vision of the project [Gruber et al. 2012] in a process that thus becomes one of 'form-finding' [Menges 2012; Adriaenssens et al. 2014].
If we then consider that where the boundaries between designing and producing are lost [Kolarevic 2004; Kolarevic et al. 2008] due to the new logics of digital manufacturing [Sheil 2005; Sakamoto et al. 2008; Corser 2010; Krieg et al. 2014; Austern et al. 2018] inherent in CAD/CAM systems [Sass et al. 2006; Chaszar et al. 2010; Sass 2012], in robotics [Menges 2012; 2013; Gramazio et al. 2014; McGee et al. 2014; Menges et al. 2017; Eversmann et al. 2017] and 3D printing [Correa et al. 2015; Le Duigou et al. 2016; Bianconi et al. 2019], it is understood that the accusation is not aimed at the 'modelling technique', but in the value of the new way of 'doing architecture' [Oxman et al. 2010, p. 24], a process characterized by a substantial hybridization between reality and virtuality.
The digital revolution consequently entails a profound renewal of the role of variation also of analogue models in an inversion between reality and virtuality which confuses temporal linearities: if previously the form was 'drawn' in the mind and on paper, with the models that served to test and materialize the multiple performances of what had to be built, today however in the computational design approach the idea and the figure remain in the mind, with the digital drawing that 'finds' the form due to the multiple performances sought, which they must be verified through the first prototype creations that anticipate what will be built. This thesis, in light of the pre-established hypotheses, finds verification in the experiments carried out by the writer, selected to highlight specific aspects in the 'defence' of representation.

Fig. 1. Projective morphogenesis of one among the possible Ames rooms (graphic elaboration by the authors).



The model as perceptive experimentation: the Ames room

The first case study concerns the construction of the Ames room, which takes its name from the American psychologist and ophthalmologist [Behrens 1993] who proposed it in 1946 [Bamberger 2006]. It is an iconic

theme of perception, which was created as a temporary pavilion, generated through generative algorithms, BIM models and digital fabrication. The well-known case study is based on a spatial distortion that generates an illusory image, exploiting the value of the bias in perception and the lack of correspondence between the projected image and space. The reasons that led to tackling this research and, specifically, the creation of a built space, derive from the fact that the Ames room is experienced almost exclusively through images but not through the experience of space. The research therefore explored the morphological transformations starting from the visual pyramid of a canonically stereometric room: by limiting the point of view and varying the base of the pyramid, distorted spaces are formed, characterized by solid perspectives defined by divergent lines and inclined horizontal and vertical surfaces, which mislead observers in spatial assessments (fig. 1). The protracted form-finding approach is structured through generative modelling, using Grasshopper algorithms, to address spatial constraints and optimize the design for the exhibition context (fig. 2). This exploration revealed the different facets of architectural design, linking classical principles to computational design paradigms and highlighting the active role of the environment in the design process. Generative logic has integrated with BIM systems for wood design (SEMA), pushing the boundaries between design and implementation according to manufacturing processes (fig. 3). The analogue model of the architecture was created through the pavilion's platform-frame structure composed of *Oriented Strand Board* (OSB) panels, *Medium-Density Fiber* (MDF) panels and an external finish in micro-perforated black PVC (fig. 4). Among the design choices was a panel corresponding to the constrained point of view, creating a box that reveals the illusion only through the screen of a smartphone, showing how limited views adapt perception despite stereoscopic cues.
The creation of the Ames room, beyond its visual charm, shows a transformation of experience and thus became an opportunity for further experiments on the measurement of perception, using digital biosensors. The correlation between the eye-tracking data and the neural frequencies has provided insights into the behavior and emotional responses of the spectators to the epiphany of the illusion, which arises only from the constrained perspective, implemented by the smartphone: the data collected show the complexity of human perception [Palmer 1999] and how the appearance of the deceptive image captures the confused spatial exploration, the access key which in amazement activates an increase in attention in that process of knowledge which puts preconceptual images and models into crisis, according to a condition that has general validity for all analogue models of architecture.

The model as verification of simulations: the test room

The second case study presents the creation of a test room, a model built to monitor in real-time and compare actual performance with simulated data through digital

Fig. 2. Generative design and optimization of a possible Ames room (graphic elaboration by the authors).

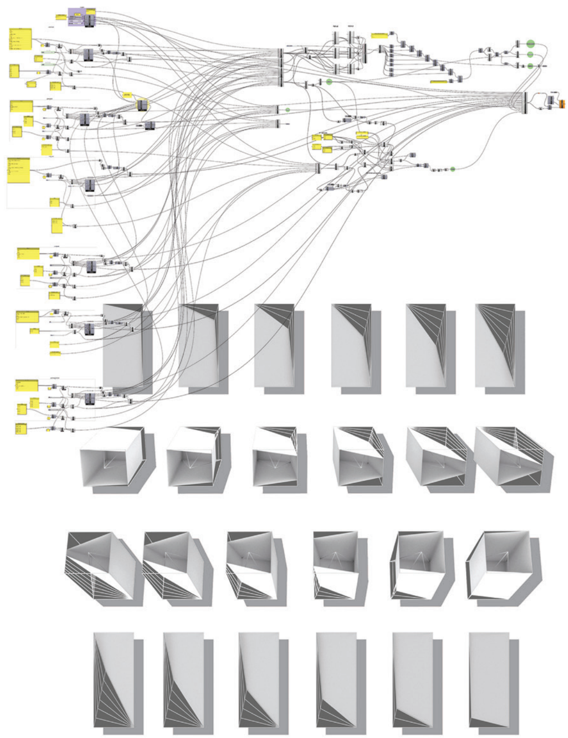
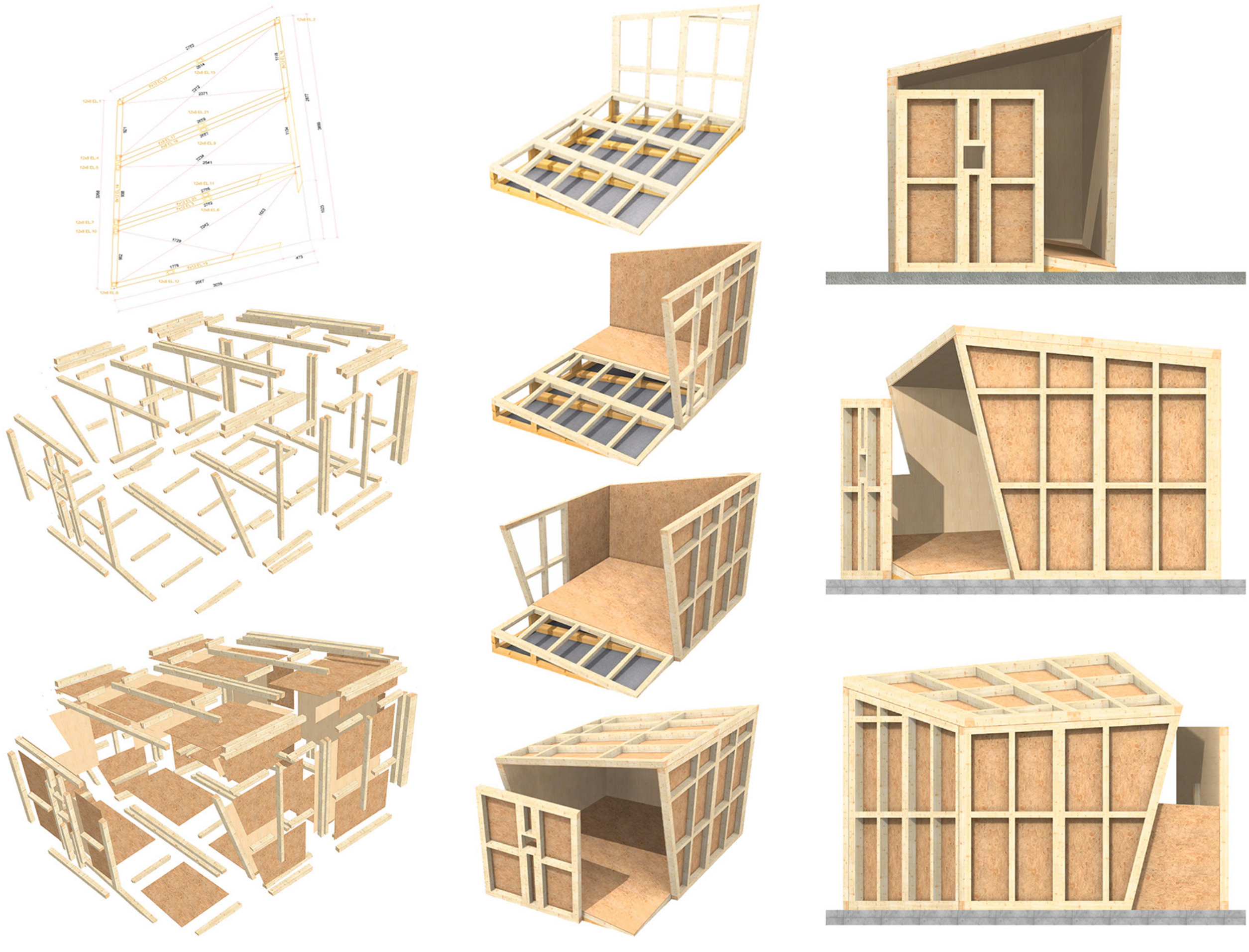


Fig. 3. Drawings for Ames room digital fabrication (graphic elaboration by the authors).

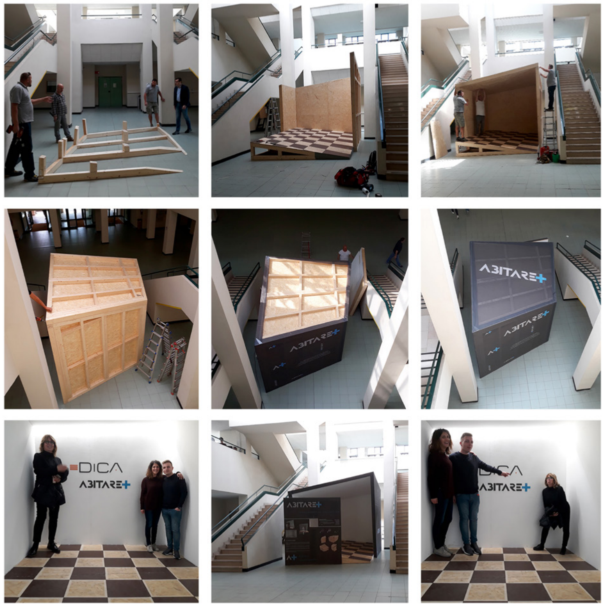


optimization processes defined by multi-objective algorithms. The research set itself the task of innovating wooden buildings to increase their performance, seeking meta-design solutions aimed at designers, who encounter difficulties due to the lack of specialized training in wooden buildings [Bianconi et al. 2023]. Using Octopus evolutionary optimization algorithms in Grasshopper, the solutions identified were shared by developing a web interface to explore and choose alternatives based on the imposed conditions. Extending the principles of mass customization [Benros et al. 2009] to architectural elements, the research has explored the optimization of perimeter walls, examining, in particular, the Platform-Frame and X-Lam construction systems [Bianconi et al. 2019b]. Algorithms were then developed to analyze and combine the data to obtain diversified wall solutions, taking into account costs and energy performance [Seccaroni et al. 2019] (fig. 5), simulations that identified combinations of wall elements with significantly better performance than the standard ones used, with lower costs (fig. 6).
Digital simulations, in the attractiveness of these results, offered a structural revolution of the products, which before being implemented required its validation in the face of an implicit prejudice on the value of the digital representation. To ensure the quality of digitally optimized solutions, a temporary wooden test room with a Platform-Frame structure was built equipped with a heat pump, thin-film photovoltaic panels, humidity-sensitive wooden panels, sensors and probes (fig. 7). Monitoring and measurements were conducted to compare simulated and actual performance, through the creation of a real-time monitoring system and digital twin in the BIM environment [Bianconi et al. 2021], with data demonstrating the full reliability of what had been digitally designed (fig. 8).
The test room is a paradigm of contemporary research, an analogue model of architecture, built in scale, which makes visible not what is in the mind, but what remains internal to the design ecology of virtual space, where data seem to have their existence which we want to be sure that corresponds to the simulated reality.

The model for material programming: 4D printing of hygro-responsive actuators

The third case study concerns experimental research on hygroscopic architectural elements in wood, similar models that show the role of representation in the relationship between creation, programming and optimization of their responsiveness, derived from the meso-scale of the material and constructed through additive printing that thus includes the design of the fourth dimension (fig. 9). By exploring solutions with digital simulations, the potential of intelligent materials such as wood, known for its hygroscopic properties, was highlighted, which instead of being contrasted as happens with plywood panels, was supported to activate responses to humidity variations. The study was therefore inspired by nature by replicating the hygroscopic behavior of pine cones to create an artificial composite for the hygrometric well-being of internal environments. The principles have extended to the 4D printing of wood-based composites, introducing a fourth-time dimension to adapt to environmental humidity. The research involved natural ventilation principles, which integrate air conditioning systems and regulate humidity through bioclimatic principles, and biomimicry [Benyus 1997; Vincent et al. 2006] is exploited here to create responsive passive actuators.

Fig. 4. Execution and installation of the Ames room for the experience verification (graphic elaboration by the authors).



Over the past decade, 3D printing, especially *Fused Deposition Modeling* (FDM) technology, has emerged as a promising avenue for developing materials with complex architectures, including smart materials and various sensors [Mustapha et al. 2021]. To improve building performance sustainably, key priorities include achieving low embodied energy, minimizing energy consumption during operation and reducing the environmental impact of new technical applications. The search for intelligent and autonomous environmental solutions, based on real-time data, has led to the study of natural sensors, which exhibit passive behavior in response to specific stimuli, such as the passive expansion and contraction of hygroscopic materials following variations in environmental humidity [Dawson et al. 1997; Elbaum et al. 2014; Elbaum 2018; Correa et al. 2020].
The adaptive behavior of these elements is based on their material architecture, which is designed, programmed and simulated through computational design and visual scripting tools, and then manufactured directly via 3D printing, which therefore allows for the creation of similar models (fig. 10). Leveraging wood as a biomimetic template for 3D printed composites means amplifying the shape deformation characteristics of wood to create responsive structures. Biomimetic principles inspired by the opening of pine cone scales are transferred to engineered artificial structures, resulting in double-layered structures with a pre-programmed response to changes in humidity (fig. 11). These solutions are conceived and calculated in the virtual sphere of digital computation and concretized in similar models necessary to verify the actual simulated behavior (fig. 12). The fabrication of this actuator was

Fig. 5. Performance morphogenesis of timber frame wall system (graphic elaboration by the authors).

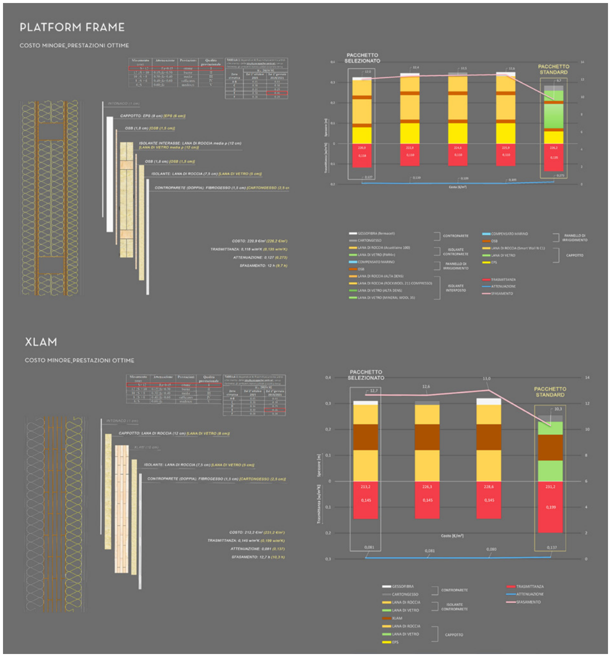


Fig. 6. Generative design and multiobjective optimization of timber frame wall system (graphic elaboration by the authors).

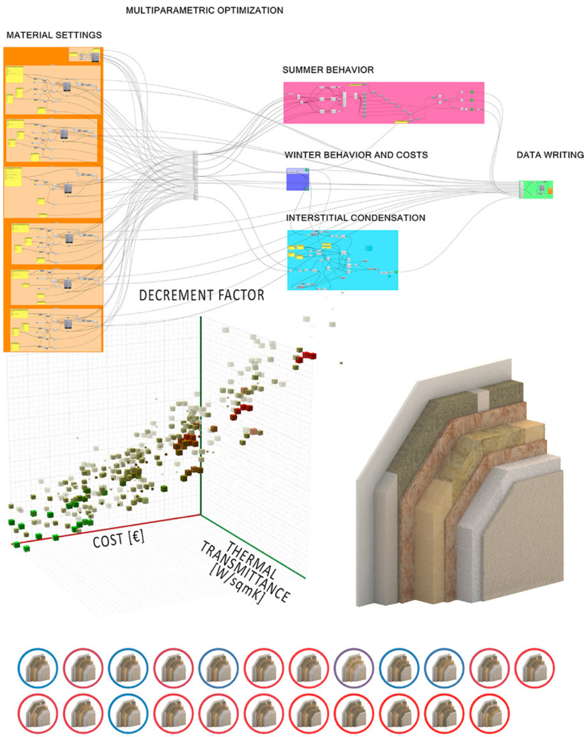
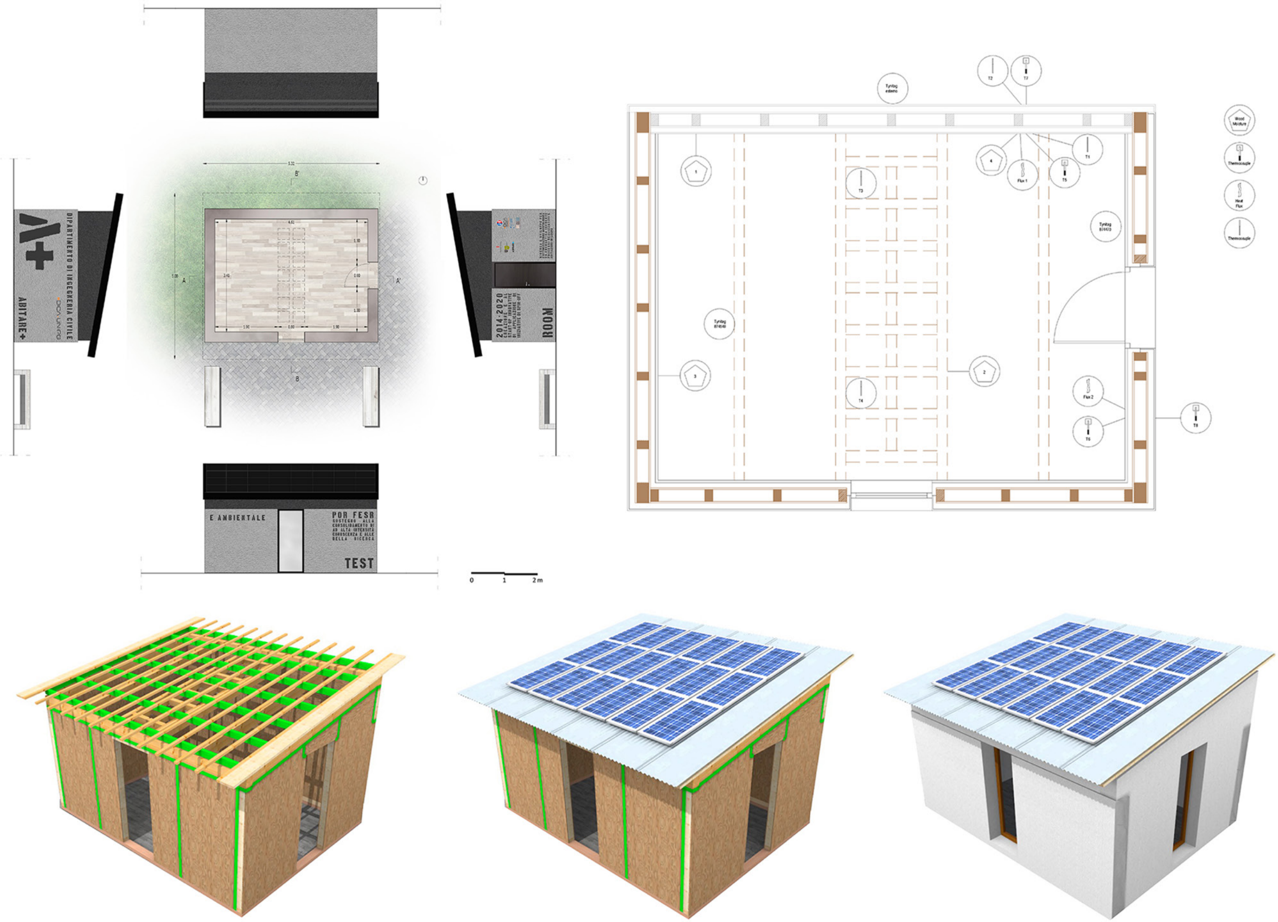


Fig. 7. Drawings for test room digital fabrication (graphic elaboration by the authors).



achieved through an additive manufacturing process, called 4D printing [Tibbits 2014] since the time dimension constitutes a crucial aspect in defining the shape and final configuration of the printed analogue models. Through visual scripting algorithms, representation is the first player in the programming of *Stimulus Responsive Materials* (SRMs) but also in 4D printing, a data-driven process that aims to offer solutions to improve interior environments with low-cost and cost-effective renewable materials with minimum operating conditions [Bianconiet al. 2023]. The representation thus manages to draw time in its simulations but also to include it and materialize it in the material, in its forms and in the future behavior of what is drawn through computational design machines. It is thus possible to create similar models that appear canonical, purely material, but profoundly innovative as they are the result of a design that directly influences their physical behavior and spatial configuration.

Conclusions

The article presented allowed us to explore in depth the crucial role of representation in contemporary architecture. The transition from traditional analogue models to the centrality of digital models is analyzed through a lens that embraces the history of art, design theory and the evolution of technologies. Through the transformations activated by the digital transition, the centrality of models in modern thought emerges and underlines the critical role of representation as a theoretical construction. Verification through analogue models in the context of digital images, often the subject of mistrust, is fundamental in this context.
The three case studies highlight how analogue models continue to play a fundamental role in the context of digital architecture. While the Ames room constitutes a tangible verification of the perspective deception created digitally through an analogue model, the test room demonstrates the importance of validating simulations through a physical model. Digital representation also takes on a further crucial role in the programming of responsive materials, in which the analogue model is fundamental for verifying the actual digitally simulated behavior. The research presented here demonstrates how analogue models are key witnesses of the process of cultural transformation that is affecting architecture. First of all, the Ames room highlights how the need for concretization is implemented in a model that is not just a reduction but, by digital manufacturing, is what leads to the built, which is a precise concretization of a family of solutions, of a reality that has incomparable potential in digital. The second case study highlights more the distrust towards the digital, which, in its autonomy as a model, needs the analogue as a verification space, inverting the primordial representations that were used to verify the drawings with their dimensional loss. The third case study highlights how in the dichotomy between virtual and real the difference between the analogue model and construction is lost, with digital manufacturing generating forms programmed to have their simulated vitality. The initial concretizations are tests transformed into smart solutions inherent in the natural intelligence, that is transcribed into a design of time, inherent in the realization as well as in the response to stimuli.
Design shows itself as the deep soul of architecture: just as the score for music remains beyond execution, so

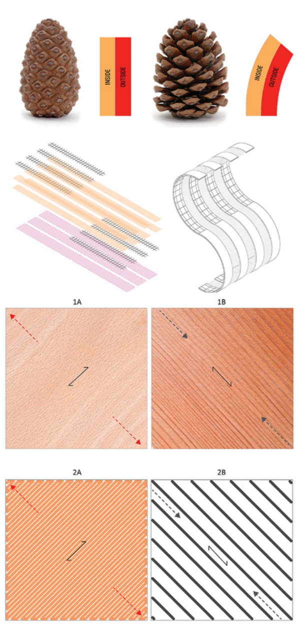
Fig. 8. Execution and installation of the test room for simulated performance verification graphic (graphic elaboration by the authors).

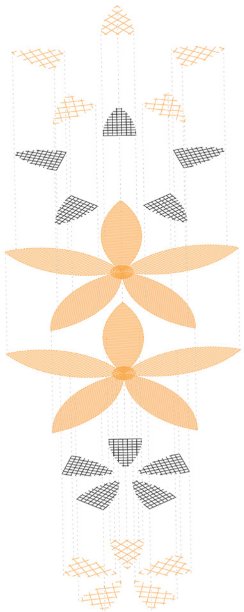
Fig. 9. Programmed morphogenesis of the hygro-responsivity of wooden actuators made by additive printing (graphic elaboration by the authors).

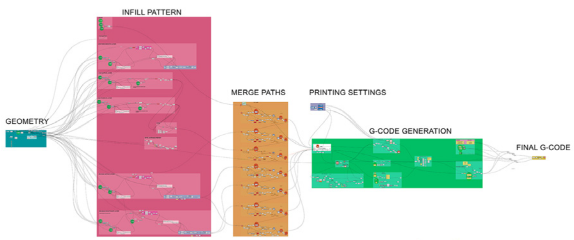
Fig. 10. Generative design and kinematic optimization of the programmed hygro-responsivity of wooden actuators made by additive printing (graphic elaboration by the authors).

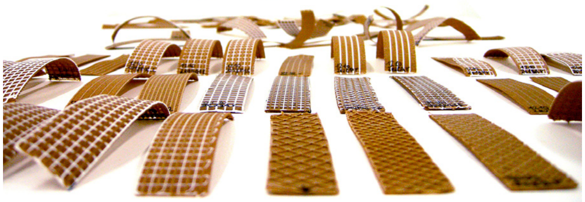
Fig. 11. Drawings for digital fabrication of the wooden actuators made by additive printing (graphic elaboration by the authors).

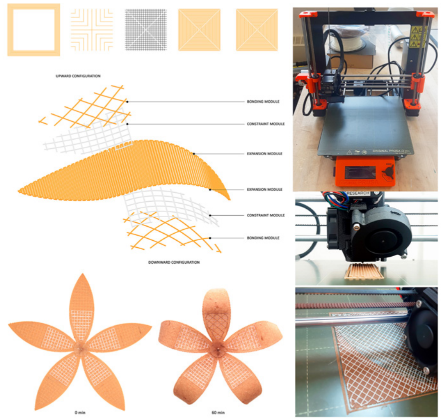
Fig. 12. Execution and installation of the wooden actuators made by additive printing for verification of the hygro-responsivity and kinematics (graphic elaboration by the authors).

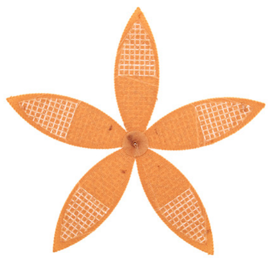


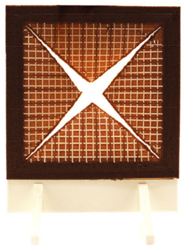


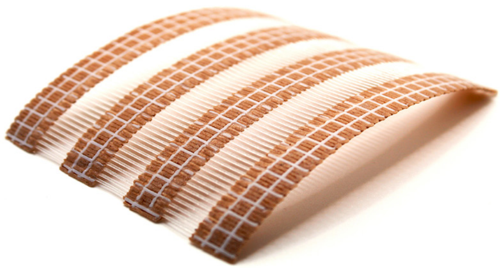












representation is the place where what remains ethereal and blurry in ideas takes shape. The analogue models of architecture have always been moments of checks, similar to when someone reads a musical score and plays some key passages to concretize what he feels without hearing. The scale factor that has characterized their realizations has always been fundamental, with digital emphasizing this loss of measure. This condition is at the origin of the current value of models, so marked by a spatial atopicity that leads to autonomy that generates as much suspicion as the world of ideas. In computational design, the possible universes of infinite combinations highlight how representation is capable of accepting increasingly complex challenges, but equally, even though virtual universes are built, its statutory role of projecting itself towards creation, towards construction, towards architecture.

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Analogue Artefacts for Structural Mechanics and Engineering. A Critical Survey

Maurizio Marco Bocconcino, Mariapaola Vozzola, Martino Pavignano

Abstract

Since time immemorial, Drawing has been the visual language of all activities related to the world of building. It allows for the prefiguration, configuration, realisation and critical analysis of construction. Among its applications is the analogue scale model, which represents a tangible expression of design thinking However, what happens when the object in question is not a work of architecture, but rather a single structural component of a building or an engineering artefact?
This paper offers an analysis of models representing the structural essence of architectural and engineering artefacts. It examines artefacts from an academic collection (second half of the 19th century), the scientific work of G. Curioni. The collection consists of more than 140 models designed as scientific supports for the didactics of Structural Mechanics and Engineering, a field in which Curioni was a prominent figure in Italy. The research represents a potential avenue for the university's Third Mission, namely the dissemination and dissemination of knowledge about the Curioni Collection. This is achieved by creating a virtual museum that hosts the virtual models of the collection in different sharing environments, with the aim of reaching as many users as possible. The model becomes a communication tool brought up to date through the reinterpretation and reinterpretation of manuals and models, transforming the material artefact into a virtual model and introducing new forms of representation.

Keywords: academic heritage, communicative culture, tangible model, virtual museum, woodworking art.

Introduction

Several national studies address the preservation of cultural assets by universities and show a significant 'patrimonial status'. However, there is often a lack of organization to ensure their proper use and valorisation. The issue is also debated internationally and has several main stages [1]. In the first decade of the 21st century, the perspective on university cultural heritage has shifted from being considered 'active resources for teaching and research' (Halle Declaration 2000) to being viewed as a means of transmitting and disseminating knowledge for the development of the territory and its inhabitants. This includes producing social inclusion through direct public involvement in university museums (Carrion Garcia 2012).

In addition to conservation, the Politecnico di Torino has been promoting and disseminating its historical and archival heritage as a unitary system of knowledge and technical information. This system is hosted and preserved in the various components of the University, including the library and museum system and departments. Between 2015 and 2016, the Politecnico adopted a single, open-source, web-based software platform for the description, management, communication, and enhancement of its Historical Collections in the fields of Architecture and Engineering. The Library and Museum Area, as well as the Departments, preserve various types of assets that form a rich heritage of archive collections. These collections are ascribable to a system characterised by cultural matrices common to the

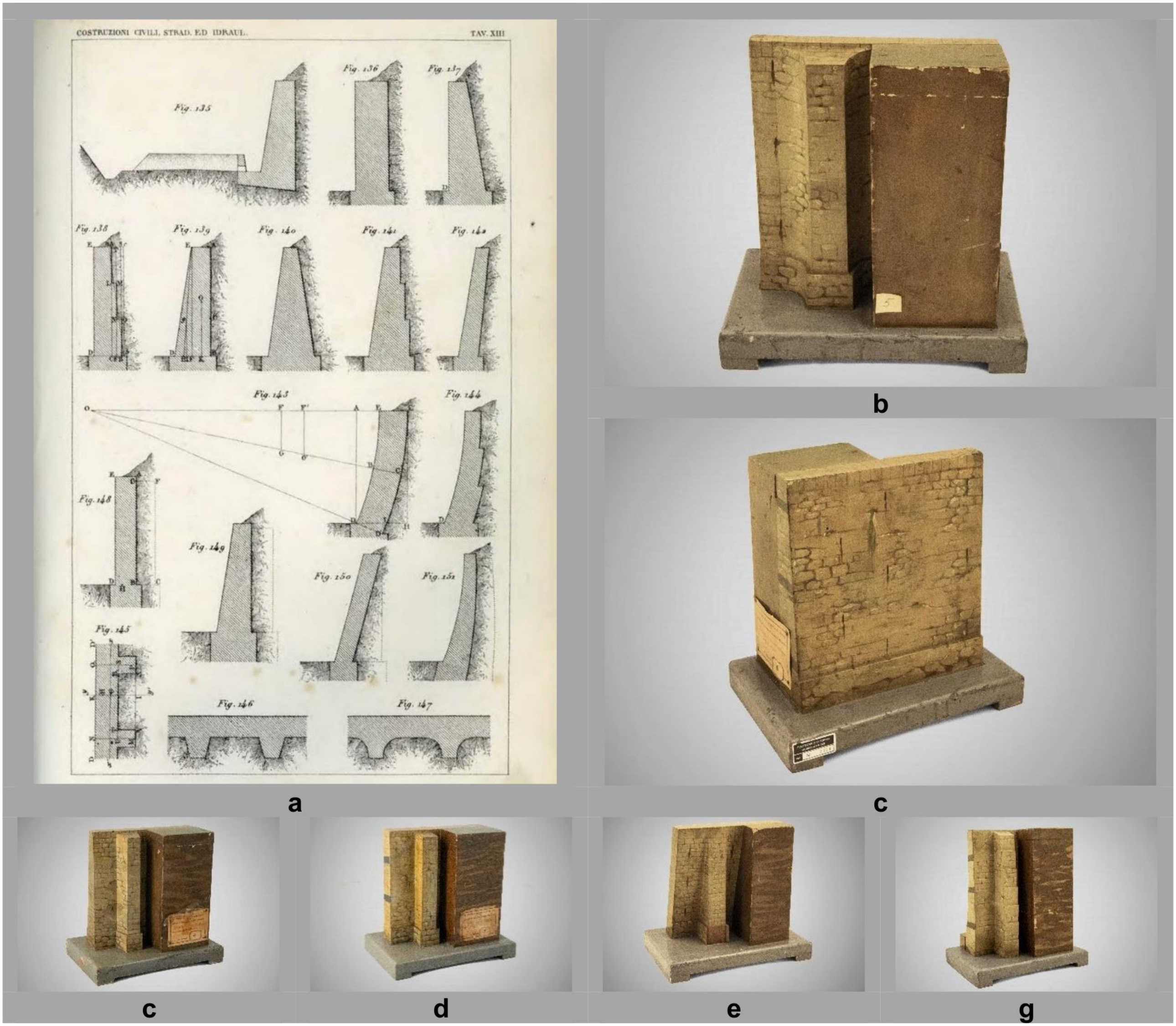

Fig. 1. Retaining walls with internal buttress. a) Curioni 1870. Tav XIII; b-c) model (m. from now on) 5, dim. 240 x 240 x 155 mm; d) m.1, dim. 245 x 250 x 160 mm; e) m.2, dim. 235 x 250 x 160 ; f) m.3, dim. 255 x 260 x 170; g) m.4, dim. 290 x 250 x 180 (graphic elaboration by M. Pavignano).

fields of polytechnic education and research. In addition to traditional documentation, they also contain collections of graphic plates, photographic images, and a significant number of material and plastic models.
The collection of wooden models known as the "Giovanni Curioni" collection, located at the Department of Structural, Building and Geotechnical Engineering of the Politecnico di Torino (DISEG), demonstrates Professor Curioni's dedication to the educational field of construction science and technology and to structural design. This collection supports the content published in his volumes *L'arte di fabbricare. Costruzioni civili, stradali e idrauliche*, which were published in 1870. The models' didactic function is being rediscovered as part of a project to enhance and enliven them, conducted by a composite research group [2]. The research group's articulation demonstrates the collection's intra- and multi-disciplinary interest. The collection has an intangible dimension linked to the didactic information heritage that can be updated, consolidated, and passed on to future generations.
The research on the DISEG archives has been the subject of various reflections expressed in publications and conferences, exploring different aspects [3]. In this contribution, we aim to present the foundational aspects of the work being conducted, the methodological approach to the critical survey of models, and the approach to the subject from the perspective of the survey and expeditious measurement system and processing procedures. Also, concerning both material and digital products, and the relevant elements for managing and representing data, as well as organizing it within knowledge information containers, this text aims to describe the operational elements that characterize the study experience.

Curioni collection: a critical exploration

The collection of models produced on Curioni's commission and for his use has been housed in various institutions over time. Faraggiana's study [1989] identified 137 models and classified them into eight families based on the subdivision of the text of *L'arte di Fabbricare* [Faraggiana 1989, p. 63]. However, the eight families did not consider the 15 models of vaults or the models of the *Mosca*, *Isabella* and *Regina Margherita* bridges, as well as the *Galleria dei Giovi* tunnel. The current study shares Faraggiana's scientific approach but also recognises the visual value of models as (visual) artefacts [Gay 2016b]. It highlights their epistemological value in the context of "didactic theatres" that characterised science education from the second half of the 19th century to the first half of the 20th [Gay 2000; Müller 2009; Cumino 2022; Zich 2022]. The study suggests unifying the models of the three bridges into the bridge family, including the *Galleria dei Giovi* model among the galleries, and officially recognizing a ninth family dedicated to vaults, since Curioni [Curioni 1873, pp. 325-369] extensively treated vaults, like the other families. The cataloguing excludes four models that were present in the 1989 cataloguing but are no longer found in the polytechnic premises. The families are presented in Table 1, which summarises the names, number of models for each class, and reference to Faraggiana's catalogue number. This catalogue number is still used as the basis for the last inventory [Borri Brunetto 2017].

Family	Numbers of models	Current archive numbering
Retaining walls	13	1-13
Foundations/Ground works	21	14-21, 23-34, 116
Centering/frameworks for bridge construction	13	35, 38-47, 65
Bridges	19	48-60, 63, 64, 115, 117, 118, 119
Railways	16	61, 62, 66-79
Tunnels	16	81-95, 123
Building site structures/ machines	9	96, 97, 99-105
Hydraulic constructions	7	109-114, 121
Vaults	25	v1-v25
total	**139**	

Tab. 1. Families of Curioni's models with model listing.

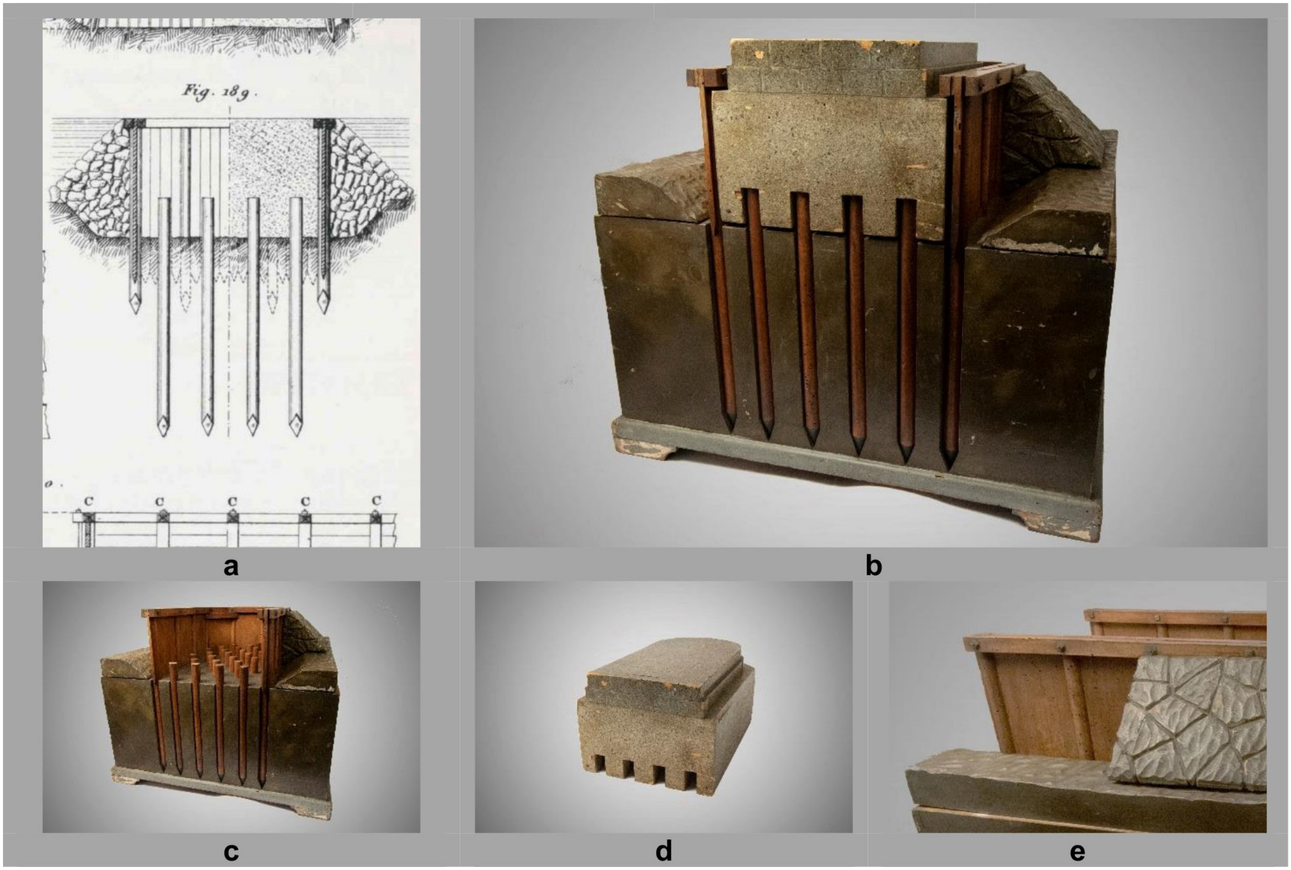

Fig. 2. Retaining walls with arches. a) Curioni 1870. Tab. XIV; b) m.12, dim. 245 x 375 x 190 mm; c) m.13, dim. 240 x 375 x 190 (graphic elaboration by M. Pavignano).

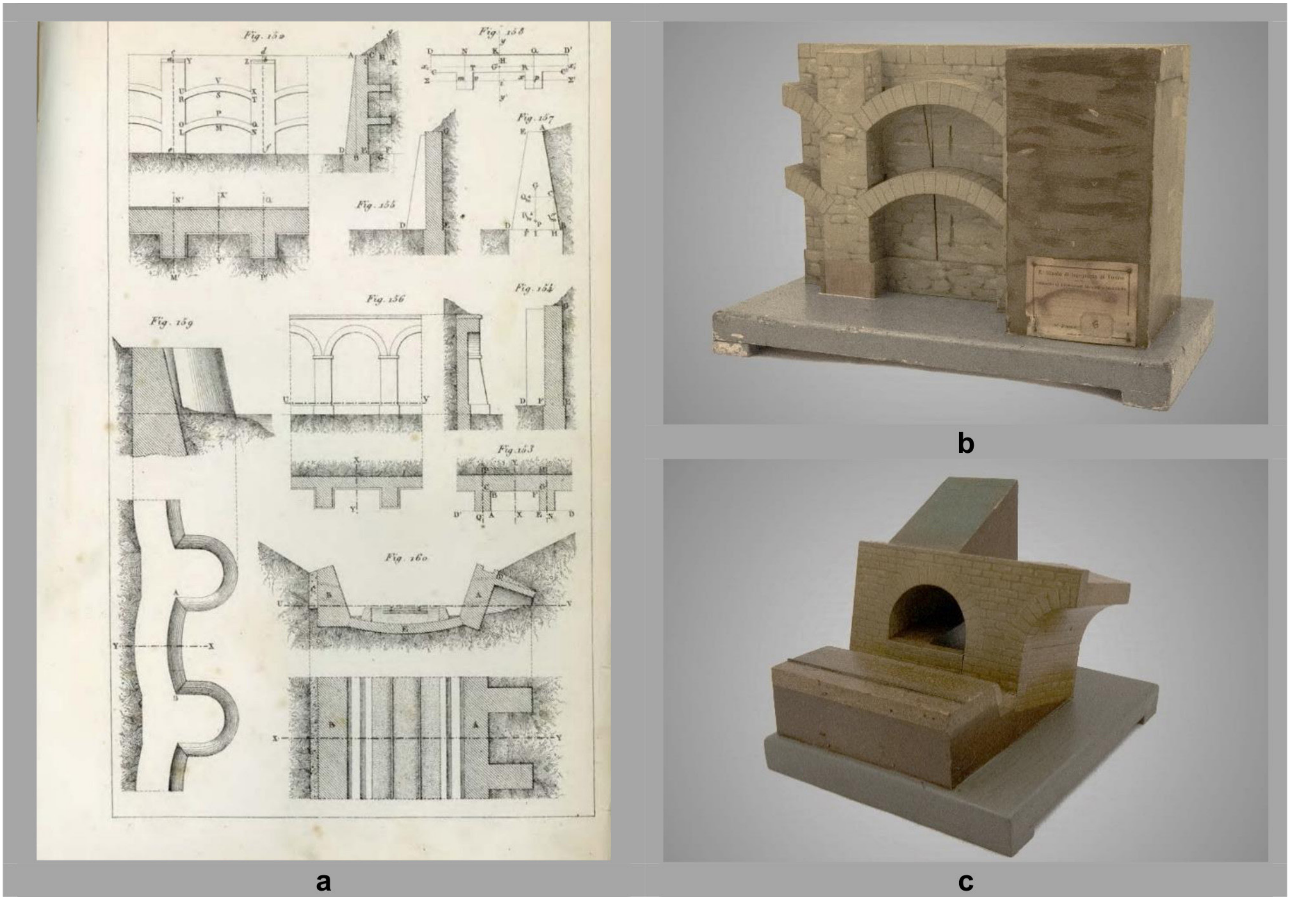

Fig. 3. Foundation with formwork and piling. a) Curioni 1873, Tav. XVII, detail 189; b) m.23, dim. 495 x 580 x 585 mm; c, d) m.23 dismantled; e) use of metal parts (graphic elaboration by M. Pavignano).

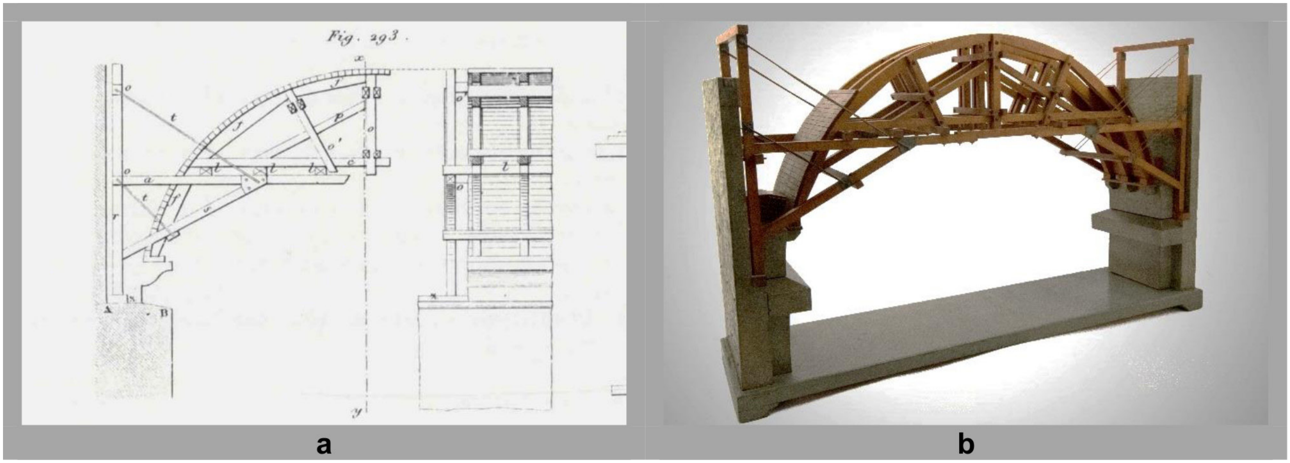

Fig. 4. Complete suspended framework with its hardware. a) Curioni 1873, Tab. XXIV, detail of figure 293; b) m.43, dim. 460 x 760 x 205 mm (graphic elaboration by M. Pavignano).

The new cataloguing, which is based on the recognition of the visual value of the tangible representation as well as on the typological and/or structural characteristics of the modelled artefacts, is not a rigid tool and is open to modification and addition, as some artefacts may belong to more than one family. For instance, models 58, 59, and 60 were described in 1989 as single-arch wall structure bridges for single-track railway. They were included in the family of Bridges rather than railways because they do not represent the tracks, but only the structures (arches, walls) of the bridges. However, such models may be included in the Railways family, depending on their preferred communicative value.

From *L'Arte di Fabbricare* to the model

The visual value of these models, that are heritage of our Politecnico, as tangible declinations of the statutes of representation (Ugo 2008) can now be discussed. It is important to note the reciprocal relationship between the drawings proposed in the figures of *L'arte di Fabbricare* and the models realized by the craftsman Giuseppe Blotto. Most of the artefacts reveal their conceptual derivation from the illustrations of Curioni's manual.

Starting with the family of Retaining walls, Curioni extensively covers this topic in Part Two, Chapter II, which is dedicated to Road Constructions, in the volume on General Works of Civil, Road and Hydraulic Architecture (*Lavori generali di architettura civile, stradale ed idraulica*), which we are here referring to the 1870 edition of Curioni's work [Curioni 1870, pp. 265-303]. Plates XIII, XIV and XV, as well as figures 136 to 144, referred to by Curioni [Curioni 1870, p. 266], illustrate possible wall sections for different configurations of internal and external elevations. Figures 145 to 151 illustrate the sections of four walls between a pair of buttresses. The internal buttresses in figures 145, 146, and 147 do not correlate with the orthographic projection planes, requiring an effort of imagination or integration of another visual support. Models 1 to 5 depict walls with internal buttresses (fig. 1) [5] and illustrate the connection between the vertical and horizontal sections (that are orthographic projections) of the manual. The artefacts are made of wood covered with a smoothing material and feature uniform pictorial finishes, reminiscent of walls made of stone blocks and supporting earth volumes. Sometimes the textures evoke technological elements, such as water drains, which are defined on both the inner and outer elevations (figs. 1a, 1b, and 1e) and in the cross section (figs. 1d and 1g).

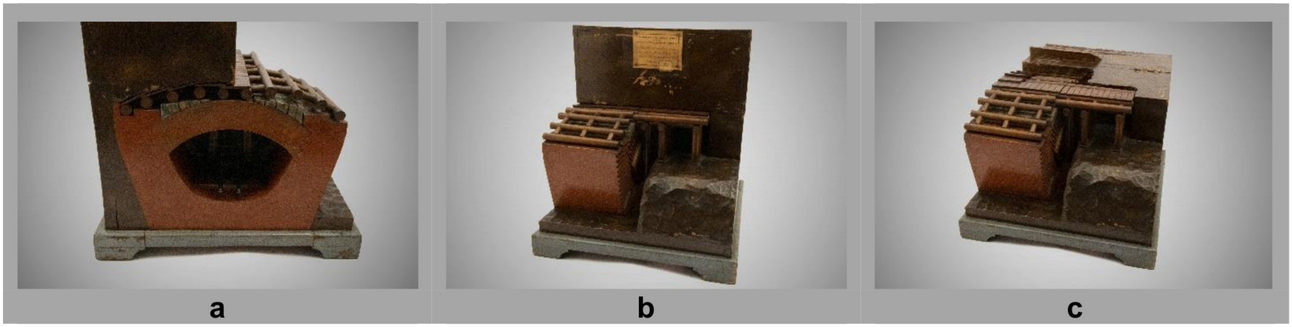

Fig. 5. Framework for tunneling (1st phase), m. 87, dim. 350 x 320 x 325 mm a-b) closed model; c) open model (graphic elaboration by M. Pavignano).

Like the previous models, Curioni highlights the solutions depicted with models 11, 12 and 13 as significant evolutions of the period [Curioni 1870, p. 267]. Model 13 (fig. 2c) is a retaining wall with inclined piers and superimposed arches, which Curioni suggests is a suitable structure for the support of an open trench in compressible and mobile terrain [Curioni 1870, p. 303]. The model section does not display an important aspect of the structure, which is the inverted arch located under the embankment connectingtwo opposing walls. The section only shows the ground, embankment, and wall texture of the retaining structure, including the ashlars of the arches.
A similar method to Model 13 is found in the artefacts devoted to foundation structures. These are discussed in detail in the 1873 update of the volume devoted to civil, road and hydraulic architecture. Tables XIV, XV, XVI and XVII include explanatory illustrations of the content described in Article III. Chapter V discusses the Hydraulic Foundations (*Fondazioni idrauliche*). Model 23, which can be found in figure 189 of table XVII, is of particular interest. The foundation includes formwork and piling, as described by Curioni [1873, p. 271] (see figs. 3a, 3b). The artefact is made of multiple materials and can be disassembled into two pieces (figs. 3c, 3d). It mainly consists of pieces of wood that are painted differently to represent various components, such as piles, planks of the formwork, earth, concrete, and the base of the pillar. Additionally, small bolts with metal nuts are used to indicate the mechanical joints between the formwork beams and planks (see fig. 3e). The foundation soil profile, piles, and formwork structure adhere to the drawing presented in figure 189. However, the model includes two additional aspects. Firstly, it contextualizes the planimetric shape of the formwork with a semicircular course at the head. Secondly, it represents the base of a bridge pier, as specified in the textual description [Curioni 1873, p. 271].
Chapter VIII deals with reinforcement for bridge construction. Article III discusses frameworks and centring [Curioni 1873, pp. 419-424]. Model 47 is of great interest; it is a suspended composite centring with hardware. Two projection planes of the model can be found in figure 293 of Table XXIV. The artefact completes the representations that depict just a half of the structure, and materializes its three-dimensionality, allowing a better understanding of the spatial complexity of the structure (fig. 4).
Some models can be disassembled or have kinematics that allow them to be opened up, thus revealing certain internal details, as already mentioned in relation to model 23 (fig. 5). For instance, in model 87, which pertains to reinforcement for tunnel construction during the first phase of attack with a reinforcement arch, it is feasible to relocate the section of the ground supported by the centring, thereby exposing the planking for viewing. The textures of the wall sections are distinguished from the floor and wooden structures in this model by surface painting.
Finally, the wooden models of the vaults (fig. 6) are of great interest. They are discussed in Chapter VII [Curioni 1873, pp. 325-369] and illustrated in Tables XXII to XXVI. In this case, all vaults are described by two projection planes, and the textual descriptions provide the spatial genesis in terms of descriptive geometry applied to the structure to be designed, as in the case of the barrel vault with pavilion head and lunettes. The description of the geometry consistently

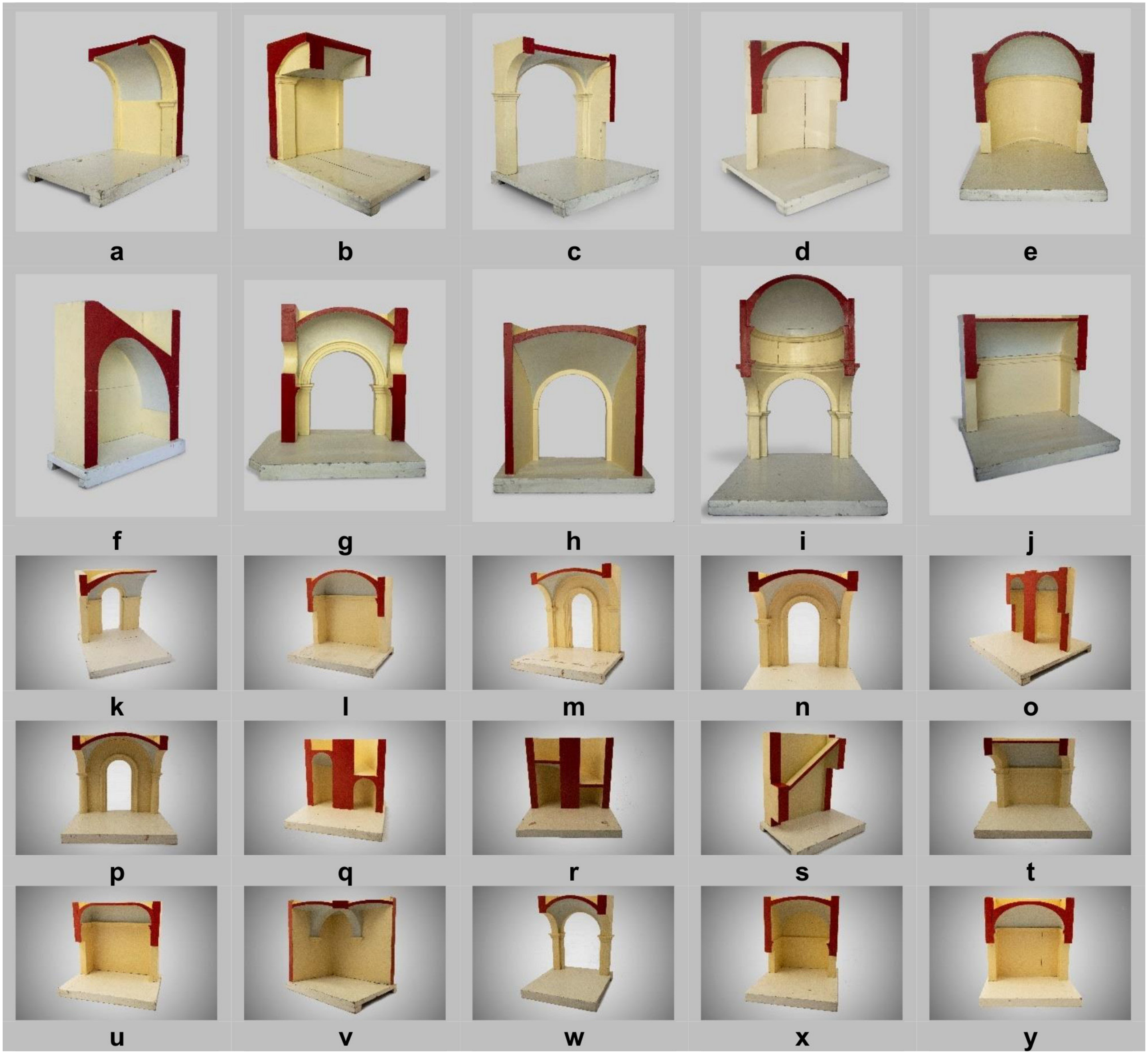

Fig. 6. Vault models, whole family (graphic elaboration by M. Pavignano).

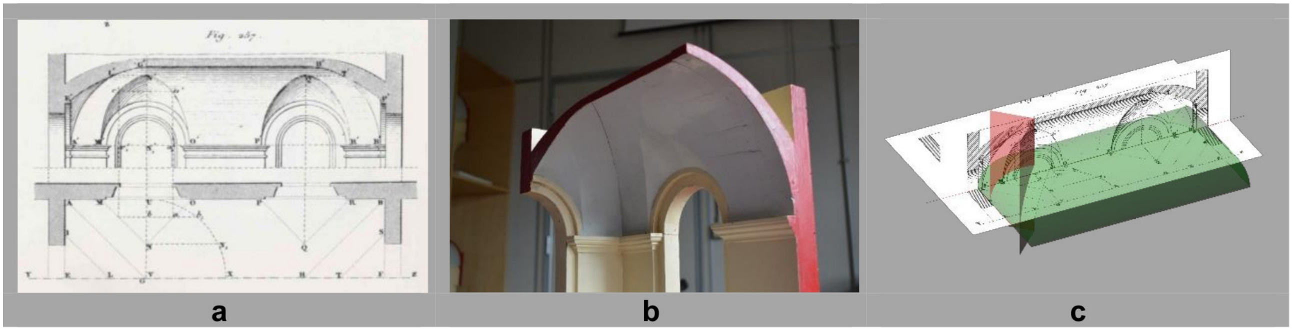

Fig. 7. Barrel vault with pavilion head and lunettes. a) Curioni 1873, Tab. XXV; b) m.123, dim. 345 x 360 x 300 detail (picture by M. Pavignano); c) Geometric interpretation (drawing and graphic elaboration by M. Pavignano).

refers to the data annotated on the drawings, following the method used by Guarini [Spallone 2018, pp. 816, 817] (fig. 7). Such models all have a finish with uniform colours, which are used to differentiate the supporting structures (masonry) from the vaulted surfaces and to highlight the vertical sections.
Based on the preceding discussion, it can be concluded that Curioni aimed to achieve a closer visual and geometric correlation between different types of representations, preceding Paul Deschamps, who later became the director of the *Musée des Monuments Français*, by half a century. Between textual descriptions and, in particular, the words depicted in the illustrations of *L'arte di fabbricare* and didactic models [Gay 2016a, p. 126], there is an advocacy for the 'imaginative dramatisation' that is of fundamental importance for the didactics of architectural and engineering facts [Gay 2020, p. 73].

The digitisation process: from drawings and material models

The field of research that involves the application of 3D digital survey and modelling to museum collections or archaeological artefacts is continuously developing. Its principles are based on the communication, sharing, and dissemination of knowledge of objects that may not always be accessible to users.
The digitisation of the Curioni collection models has been motivated by several needs. The primary need is to create a digital catalogue of 3D models that includes all data and metadata related to the artefacts. Additionally, the digitisation allows for analysis and study of the models without the need for direct physical contact, thus eliminating the risks associated with damaging the original artefacts. Simultaneously, the ability to create a database of 3D models that can be navigated, measured, and examined satisfies various modes of use and interaction, reaching all target users interested in the artefacts. The type of experience can be customized according to the user.
The digitisation project was carried out in several stages, following the guidelines for the use of information and communication technologies (ICT) in the context of Cultural Heritage. The processes of digital reproduction aimed to maintain a high level of morphometric and visual fidelity to the real object, while preserving the scientific integrity of the data [Picchio, Pettineo 2023]. The creation of digital twins was initiated through four different strands of representation and digitisation techniques (fig. 8). The first strand was based on range-based techniques for acquisitions. Due to the peculiarities of the models, two different instruments were used initially. Numerous scientific publications [Allegra et al. 2017] have shown that the final geometry resolution acquired through various survey tools and representation techniques depends on several factors [4]. The Mantis F6 structured light laser scanner was used for more complex objects, while the low-cost lidar scanner supplied with the iPhone 13 Pro was used for less complex models.

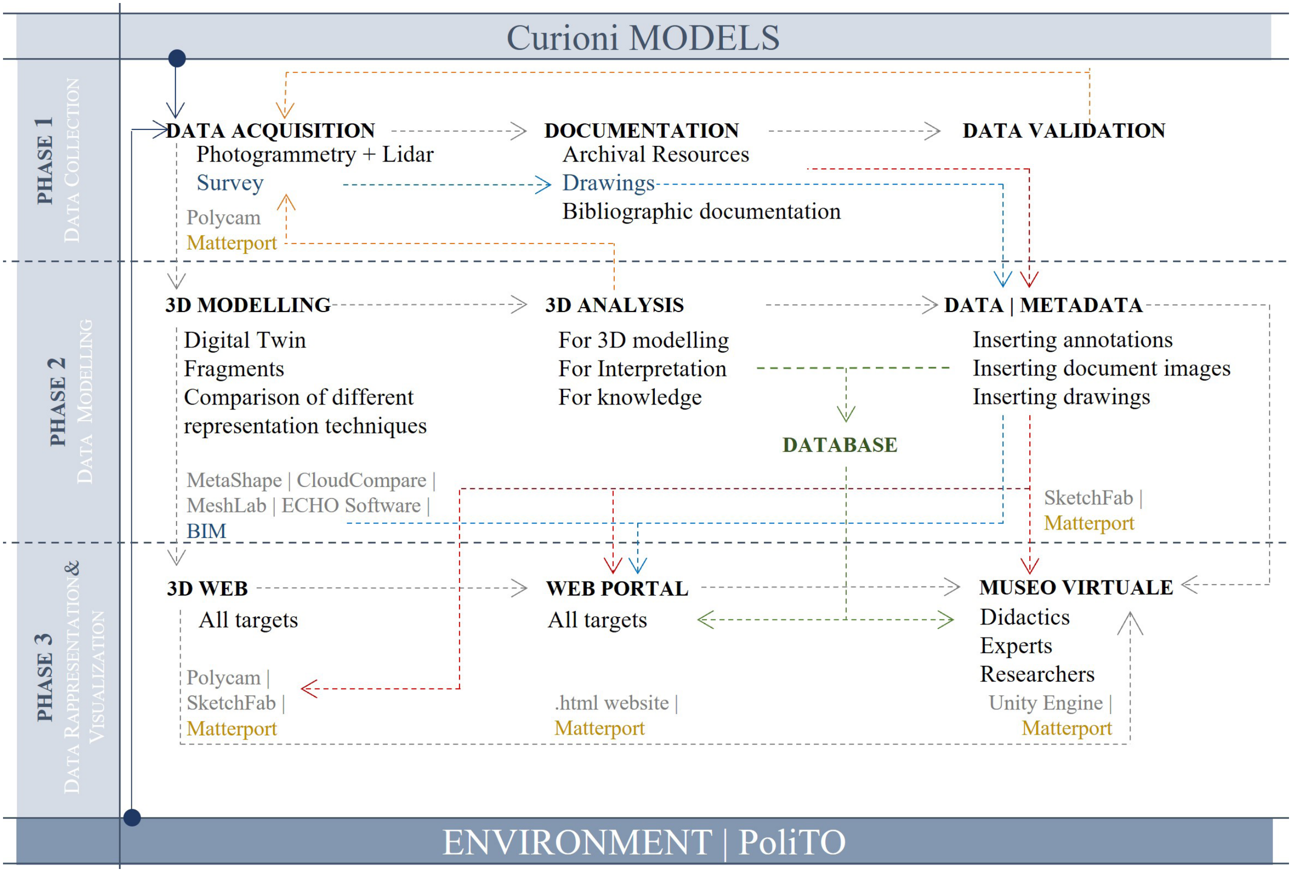

Fig. 8. Methodological workflow for the digitisation of the virtual museum - digital models and museum environments of the Politecnico di Torino (graphic elaboration by M. Vozzola).

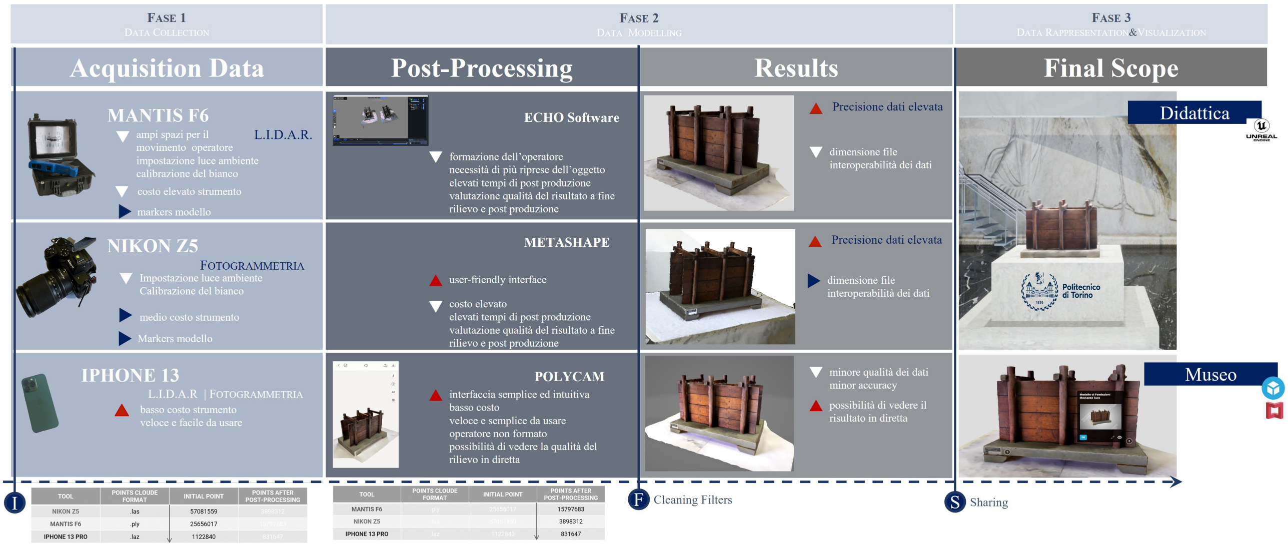

Fig. 9. Comparison of acquisition techniques and results obtained (graphic elaboration by M. Vozzola).

Both procedures enabled the creation of a virtual model from a point cloud. The first method involves exporting to appropriate processing and modeling environments, while the second method involves using dedicated apps like *Polycam*. These apps allow for sharing the model in web environments like *Sketchfab* or exporting point clouds to suitable computing environments (6). The second method of acquisition utilised image-based techniques, employing a Nikon Z5 digital camera with calibrated 18-55 mm lenses to produce a detailed three-dimensional model with high-resolution textures. The third method involved a direct survey of the physical model using analogue tools, from which all geometric data of the elements were deduced to create the parametric virtual model in a BIM environment. The previous modelling method involved directly reading the manual drawings of engineer Curioni. This allowed for the deduction of information and geometric data to create a parametric virtual model in a BIM environment [Bocconcino et al. 2023]. The processes and final models obtained from the first two acquisition methodologies were analysed (fig. 9). To evaluate the optimal solution in terms of tools, the cost ratio will be analysed. This is understood as the ratio between execution and operator knowledge. Additionally, the quality of the collected data will be assessed in terms of quantity and quality, linked to the acquisition times and interoperability in the input phase. The optimal solution will depend on the final quality of the model, metadata, and processing times. Above all, it will depend on the level of interoperability and sharing of the final virtual model in order to speed up the entire acquisition and/or modelling flow.

The above shows that to comprehend the best workflow for acquiring models, it is crucial to understand the desired representative quality of the virtual model. Different digital models, obtained through various acquisition and modelling techniques, serve different narrative and informative objectives, catering to users from diverse fields of knowledge and belonging to different processing/sharing environments. The main objective of this research is to create a path for digitizing models, enabling communication between drawings and models [Parrinello et al. 2022]. The aim is to define a language that can explain information and alphanumeric data to end-users. The work carried out aimed to digitise and create three-dimensional models of the wooden models for various purposes, with the primary goal of making them accessible to a wider audience.

Fig. 10. Visualization of a wooden vault in a processing environment, including possible paths for knowledge and in-depth analysis through the insertion of data and metadata (models and graphic elaboration by M. Vozzola).

On one hand, the purpose is to document the geometric system of volumes as a teaching and experimentation tool for multiple disciplines within the University. On the other hand, the aim is to experiment with new techniques and technologies of interactive navigation and dynamic exploration by creating a virtual University Museum that serves as a container of Polytechnic Culture. Finally, rapid prototyping can be used to create entire physical models or parts of them for direct dissemination. This allows different types of interested users, particularly the academic public, to perceive the models in line with the directives provided by design for all. The previous imperative prohibition on tactile enjoyment of models in museums has been replaced with the more inclusive "forbidden not to touch" [Sdegno, Riavis 2022].

In this context, the methods of preserving and disseminating memory, and sharing and communicating knowledge, are undergoing significant changes. Interdisciplinary training is becoming a fundamental tool for preparing future professionals. The Curioni Collection contains drawings, texts, and models that demonstrate a multifaceted culture from several disciplines. To systematize the knowledge gained from analysing this collection, a digital container has been created to collect, systematize, organize, integrate, and share all documentation. This ensures that the documentary heritage is not exclusive to certain fields or circumscribed within isolated subject areas.

A new narrative for knowledge: from models to collections

The presented research places cultural storytelling at the heart of communication. This is understood as the relationship between the cultural asset and the user, which serves to transmit, reinterpret, and translate the communicative vocation inherent in an artefact. Additionally, it highlights the multiple stories contained within the artefact [Dell'Amico et al. 2023]. The museum, whether populated with virtual or real objects, is transformed from a storage and exhibition of artefacts from the past into an open and interactive space. Visitors are involved in a dialogue and interaction that updates the use of virtual museum resources in the educational process. This allows users to have their own cognitive experience. The research aims to address the absence of a fixed museum structure that is always accessible for the direct exploration of the Curioni collection. To achieve this, a virtual museum was created based on the design of user-centred environments and contents. The approach involved a balanced combination of different types of representation, including 360° views, 3D virtual models, video art, and descriptions. The language used is clear, objective, and value-neutral, with a formal register and precise word choice. The text adheres to conventional structure and formatting features, with consistent citation and footnote style. The sentences and paragraphs create a logical flow of information with causal connections between statements. The text is free from grammatical errors, spelling mistakes, and punctuation errors. No changes in content were made. The purpose of this initiative is to promote and raise awareness about the importance of conserving, protecting, and promoting cultural heritage, particularly through the digital transformation and reuse of 3D digitized cultural heritage. This is in line with the work of Debuch et al. [2024] as shown in fig 10.

Different versions of the same digital object have been developed for various platforms and sharing environments. These versions cater to different levels of communication and in-depth analysis. One such version has been developed in *Unity Engine*, which configures an educational museum. Here, the user can query the model, measure it, read the associated metadata, and enter gaming mode to answer educational questions. To ensure maximum accessibility for users, a second *Sketchfab*

Fig. 11. The image shows the laboratory for testing materials in the Sala delle Colonne of the Valentino Castle. The Sala delle Colonne (Castello del Valentino, historical headquarter of the Politecnico di Torino) is currently being surveyed using an INSTA360 ONE RS camera (graphic elaboration by Mariapaola Vozzola).

virtual environment has been created. Here, users can view and query the model, accessing all associated data and metadata. Finally, we are using indoor mapping techniques to recreate the rooms where the Curioni models were preserved and to place them back into the context in which they were experienced by the students of the former *Regia Scuola di Applicazionie per Ingegneri* (now being our Politecnico) (see fig. 11). *Matterport* technology was utilised to create the museum 'container'. This offers a web platform that enables users to create and share immersive 3D models of physical spaces. It is particularly useful for visualising physical spaces in a virtual environment. Users can insert tags, not links, to external models and/or data and metadata describing the artefacts exhibited in the museum. The creation of one or more environments on the university campus dedicated to the models preserved at DISEG offers new possibilities for the use of virtual environments. These environments can replicate the original settings in which the models were preserved for years, providing an unprecedented mode of use that is no longer passive, but active, interactive, and participatory [Giovannini 2023].

Conclusions and future developments

The study demonstrates that the potential of physical models also lies in the close connection between the theoretical object to be represented through the relevant artefact. Still, the study reveals that "in three dimensions, we can model a solid shape by making an object whose surface is this surface. We can model a two-dimensional surface by making an object whose surface is this surface" [Müller 2009, p. 654].
Placed in their original context, Curioni's models seem to evoke a need for "deferred construction" [Ragazzo 1994, p. 408], which not only supported technical thinking but also instilled in the minds of the students at the *Regia Scuola di Applicazione per Ingegneri* the possible *libido aedificandi* of Albertian memory. In this sense, it is immediately noticeable that there is a clear break in the aesthetics of the models. The vaults reproduce purely theoretical elements and are not characterized by a camouflage appearance. They are limited to the definition of neutral artifacts, where the only chromatic dissonance is between the white of the wall volumes and the red of the sections. This completes the reading with meaning.
The aspects highlighted mainly concern the taxonomic analysis of the wooden models, the cognitive and operational tools used and compared, and the methods for creating parametric digital models that operate within internal information systems and integrated consultation and navigation environments.
The disciplines of visual and graphic analysis and representation are closely linked to the integration of current practices for the preservation, re-use, and dissemination of collections. It is possible to implement

cataloguing sheets that conform to technical regulatory frameworks and include design-specific aspects such as scale of representation, thematic content, functions of individual parts and the whole, material aspects, and methods of assembly and disassembly for restoration and conservation. This will allow for multidisciplinary interrogation filters.
Finally, it is important to highlight that the Collections of our Politecnico are essential testimonies of the 'polytechnic thought' and its constitution. They serve as true "memory repositories" of the Institution [Pagella 2009]. The Curioni models were designed for dynamic and tactile consultation by the student engineers of that time. By 'framing' them in a material and digital display, their original function is transformed. However, digital consultation expands the scope of exploration for the model, with cross-references to complementary textual and graphic information that enable specific in-depth analysis of both general themes and detailed parts and elements. This aspect may encourage the re-use of certain physical examples, as the models or their replicas, or specific parts of the model relevant to the fields of design, structural analysis and visual representation and communication, may be included in the classroom.

Credits

Although the contribution was conceived jointly, M. M. Bocconcino is author of paragraphs *Introduction;* M. Pavignano is author of paragraphs *Curioni collection: a critical exploration* and *From* L'Arte di Fabbricare *to the Model*; MP. Vozzola is author of paragraphs *The digitisation process: from drawings and material models* and *A new narrative for knowledge: from models to collections*. The authors wrote together the paragraphs *Conclusions and future developments*.
Pictures in figure 1, 2, 3, 4, 5, 6 are courtesy of Politecnico di Torino, Ufficio Gestione del Patrimonio Storico dell'Ateneo (arch. M. Bongiovanni).

Notes

[1] In 2000 twelve European universities signed the Halle Declaration, which gave birth to the network Academic Heritage and Universities, i.e. the Universeum project; one year later the International Council of Museums (ICOM) founded the *Committee for University Museums and Collections* (UMAC); in 2005, again at the European level, the Committee of Ministers of the Council of Europe published the *Recommendation on the Governance and Management of University Heritage*; finally in 2009 a project financed by the European Commission was launched, which led in 2012 to the drafting of the Green Paper on the Third Mission of Universities. In this same period in Italy the Commission of Rector Delegates for University Museums at the Conference of Italian University Rectors (CRUI) is active.

[2] It brings together specific skills and disciplines, under the scientific responsibility of Maurizio Marco Bocconcino and the coordination of Mariapaola Vozzola and Martino Pavignano. In the field of Structural Mechanics Professor Mauro Borri Brunetto; for the responsibility of the cultural and scientific heritage of the Politecnico the architect Margherita Bongiovanni; for Structural Engineering Professors Paolo Castaldo and Fabio Di Trapani, on the sciences of representation and information modelling the Authors of the contribution; on Geomatic and Survey skills Professors Marco Piras and Paolo Dabove; as support for acquisitions and elaborations the DISEG technician Pierluigi Guarrera and the junior civil engineer Luca Gioberti.

[3] The following memoirs contain the main moments of the study work: Bocconcino [2006]; Santagati et al. [2017]; Novello, Bocconcino [2018]; Novello, Bocconcino [2018b]; Novello, Bocconcino [2020]; Bocconcino, Vozzola [2022]; Bocconcino et al. [2023]; Bocconcino et al. [2023b]; Bocconcino, Vozzola, Pavignano [2023c].

[4] Regarding the figure captions, the models are identified by the progressive number of the Faraggiana-Borri Brunetto cataloguing and their dimensions are provided.

[5] The quality of acquired data varies depending on the complexity of the geometry, material properties (e.g. colours of different elements), and ambient light intensity during survey phases.

[6] Due to the unique features of certain models, even those that are small in size, it was necessary to increase the number of scans. For instance, in the case of the 87 model, which is characterized by a kinematic mechanism that enables it to be opened for the purpose of dismantling parts of the model and viewing its interior, both external and internal scans were conducted. Similarly, for artefacts that present specific details, such as model 43, scans were carried out to acquire the entire artefact and its construction details, including the tie rods.

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The Construction of Multisensory Models of Ancient Statuary, between Innovation and Tradition

Luca James Senatore

Abstract

The research focuses on the development of a scientific methodology for the creation of copies of Cultural Heritage without scale reduction, capable of simulating the physical qualities of original materials such as marble, to allow for multi-sensory enjoyment. Using innovative technologies and traditional techniques, the process begins with a massive data survey, identifying a digital reference model. Subsequently, the construction of a 'new original' by 3D printing in PLA and deblocking paves the way for the creation of copies by casting with a cement mixture that can simulate the materiality of marble. The choice of materials, subjected to perceptual and thermal tests, plays a crucial role in the selection of the material to be used to replicate the characteristics of the original. The validation of the geometric results demonstrates the compatibility of the physical models with the research objective. Finally, the study introduces the concept of 'metric reliability level' as an essential parameter for the scientific validation of the results. The research, carried out with the collaboration of the Soprintendenza Speciale Archeologia, Belle Arti e Paesaggio of Rome and the Pontifical Commission for Sacred Archaeology, focuses on the copy of the Head of St. Elena in the Mausoleum of St. Elena in Rome, highlighting the applicability of the proposed methodology in the context of Cultural Heritage.

Keywords: 3D model, Structured Light Scanner, SfM, Head of St. Elena, 3D Printer models.

Introduction

Current 3D printing technologies have substantially modified the construction methods of analog models. Depending on the type of object and the scale of the physical model desired, it is possible to select the most suitable printing technology and support based on the required performance characteristics, offering users a considerable number of possibilities. The market for printing materials has focused particularly on identifying solutions, all based on plastic or resin, which vary substantially in the mechanical qualities of the finished product, but currently, there are no methods that allow for the simulation of the typical qualities of materials used in sculpture. This is not about simulating chromatic properties, which is possible in some cases, but rather about being able to create objects capable of simulating physical qualities, such as temperature and texture of the original material, which would find an interesting application for the multisensory enhancement of many Cultural Heritage assets, especially for the reproduction of ancient statuary.
This contribution focuses on the results of research aimed at defining a methodological and technological solution capable of overcoming this limitation by allowing the creation of copies of Cultural Heritage assets without scaling down and capable of simulating the qualities of the original marble materials. The copies thus produced, precisely because they can reproduce all the characteristics of the original, can find immediate use in

the enhancement field, allowing for a multisensory enjoyment of the assets while ensuring the preservation of the originals [1].
Tradition and innovation meet in this experience that, starting from reality, allows for a return to reality through the creation of a "new original" built with a 3D printer, with which to create a contact matrix to be used as a mold for the construction of a copy through casting, capable of reproducing the material properties of the original object.
Through a structured process that integrates innovative technologies and traditional techniques, the research focused on the entire process of creating the copy, scientifically validating all work phases: from the acquisition of surfaces to the identification of procedures for the realization of copies, to the evaluation of the specific characteristics of the material with which the originals are made to ensure that they are reproduced in the copy, to the identification of procedures for the control and scientific validation of all work phases.
The research, conducted with the contribution of the Soprintendenza Speciale Archeologia, Belle Arti e Paesaggio of Rome and the Pontifical Commission for Sacred Archaeology, describes the activities necessary for the construction of a copy of an archaeological find at a 1:1 scale to allow for broader multisensory enjoyment within the museum path of the Mausoleum of Saint Elena in Rome.

Fig. 1. Head of Saint Elena, IV century, Mausoleo di Saint Elena, Rome (photo by the author).

The case study

The object of the case study is the so-called *Head of Saint Elena* [Inv. PCAS-82] (fig. 1), preserved at the Antiquarium of the Mausoleum of St. Elena, a cultural site of the Special Superintendence for Archaeology, Fine Arts and Landscape of Rome reopened in 2019 after extensive restoration thanks to the Pontifical Commission for Sacred Archaeology, which currently manages part of the exhibition that includes the nearby catacombs of Saints Marcellinus and Peter [Giuliani 2015; Bochicchio 2019].
The Mausoleum of St. Elena is one of the most important architectural complexes of paleo-Christian Rome from the 4th century. Built between 315 and 326, originally intended to serve as a burial place for Emperor Constantine himself, it was later used as a tomb for Flavia Julia Elena, the emperor's mother, who died in 329.
The study aims to physically reconstruct the Head of St. Elena, a marble artifact from Mount Pentelicus that is in good condition. The head consists of a fragment of a face measuring 215 × 213 × 218 mm characterized by a "turban" hairstyle with a large braid wrapping around the hair, divided by a central parting, and folded into regular waves that descend to the nape, hiding the ears.
The study of the artifact, authorized by the Pontifical Commission, is part of a promotional effort initiated in 2021 by the Special Superintendence of Rome for the completion of the Antiquarium of the complex [Giuliani 2016].

The survey

The survey constitutes an essential step for the construction of the database necessary for obtaining a copy, whether it be digital or physical. Much has been written in recent years about the possibilities offered by various mass acquisition technologies applied to statuary objects, with the development of dedicated workflows that exploit Lidar techniques and SfM methodologies. Among the various contributions in the literature, it is useful to mention some studies dating back more than 20 years ago [Levoy et al. 2000; Bernardini et al. 2002; Fontana et al. 2002; Guidi et al. 2004] that allowed for the first time testing the potential of range-based acquisition tools, defining the pipeline [Bernardini, Rushmeier 2002; Godin et al. 2002] and paving the way for their extensive application in the Cultural Heritage domain.
The reasons that have seen attention focused on statue complexes can be traced back to the geometric and formal nature that characterizes statuary surfaces, which are of considerable complexity. Given the sensitive nature of the objects under study, the use of contact surveying tools is not applicable, and this fact has led to the development of techniques suitable for collecting a considerable amount of data necessary for understanding the surfaces themselves. Experimentation began around 2000 with photogrammetric techniques, which, although not yet able to extract a significant number of homologous points in space from pairs of photographs, already highlighted the potential of these methodologies for the construction, albeit simplified, of free-form surfaces [Grün et al., 2002]. Certainly, some early discussions on the potential use of images for building 3D models [Curless 2000] led in the first five years of the 2000s to the definitive development of Visual Structure from Motion techniques [Szeliski, Kang 1993] capable of reconstructing complex 3D artifacts, sparking discussions on the use of active or passive systems for small artifacts [Remondino et al. 2005] and leading image-matching techniques to be an effective alternative to range-based systems [Remondino et al. 2014]. These experiments have allowed the implementation of a now established surveying process applied in multiple fields of Cultural Heritage. These boundary conditions define a complex research framework that motivates the numerous experiments in the field of statuary.
In this context, the research fits in, building on the information obtained from some previous experiences [Russo et al. 2022], aiming to define scientific parameters for the construction of the database and for result validation. Considering the objective, namely reproduction without scale reduction, attention has been focused on identifying control parameters and threshold values capable of ensuring the best metric reliability for all models. The parameters considered were point accuracy (with a threshold value of 0.1 mm) and point cloud resolution (with a threshold value of 0.2 × 0.2 mm). These values have been shown to be achievable both in the acquisition and printing phases [2] (fig. 2).
For the acquisition carried out within the Antiquarium (fig. 3), two different survey methods were tested: using SfM technique and Structured Light Acanners [3].

The SfM methodologhy

The Structure from Motion (SfM) methodology represents an effective solution both in terms of time and logistics. The ability to take a considerable number of shots allows for the construction of high-detail models, namely point clouds with resolutions even lower than a tenth of a millimeter, and therefore compatible with threshold values.
The use of this methodology has allowed the attainment of a point cloud model quantitatively compliant with the project's threshold values. For scaling the point cloud, a cloud-to-cloud comparison was performed with a

Fig. 2. Results of the acquisition phase: on the left, textured point cloud model obtained with SfM; on the right, textured point cloud model obtained with structured light laser (graphic elaboration by the author).

model whose reliability is compatible with the project parameters. Since it's not possible to interact with the original artifact using contact instrumentation with accuracies lower than a tenth of a millimeter, it was decided to use the model created with structured light scanning as a reference, with instrumental reliability declared at 0.1 mm and a resolution of 0.2 × 0.2 mm. The construction of the interpolation mesh surface of the point cloud highlighted the limitation of this methodology, particularly due to the presence of a large amount of noise, especially in areas where the original surface was smooth.

The structured light scanner

A second scanning activity was carried out with a handheld structured light scanner [4], considering the variable acquisition distance, which can be estimated at 0.2 mm and capable of producing a point cloud with a mesh of 0.2 × 0.2 mm. The use of this tool allowed for the construction of a reliable and metrically reliable model with accuracy consistent with the study's requirements. The analysis of the resulting point cloud from the acquisition highlighted an almost total absence of noise, with positive effects for the subsequent mesh surface processing. The best results were evident in the definition of smooth surfaces that the instrument can recognize and discretize with a very low level of noise. Precisely due to its geometric characteristics, the models created from the database obtained with this instrument –both point clouds and meshes– were considered "Gold Standard" in all validation activities of the various phases of the research. Due to the better quality of the mesh surface, the model generated from the data acquired by the structured light scanning was used in the 3D printing phase for the creation of the "new original".

Fig. 3. The acquisition phase carried out after setting up a set at the Antiquarium of the Mausoleum of Saint Elena (photo by the author).

The construction of the copy: from the real to the real through the digital

Once the digital mesh model of the original object was created, it was possible to construct the physical model with 3D printing. Among additive manufacturing technologies, filament printing was preferred using a Delta Wasp 4070 loaded with white polylactic acid (PLA), extruded with a 0.4 mm nozzle, and set to produce slices of 0.2 mm. The *Fused Deposition Modeling* (FDM) technology was chosen particularly because currently this solution is the only technology capable of reproducing objects of considerable size and therefore potentially the only one usable for the construction of copies of large statues (fig. 4).
Once the PLA copy was built, it was subjected to sanding (fig. 5) with a mixture based on calcium carbonate and resin applied with a brush to eliminate the ridges typical of the slicing process. The result of this operation allowed the definition of a new original with which traditional techniques for constructing copies by contact could be applied. Specifically, a mold was created using silicone rubber capable of adhering perfectly to the surface of the new original to produce a negative to be used for the elaboration of the final copy (fig. 6).
Once the silicone rubber was made and the mold reassembled (fig. 7), the physical copy was then made by pouring a cement-based mixture selected according to the desired material effect to simulate the material of

the original.

The materials for the construction of the copy

The choice of materials to be used in the casting operation inside the silicone mold was a substantial part of the research due to its key role in the perceptual characterization of the copy [Senatore et al., 2022]. Among the characteristics capable of qualifying a surface, texture to the touch, resistance to abrasion, hardness, permeability to liquids and fats, and heat dispersion capacity were evaluated. For the assessment of the specific qualities of the possible solutions for the mixture to be used in reproduction, samples were constructed with two different binders, one cement-based and one resin-based, to which marble powder was added in various percentages. The samples were subjected to tests to qualify them in relation to the parameters previously defined.
At the same time, the same control tests were carried out on some original pieces made of clay or marble material to create references for comparison (fig. 8).
The verification revealed some common properties among the samples in relation to the binder used:
- mixtures with a high resin content were characterized by excellent resistance to external agents, good wear resistance, good elasticity, and excellent insulating capacity, meaning they could retain heat for a long time. Perceptually/tactilely, the samples showed almost no texture. Further investigation regarding heat dispersion capacity revealed that, under similar environmental conditions, resin-based materials took up to 5 times longer to disperse a certain amount of heat compared to stone, leading to the perceived sensation of warmth when in contact with plastic surfaces;
- cement-based mixtures showed lower resistance to external agents with wear-related issues, partial permeability to liquids and fats, greater rigidity, and good heat dispersion capacity. Perceptually/tactilely, the samples exhibited a texture stone-like. A specific study of the thermal capabilities of the materials identified some mixtures with heat dispersion similar to that of stone and marble;
- for cement-based mixtures, it is possible to improve resistance to external agents by applying a resin-based film at the end of the drying process, thereby modifying heat dispersion capabilities.

Once the comparison values were determined by measuring the same parameters on the original objects, it was possible to compile a list of solutions classified according to their ability to reproduce the characteristics of the originals. These solutions could be used as needed for the different materials for which a physical copy was required (fig. 9).
Considering the haptic use of the new copy, i.e., the copy's ability to tactually convey the sense of the original material to the user, the choice of material for casting fell on a mixture (sample 5) based on cement and marble powder with properties that closely resemble those of the original marble.

The validation of the geometric results

All models obtained, both digital and physical, underwent metrological verification by comparison with the reference digital model identified in the structured light

Fig. 4. 3D printing: on the left, the printing process; on the right, detail of the surface: the typical steps of the production process are evident (photo by the author).

Fig. 5. Blending: on the left, the new original obtained with blending; on the right, detail showing the elimination of the steps from the printing process (photo by the author).

Fig. 6. Construction of silicone molds starting from the new original (photo by the author).

Fig. 7. The reconstructed mold ready to receive the cement and marble powder mixture for the construction of the copy (photo by the author).

scanning of the original object (Gold Standard). For the physical models, a new survey was conducted using the structured light scanner. To verify the actual instrumental response to the case study, no smoothing or filtering algorithms were applied to the digital models used for comparison.
The different models were imported into the CloudCompare program, and after performing the rotation-translation operation without scaling, deviations between the individual models were analyzed. Each model was used at its native resolution, avoiding the introduction of decimation processes that could affect the model's shape and thus preserving the detail obtained during acquisition.
From the metrological comparison, several considerations emerged. Overall, the discrepancies between the different models were extremely small and not significant. Regarding the SfM methods, it emerged as an extremely reliable technique for geometric and radiometric detection, albeit with considerable levels of noise detectable, particularly for portions of extremely smooth surfaces. The application of a smoothing filter was discarded due to the variations in the nature of the surfaces that would have affected the result.
Regarding the comparison between the reference digital model and the physical models, both the one in PLA with subsequent sanding (matrix) and the one made for casting, it was noted that the various production steps introduced geometric variations that were quantitatively insignificant, except for specific abrupt changes in orientation or for the presence of significant depth variations. In general, the difference between the physical models and the Gold Standard was found to be compatible with the research objective, as evidenced particularly by the standard deviation data, which was found to be less than or equal to 1 mm for all models (fig. 10).

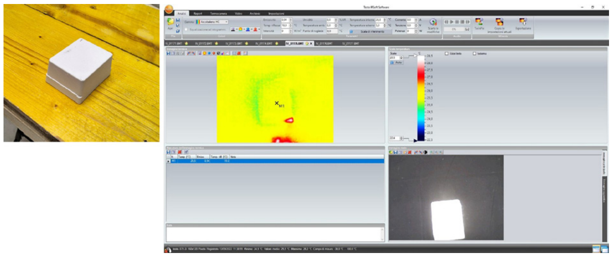
Conclusions

The study aimed to identify a scientific no-contact methodology for creating copies of Cultural Heritage artifacts without scale reduction, consistent with the originals both metrically and materially, aimed at multisensory fruition.
Current production methods still have a series of technological limitations that do not allow for the automated construction of this type of artifact, which could have enormous benefits for the conservation and valorization of Cultural Heritage items within collections and museum

deposits. To overcome this limitation, the study, integrating innovative technologies and traditional techniques, has demonstrated how the construction of copies capable of reproducing the form, texture, and material of the original is possible (fig. 11).
Simultaneously, the research sought to define some objective parameters based on which copies and models can be scientifically validated. This aspect, relevant when activating digitization processes, becomes a priority when it is necessary to construct an object at real scale. To this end, the study considered the level of metric reliability, a quantitative scientific datum that can be considered as the amount of information necessary to ensure the reliability of results, usable both in the construction and validation phases. In the past, the amount of information provided by a model was inherent in the concept of scale and represented an essential reference for evaluating the quality of a product. The ability to build digital models has introduced new complexities in defining the level of quality, requiring the determination of new parameters for controlling results –the level of metric reliability, a parameter closely linked to acquisition and production technologies– has proven to be a valid tool for validating processes and results.
The research has shown that operating in the field of digitization, only the construction of a system of parameters for the scientific evaluation of products will allow adequately considering the quality of models, and this attention is desirable to become a practice not only in the context of the study described here but, more generally, whenever a digital model is constructed, in order to qualify it and simultaneously to give value to the information that can be derived from it.
Regarding future developments, the study presented here has demonstrated the possibility of simulating objects made of earthenware and marble, and activities are already focusing on identifying a low-cost strategy capable of reproducing the texture and temperature of metallic objects, expanding the possibilities of constructing copies to all artifacts characterized by this type of material. In parallel, due to the close relationship between physical copies and the instruments used in the process of digitization and 3D printing, the study is focusing both on improving the accuracy levels of different models and on identifying technological solutions capable of automating the process of constructing the copy, minimizing human interaction to improve accessibility to the use of copies in the context of Cultural Heritage valorization.

Fig. 8. Test with thermocamera on samples for the evaluation of the return time to ambient temperature of the material following contact (photo and graphic elaboration by the author).

Fig. 9. Evaluation of the return time to ambient temperature of the mixture samples for comparison with the material of the original. The y-axis indicates the temperature in degrees Celsius, and the x-axis indicates the time in seconds (graphic elaboration by the author).



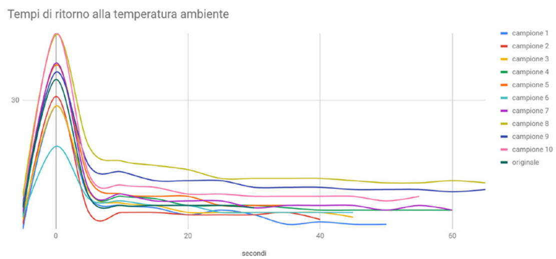
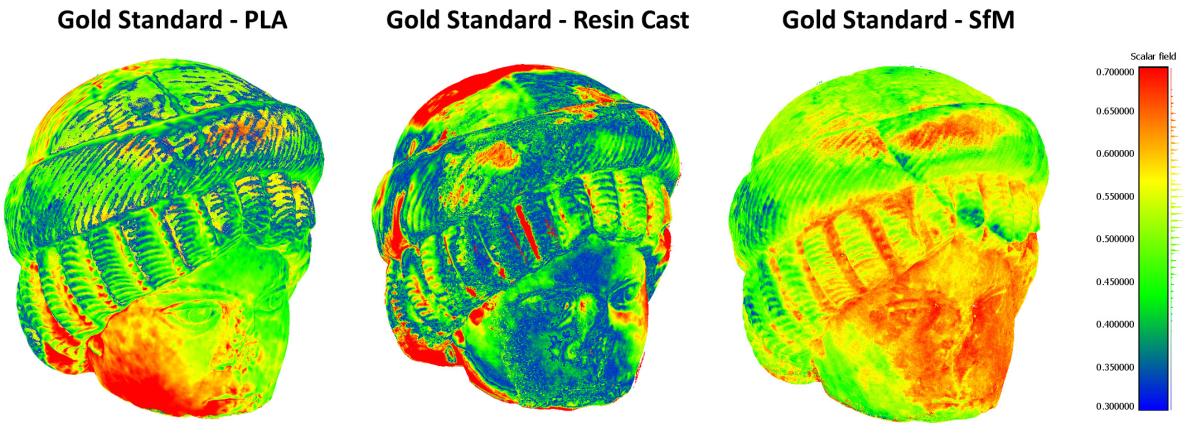


Fig. 10. Comparison and deviation in mm: Gold Standard - PLA physical copy; Gold Standard - Cast physical copy (graphic elaboration by the author).

Fig. 11. The new copy made by casting (photo by the author).



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Notes

[1] The proposal, using non-contact methodologies, complies with current legislation, particularly the limitation imposed by the Code of Cultural Heritage, Art. 107 paragr. 2 of Legislative Decree 42/2004, which prohibits the construction of copies of works subject to protection using traditional contact techniques.

[2] - The contribution constitutes the concluding summary of the results of a long research activity funded by the University of Rome Sapienza (Seed PNR 2022 and 23 Call for Proposals), with the undersigned as PI. Over time, some of the partial results achieved during the study phases, which are systematically and organically presented here, have already been published in national and international conferences. For specific insights, please refer to the bibliographic references present in the text and bibliography.

[3] Reference is made specifically to filament printers, which currently represent the only operationally feasible solution to produce large-scale copies. Although of significantly higher quality with the ability to create submillimeter layers, resin printers are still limited to objects no larger than 30x30x30 cm, incompatible with most Cultural Heritage artifacts. At the same time, filament printers allow the construction of objects, including considerable dimensions, which can reach, in some industrial versions, a size of 1x1x1 m.

[4] The choice of sensors did not include the use of terrestrial laser scanners due to the impossibility of obtaining point clouds with reliability compatible with the project's defined requirements.

[5] Scans were performed using the Skantech Ireal 2S capable of producing a point cloud with a resolution of 0.2x0.2 mm and point accuracy of 0.1 mm. The instrument is specifically designed for body scanning. This feature, along with the presence of dedicated optimization filters, proved to be a significant advantage in constructing an orderly and optimized point cloud, which was effective in building a mesh surface describing both smooth and rough surfaces.

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Architectural Models for Tactile Perception

Alexandra Fusinetti

Abstract

The article discusses the role that physical models play in the process of incorporating and breaking down perceptual and cognitive barriers in the communication and representation of historic-architectural heritage, also in relation to what international conventions and more recent regulatory guidelines indicate.
In addition to the historically well-established purposes of the model as a design aid, other purposes have been added, such as providing a better understanding of spaces within orientation systems.
In the field of cultural heritage enhancement, the use of the physical model is cited by several guidelines as a useful element in improving accessibility conditions for different types of users.
The analog model can address both the 'haptic narrative' of the state of affairs and the narrative of hypothetical reconstructions of the same, thus being able to 'speak' not only to people with visual or cognitive disabilities, but to the totality of users.
In this regard, the article illustrates a series of case studies that use the analogous model of architecture to overcome the role historically assigned to these artifacts, which involved an exclusively visual perception, by opening them up to a new level of sensory perception capable of increasing the degree of inclusiveness.

Keywords: accessibility, cultural heritage, perceptual barriers, communication, universal design.

Introduction

Cognitive and perceptual accessibility is a fundamental building block for the effective and inclusive communication of cultural heritage. In fact, it aims to remove the barriers that hinder the understanding and enjoyment of heritage by people with disabilities, the latter understood as the set of conditions that hinder people's participation in society due to the presence of barriers of various kinds [Menchetelli, Melloni 2023].
There are several conventions and regulations that address the issue of eliminating physical, sensory and cognitive barriers within cultural venues. For example, the *United Nations Convention on the Rights of Persons with Disabilities* (Law 18/2009) [1] recognizes the right of persons with disabilities to participate in cultural and leisure activities on an equal basis with others (article 30) and obliges States to take measures to make cultural facilities accessible (article 9); or the *Faro Convention on the Value of Cultural Heritage for Society*, which emphasizes "the promotion of measures to improve access to cultural heritage, especially for young and disadvantaged people, in order to increase awareness of its value, the need to conserve and preserve it, and the benefits that can be derived from it" (article 12) [2].
In Italy, the Ministerial Decree of 28 March 2008 named *Linee guida per il superamento delle barriere architettoniche nei luoghi di interesse culturale* [Ministero per i Beni e le Attività Culturali 2008] establishes the minimum requirements for the physical, sensory and

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cognitive accessibility of cultural places according to the principles of Universal Design, while the Guidelines for the preparation of the *Linee Guida per la redazione del Piano di Eliminazione delle barriere architettoniche* (P.E.B.A.) [Direzione Generale dei Musei 2018] and the subsequent *Piano Strategico per l'Eliminazione delle Barriere Architettoniche* (Ministerial Decree No. 534, 19 May 2022) [Direzione Generale dei Musei 2022] aim to adapt museums and institutes to achieve the widest possible physical, cognitive, sensory and cultural accessibility.
Planned actions include the elimination of physical barriers through interventions to adapt spaces according to the principles of inclusive and universal design, and the elimination of cognitive barriers through interventions to facilitate the understanding of spaces and the communication of cultural artifacts through translation into simple language or the use of visual and tactile aids. In this area, physical models play an important role in the communication and inclusion process, providing a tangible three-dimensional representation that allows people of all abilities to explore and understand sites and monuments in a more complete and immersive way.
In fact, the analog model can facilitate the understanding of spatial relationships between different parts of a building or monumental complex, addressing not only people with disabilities, but the totality of users.
Physical models support the 'reading' of complex architectural and spatial concepts and consequently the creation of a mental representation of them, allowing to "visualize" the structure, the arrangement of rooms and the relationship with the surroundings; they also allow to explore architecture through touch, providing information about shapes, volumes, textures and materials, even showing details that are not always perceptible through sight; finally, they can be used for educational and awareness-raising activities, encouraging interaction with heritage and its history.
The scientific literature suggests several studies on the uses and purposes of tactile models of architecture, which may be focused on informing and orienting users [Caddeo et al. 2006], or may have as their goal the enhancement of cultural heritage. In these cases, the models may represent the building in its full volumes, either as ruins or as reconstructive hypotheses [Caldarone 2018; Empler, Fusinetti 2021; Empler, Caldarone, Fusinetti 2023], the environment on which it insists,

Fig. 1. Hagia Sophia, Istanbul, mosaic of the southern vestibule (11th century). On line source: <https://rb.gy/cjf8q5> (accessed 21 February 2024).

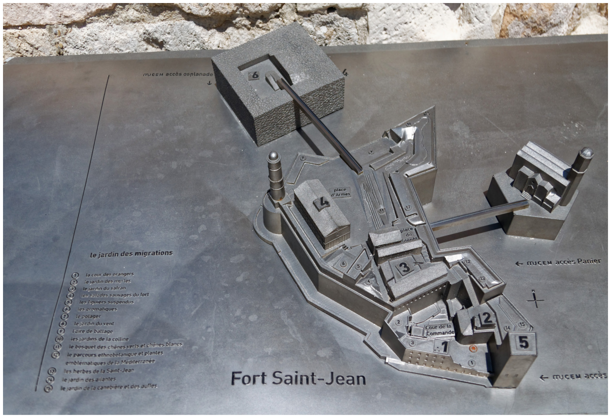
Fig. 2. Brunelleschi and Ghiberti present Cosimo the Elder with the model of the Church of San Lorenzo, executed by Marco da Faenza after a design by Vasari (1556). On line source:: <https://rb.gy/21bnrb> (accessed 21 February 2024).

the details and particularities of its external conformation or its interiors [Balletti et al. 2012; Sdegno, Riavis 2020], even the three-dimensional reconstruction of Renaissance paintings with the desire to narrate the perspective scan, a fundamental element for understanding and recognizing the value of the painting [Ansaldi 2023]. This extensive documentation is then complemented by contributions related to the conferences Il Disegno per l'Accessibilità e l'Inclusione - DAI 2022 [Càndito, Meloni 2022] and DAI 2023 [Sdegno, Riavis 2023] both sponsored by UID, proving the topicality of accessibility and inclusion issues within the discipline of drawing.

Architectural models over time

The evolution of the use of architectural models is historically documented, and it is possible to show how the purposes of use have changed over time, moving from an initial symbolic and religious use to a design use.
In the Greek world, for example, the physical models of architecture could represent the synthesis of the building, constituting themselves as *ex votos* to be given to the deity [Bigi 2017], as similarly happened in the Egyptian or Byzantine periods. An example of the latter is the mosaic inside the Hagia Sophia in Istanbul, in which two emperors are depicted, each holding a physical model presented to the Virgin Mary with Jesus. Emperor Justinian holds a model of the basilica he rebuilt in the 6th century, while Emperor Constantine holds a model of Constantinople, the city he founded, named after him, and which houses the basilica itself. The use of the model, both of the city and of the church, is valued here as a homage to the god whose grace and protection they invoke [Whittemore 1938] (fig. 1).
In the Renaissance, the physical model began to take on new meanings, playing a fundamental role in the architectural design process due to its ability to communicate the building under construction to the patron. In the painting by Marco da Faenza, commissioned by Vasari, *Brunelleschi and Ghiberti Present the Model of the Church of San Lorenzo to Cosimo il Vecchio*, it is the figure of the patron who emphasizes and at the same time points out the correspondence between the model shown and the building site under construction in the background [Limoncelli 2023] (fig. 2).

Fig. 3. Wooden model of the dome and apses of Santa Maria del Fiore attributed to Filippo Brunelleschi (Florence 1377-1446). Museo dell'Opera del Duomo, Florence. On line source: <https://rb.gy/31wr59> (accessed 21 February 2024).



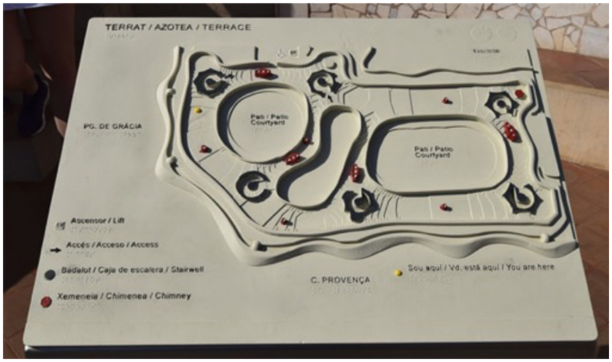


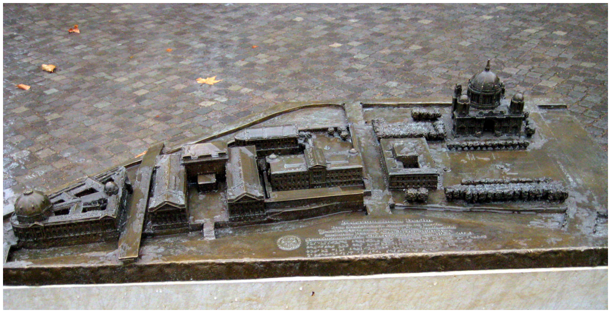
Fig. 4. Bronze model of Fort San-Jean, Marseille. On line source: <https://rb.gy/f7fduy> (accessed 21 February 2024).

Fig. 5. Casa Milà, Gaudi, aluminum tactile model of the terrace at the top of the building. On line source: <https://rb.gy/mg00tu> (accessed 21 February 2024).

In this period, the analog model was used to illustrate the grandeur of the work, innovative engineering solutions, or simply the distribution of space and construction details for the workers, as well as to serve as a useful design reference in the event of the designer's death, which was not uncommon given the long construction periods of the works. Few records of these models remain to this day, due to the fact that they were quickly disposed of at the end of the work in order to salvage the material. Extremely significant, and preserved because of the importance of the subject they represented, are the models of Antonio da Sangallo's design for St. Peter's Basilica (never realized due to the architect's sudden death) and of the dome of the Basilica of Santa Maria del Fiore in Florence, presumably by Brunelleschi (fig. 3).
The use of the model then evolved over time, first through the detailed wooden models of the Baroque period, and then through the small cork reproductions of the eighteenth century, used as travel souvenirs and designed for the Grand Tour market.
Today, the model still supports the development of the design idea and is used as a three-dimensional representation to illustrate the project to the client, but the historically established purposes have been supplemented by others, such as providing a better understanding of the spaces within the orientation systems.

Tactile models for communication

Physical models, whether related to individual buildings (fig. 4), a specific level (fig. 5), or depicting a small part of a city (figs. 6, 7), are often used in wayfinding systems, the set of strategies aimed at conveying environmental information to users through the use of wayfinding signs and other communication methods [Empler 2012].
The creation of these three-dimensional models, which are necessarily to scale, promotes orientation for all visitors, including those with vision-related sensory disabilities, who can explore the model by touch. Haptic reading allows for comparison and understanding of the spatial distribution of buildings, but for the information conveyed to be clear and effective, the processing must follow certain guidelines to meet the principles of legibility.



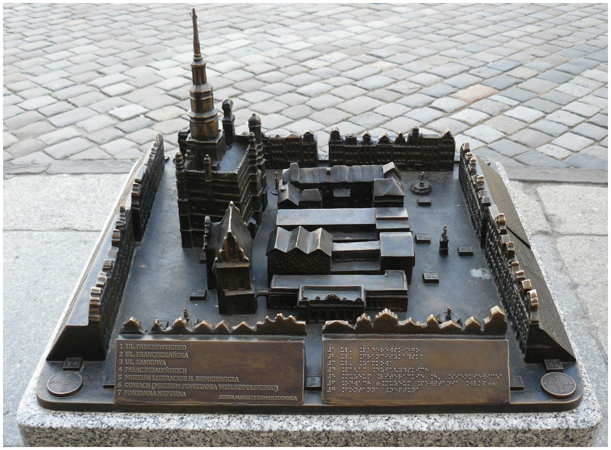


Fig. 6.: Bronze model of the Museum Island in Berlin, representing the cultural district of five Berlin museums; a UNESCO World Heritage Site. On line source:: <https://rb.gy/fw0lwt> (accessed 21 February 2024).

Fig. 7. Bronze model of the Market Square in Poznan, Poland. On line source: <https://rb.gy/od3dy> (accessed 21 February 2024).

Like two-dimensional tactile maps, three-dimensional models require a simplification of information because haptic exploration does not allow for the distinction of fine details. Haptic reading occurs through sequential exploration of the model with fingers and palms, and the perception of the whole is the result of organizing this partial information [Empler, Fusinetti 2019].
The size and materials used depend on the scale of the representation, whether urban or detailed, the final location of the model, whether interior or exterior, and the quality of the execution, which can be handmade or three-dimensional printing.
The processing of these types of models, which also have complex shapes, involves the use of digital technologies that, starting from integrated surveying methods for data acquisition and subsequent modeling, allow the model to be printed by additive or subtractive prototyping [Empler, Fusinetti 2021; Montusiewicz et al. 2022].
However, the digital processing of data for model processing must be subject to certain representational guidelines that allow the recognition of shapes to ensure proper understanding of the object by the user.
For this reason, the size of the replica should not exceed the size –ideally the width of the movement of the arms– and should be elaborated in such a way that all the elements can be distinguished, even through the use of textures or numbers to be recalled later in the legend.
The example shown in fig. 08 is the tactile model prepared for the communication of the Fortress of Marciana on the Island of Elba. The model was created from the acquisition of the current state of the fortress by aerial photogrammetry; the mesh obtained from the point cloud was then simplified with the aim of obtaining a model that would allow a correct understanding of the artifact, taking care to close or fill in the areas that could have represented a danger during tactile exploration (such as the spaces inside the four lateral walls); before production, numerical references in black and braille were added to the legend on the base to which the model is attached, allowing the various parts of the fortress to be understood. To support this reading, a brief description of the fortress in Italian, English and Braille has also been added to the base plate. The plastic was produced by an additive printing process, the volume of which was used to create the silicone matrix in which the resin was poured to obtain the final model.

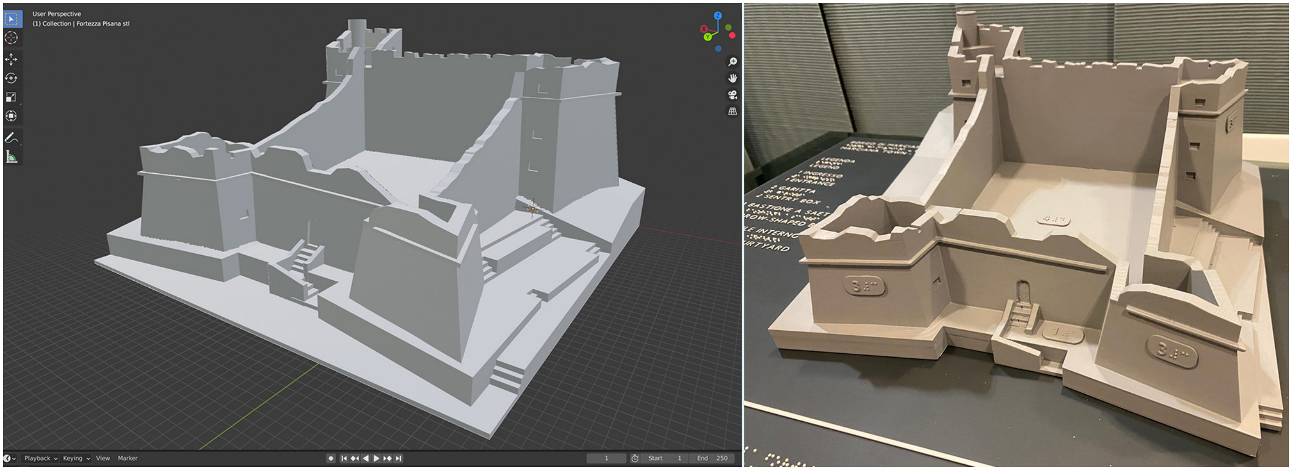


Fig. 8. Tactile model of the fortress of Marciana, Island of Elba. On the left,the model processed from survey operations; on the right, the printed model. (graphic elaboration by the author).

When preparing the models, it is also necessary to take into account the spacing of graphic marks, such as lines or textures, which, when used as textures, must be at least 2 mm apart to be correctly perceived, while the distance between individual objects, especially if they have similar heights, must be placed at a distance of more than 5 mm [Simmonet et al. 2018]. These arrangements may lead to a partial change in the proportions of the model elements, but they are useful variations to achieve correct and effective communication.
The possibility of tactile exploration of the physical model allows the transmission of architectural and spatial information, which, in the case of wayfinding systems, is translated into models whose main function is orientation. These types of models, called directories, help the user to identify the destination to be reached, facilitate the correct perception of the spaces to be traversed, and allow greater autonomy of movement, even for people with visual or cognitive disabilities in general.
In the field of cultural heritage promotion, the use of the physical model is considered by the above-mentioned guidelines as a useful element to improve the accessibility conditions for different types of users. This peculiar typology allows both a correct understanding of the spaces, facilitating the orientation even inside the cultural institutions and consequently promoting the autonomy of the user, and an effective interpretation and perception of the architectural object, through haptic exploration, within an inclusive path of valorization of the good.
The analog model of an architectural cultural artifact can be reduced to different scales, depending on the information to be communicated to the users.
At the urban scale, it can represent an area of particular value, as in the case of the tactile model of the Luma Arles cultural center in France. The complex, designed by Gehry, covers an area of eleven hectares and is described by two tactile panels characterized by the use of different colors and textures that help distinguish the different buildings in the area. The classification of the elements through the use of color is then reduced in the orientation system of the area, thus implementing an inclusive approach to the enjoyment of the site (fig. 9). In this sense, the tactile model can be used by blind people to create their own mental map of the area through touch, which is useful for safe movement and autonomous orientation in space.
It is also possible to communicate a particular urban form, as in the case of the German town of Nordlingen:

Figure 9. Tactile model of the Luma Cultural Center in Arles, France. On line source: <https://rb.gy/gk0xxi> (accessed 21 February 2024).

Fig. 10. Bronze map of the city of Nordlingen, Germany. Author: Andrew-M-Whitman. On line source: <https://rb.gy/a9xaek> (accessed 21 February 2024).

a tactile bronze model, accompanied by Braille texts, emphasizes the unique circular shape of the settlement, due to the inhabited development of the core within a meteoritic crater (fig. 10).
Architectural models of individual buildings or parts of buildings can illustrate the different elements that make them up in more detail and highlight construction details, such as the bronze model of the *Golden Gate Bridge* included as part of the *Bridge Enhancement Staging Project*, in which it is possible to tactilely explore one of the two towers to better understand its shape and proportions [Anagnos et al. 2013] (fig. 11).
Finally, one of the most important features of the use of physical models is that they can illustrate both the 'haptic narrative' of current status of a cultural object and the narrative of its hypothetical reconstructions [Caldarone 2018; Empler, Fusinetti 2021; Barvir et al. 2021]. The possibility for the blind to independently explore tactile representations of cultural artifacts is therefore a challenge that requires the adaptation of the meaningful content of the cultural object to the specific characteristics of tactile exploration [Souradi et al. 2020], although the use of these models allows them to 'speak' not only to people with visual or cognitive disabilities, to whom they are primarily addressed, but to the totality of users.

Conclusions

Developments in the use of these models in the field of heritage communication are now directed towards the implementation of new sensory levels through the use of information technologies.
The *Unesco4All* project presents an innovative approach that aims to create sensory pathways around some World Heritage sites, specifically designed for a blind audience. Users are provided with a ring equipped with NFC technology [D'Agnano et al. 2015], which, with the support of an app, is able to 'read' the pattern after haptic exploration and provide a real-time audio description.
It uses a similar approach to the research carried out for the enhancement of the Olomuc Castle, Czech Republic. Here, user-model interaction is achieved by printing model elements corresponding to points of interest with a conductive material that 'responds' to

Fig 11. Bronze model of one of the towers of the Golden Gate Bridge. On line source: <https://rb.gy/8mofb3> (accessed 21 February 2024).

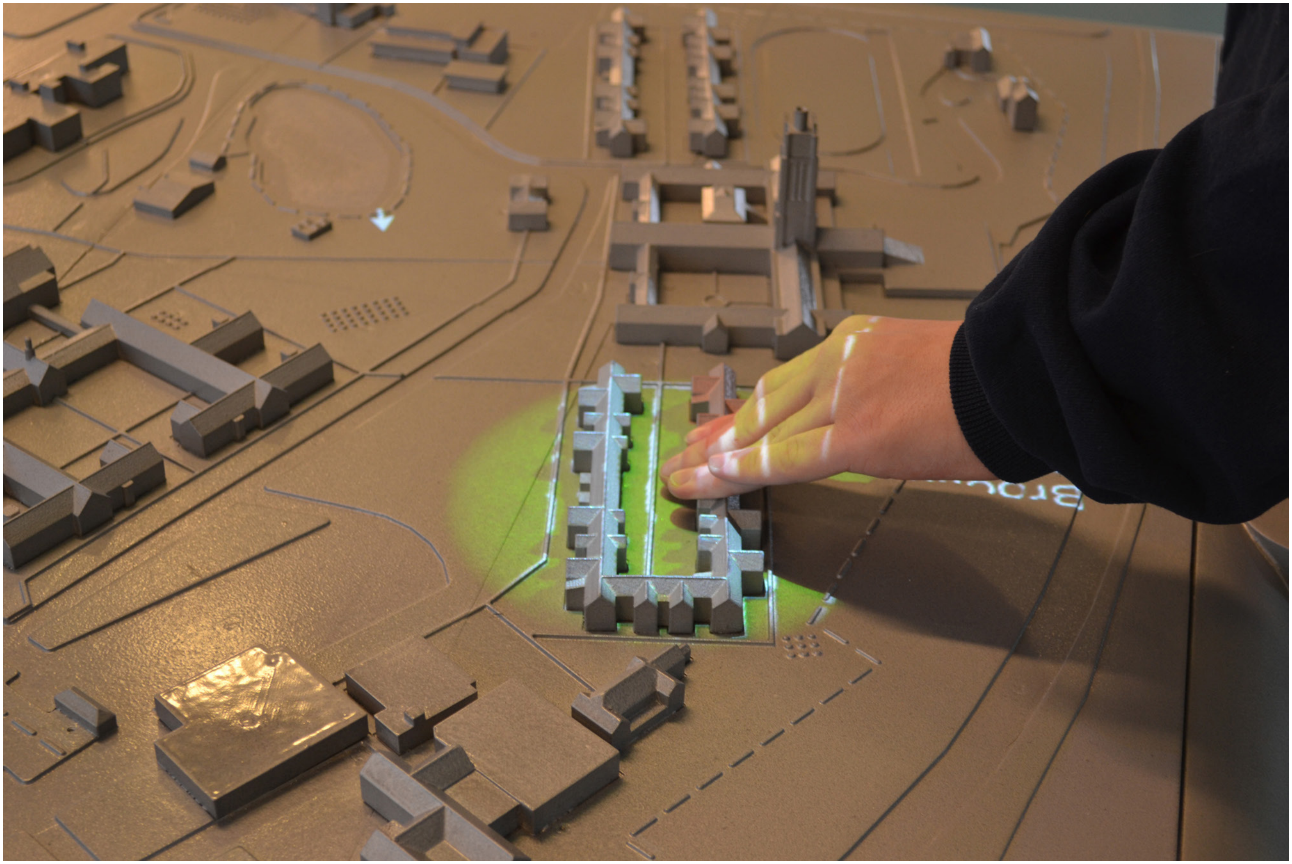


Fig. 12. Perkins School's multisensory model, which offers audio, tactile and visual cues for inclusive interaction. Credit: University at Buffalo IDeA Center. On line source: <https://rb.gy/bfj1sp> (accessed 9 April 2024).

touch. Activation of the connections by touch results in the display of detailed information on the tablet next to the 3D model and an audio description of the elements [Lazna et al., 2002].
Research by the *IDEA Center* at the University at Buffalo proposes an interactive wayfinding system. Three-dimensional maps were printed and then painted with conductive paint: when touched, a light projection illuminates the building and information about it is communicated to the user, along with directions on how to reach it, all through an audio system (fig. 12).
Today, the role historically assigned to physical models, which were exclusively visual, is being replaced by models that support new levels of sensory perception, capable of increasing the degree of inclusiveness and responding effectively to regulations requiring interventions in accordance with the principles of design-for-all.

Notes

[1] In this regard, consult the document of the *Ministero del Lavoro, della Salute e delle Politiche Sociali* (2009) regarding the *Convenzione delle Nazioni Unite sui diritti delle persone con disabilità*, in particular article 30 refers to participation in cultural and recreational life, leisure and sports, and article 9 concerns accessibility:<https://www.lavoro.gov.it/temi-e-priorita/disabilita-e-non-autosufficienza/focus-on/Convenzione-ONU/Documents/Convenzione%20ONU.pdf> (accessed 20 February 2024).

[2] Article 12 of the *Convenzione di Faro* specifically refers to access to cultural heritage and democratic participation: <https://www.journalchc.com/wp-content/uploads/2020/08/Convenzione-di-Faro.pdf> (accessed 20 February 2024).

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Models as Drawings

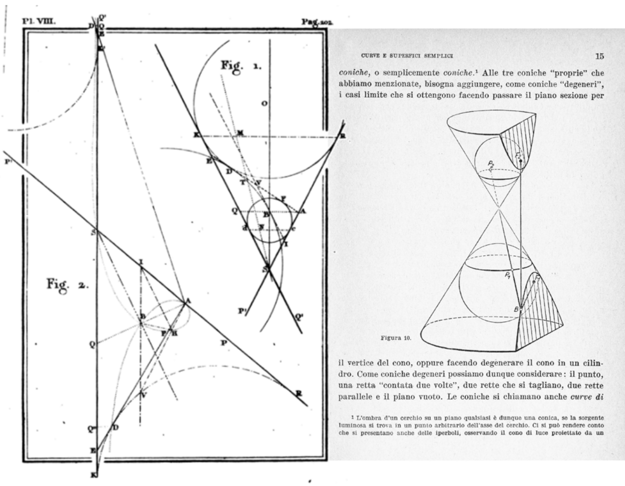
An Archetypal Graphic Model in the *Conics* of Apollonius

Riccardo Migliari

Introduction

In the ancient world, and therefore well before the codification of the double orthogonal projection method developed by Gaspard Monge [Monge 1799], it was possible to represent three-dimensional space as faithfully as methods of a projective nature allow today. These representations, while not being documented by means of graphics, are in fact documented thanks to the descriptions obtained from texts, such as that of the *Conics* of Apollonius of Perga.
The purpose of this short essay is to demonstrate, with an example, how these accurate descriptions of plane sections of solid figures, executed in such a way as to preserve the true shape of the elements, are able to allow the reconstruction in space of the architecture of geometric shapes and relationships and to perform verifications by means of graphic calculation.
Proposition 13 in *Book I* of the *Conics* provides a good example of this ancient method, which has been passed on through the centuries leaving deep traces even today in the pages of modern stereotomy. The two-dimensional figures, linked together by an artifice different, but no less effective, from the use of lines connecting projections of the same point, were intended as a three-dimensional model and ideally reassembled in space, and we can imagine them as pages of a pop-up book. This usage is suggested, for example, by the term "*subiacens*" used in the last propositions of *Book I* to denote the plane section on which the complex edifice of the geometry of the cone and its curves is constructed.

This article was written upon invitation to frame the topic, not submitted to anonymous review, published under the editorial director's responsibility.



CURVE E SUPERFICI SEMPLICI 15

coniche, o semplicemente *coniche*.¹ Alle tre coniche "proprie" che abbiamo menzionate, bisogna aggiungere, come coniche "degeneri", i casi limite che si ottengono facendo passare il piano sezione per il vertice del cono, oppure facendo degenerare il cono in un cilindro. Come coniche degeneri possiamo dunque considerare: il punto, una retta "contata due volte", due rette che si tagliano, due rette parallele e il piano vuoto. Le coniche si chiamano anche *curve di*

¹ L'ombra d'un cerchio su un piano qualsiasi è dunque una conica, se la sorgente luminosa si trova in un punto arbitrario dell'asse del cerchio. Ci si può rendere conto che si presentano anche delle iperboli, osservando il cono di luce proiettato da un

Fig. 1. Left: the Dandelin-Quetelet construction, for the cases of the parabola and the ellipse, as it appears for the first time in the memoir presented by Germinal Pierre Dandelin to the Belgian Academy in 1822.
Right: the same construction for the case of the hyperbola, illustrated by David Hilbert about 100 years later.

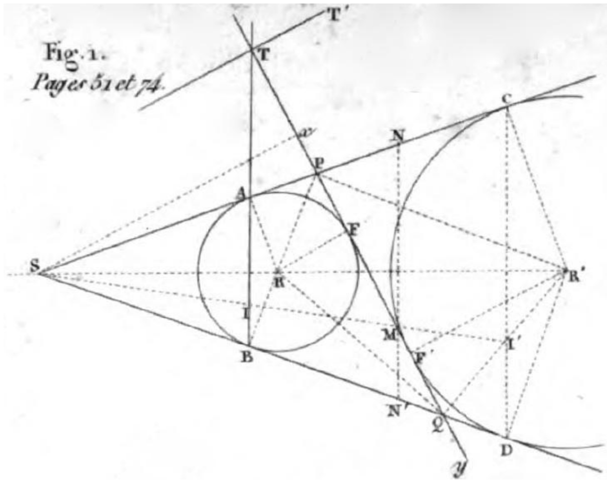


Fig. 2. Detail of the supplementary table (A) of the second edition of Jean-Nicholas Pierre Hachette's Traité de Géométrie descriptive [1828], where Dandelin's theorem was first proposed in a course on Descriptive Geometry. The representation of the sectioned cone and of the two spheres inscribed within it, to study the case of the ellipse, is very similar to that of Dandelin. However, Hachette also denotes, by the symbol T, the projection of the line of intersection of the plane of section with the plane that contains the circle of contact of one of the spheres with the cone and identifies, in this line, one of the two directrices of the curve. Hachette recalls that this additional property of Dandelin's "architecture" was pointed out to him by Mr. Blanchet, adjunct professor at the Royal Colleges of Paris, in 1826 [Hachette 1828, pp. 51, 52, 74].

Finally, it must be noted that if the editions of Apollonius's treatise, like those of other works dealing with forms generated in three-dimensional space, had contained more faithful illustrations, these would benefit, and greatly, the reading of the text as well as its comprehension. These illustrations should not merely give a vague idea of the configurations imagined by the author, but could be used as testimony to a way of thinking and doing geometry, and also as tools for verifying relationships and operational practices.
Those who deal with Descriptive Geometry are inevitably led to study conic sections, not only because these curves arise whenever a plane "meets" [1] a cone or a cylinder, but also because they generate and are generated by surfaces such as the sphere, the ellipsoid, the hyperboloid, the paraboloid, and the hyperbolic paraboloid, all of which are of extreme interest to the theory as well as to the applications of this science.
Germinal Pierre Dandelin and his friend Adolphe Quetelet devised a simple construction that makes it possible to demonstrate how the section of a right circular cone is a parabola, a hyperbola, or an ellipse, when certain properties of these curves are given as known, or to prove the properties themselves by recognizing, in the plane section of a cone, a parabola, a hyperbola or an ellipse, as the case may be [2]. And this famous theorem, at least since David Hilbert used it in his Intuitive Geometry [Hilbert, Cohn-Vossen 1972, pp. 12-19], is an essential teaching tool (figs. 1, 2) [3].
But what was the structure that allowed Apollonius of Perga [4] to define conics as sections of an oblique or, as we say today, quadric cone, and not a right circular cone as in the abovementioned theorem?
In the Dandelin-Quetelet theorem [Dandelin 1822], the image, whether drawn or mental, plays an essential role: it makes manifest the abstract reasoning that proves the theorem. And if the image can do so much, in that theorem, it is because, thanks to Descriptive Geometry, that solid construction can be projected in the pages of a book and can provide, to those who wish to reproduce it, the tool for a quasi-experimental verification.

In other words, the image is, in itself, an existential proof [5], even if it does not have the force of a logical demonstration. The image, moreover, has a heuristic value: it helps to 'find' the truth, it suggests the truth, and therefore hints at what the thinking, between intuitions and deductions, of its inventor might have been.
So, if what I have said can hold for the nineteenth-century Dandelin-Quetelet theorem, why should it not hold for Apollonius's theorems? There is only one not small difference between the two ways of thinking in geometry that lies, precisely, in the capacity to represent it.
This is because, in the early nineteenth century, there was total control of three-dimensional forms, thanks to the contribution of Gaspard Monge and of those who preceded him in the modern age, while little or nothing is known of scientific representation in the time of Apollonius. In fact, all that remains of the graphic models from that remote time are the engravings on the stone of ancient building sites, which are fragments of orthographic projections, as in the case of the tympanum of the Pantheon that is seen in Rome on the pavement in front of the Mausoleum of Augustus, or nomograms, such as those on the Temple of Apollo at Didyma [6].

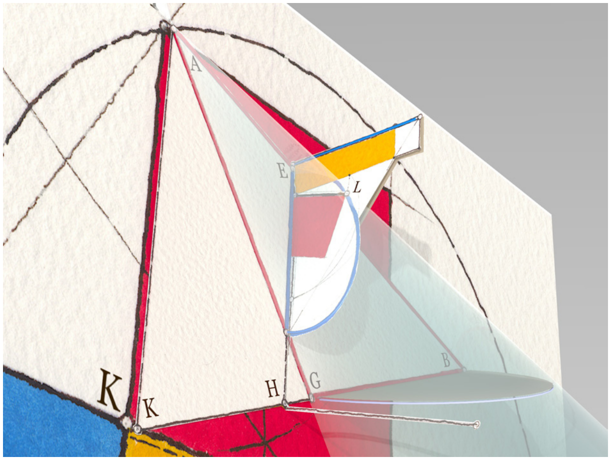


Fig. 3. Synthesis of the archetypal model described by Apollonius: against the background of the nomogram that allows the latus rectum to be calculated graphically, the planes of the axial triangle and of the section ellipse open up, as in the pages of a pop-up book, capable of evoking the mental image of the cone represented here in transparency.

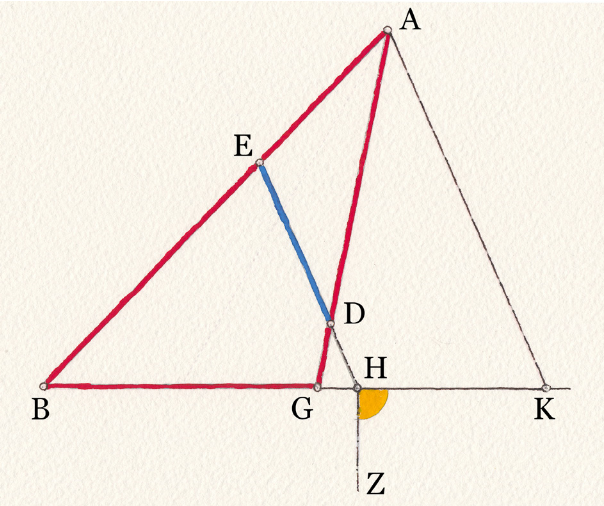
The drawing of space in *Book I* of the *Conics*

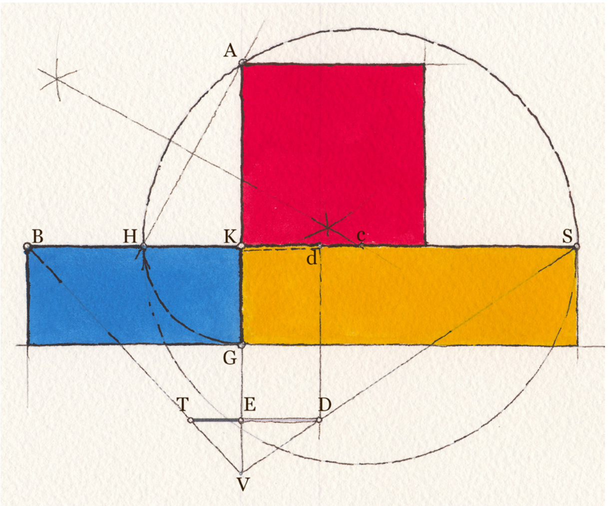
The treatise on conics not only consists of a set of logical deductions capable of textually describing the properties of the plane sections of the cone, but also describes, just as accurately, very elaborate geometrical structures that are functional to these deductions [7]. To define the ellipse, the parabola, and the hyperbola in *Propositions 11*, *12*, and *13* of *Book I*, Apollonius associates the double-napped oblique cone, which he considers for this purpose, with four planes: one as the base of the cone, a second that intersects it passing through the vertex, a third that cuts the cone and supports the conic section considered and a fourth, parallel to the base. Within these planes, there are circumferences and line segments all related to each other by relationships deduced from each other through logical steps that recall various theorems of Euclid. As a whole, these figures and their geometric relationships constitute a model of the cone and its section (fig. 3) [8].
Paul Ver Eecke observes that reading these propositions is "quite arduous" [Apollonius Pergæi 1923, p. XIII] [9] and many attempts have been made to transpose the reasoning into terms more accessible to us, either by using modern symbolic notation or through metaphors [Flaumenhaft 2013, pp. XIII-XXX]. But a faithful graphic representation is the most direct way to enter into the logic and thought of Apollonius.
Following the original text to the letter, this model consists of three drawings:

- the first is the "axial triangle" [10], described in points 3 and 5 of the *Definitions* as a section of the cone with a plane passing through the vertex and through the center of the circular section that forms its base. This triangle is represented in true shape and can evoke the idea of a solid finite cone, as in *Definition 2* [Apollonius Pergæi 1891, p. 7] [11]. The drawing is completed by the intersection of the axial triangle with the plane of the section that generates the conic (fig. 4);
- the second drawing is a nomogram [Cassinis 1928], which Apollonius defines with a relation between elements belonging to the axial triangle and two line segments belonging to the plane of the conic section: the *latus transversum* [12], that

Fig. 4. The first of the drawings described in Proposition 13: the orthographic projection of the cone. Note that the plane that the axial triangle belongs to does not coincide with the apparent contour of the cone with respect to the direction perpendicular to that plane. Which confirms the non-projective character of this image.

Fig. 5. The second drawing: a nomogram which allows us to calculate the length of the latus rectum from the segments that are measured on the axial triangle: AK, KB and KG.





is, the diameter (*Definition 4*), and the *latus rectum* [Apollonius Pergæi 1891, p. 43], whose length can be calculated graphically, thanks precisely to the nomogram (fig. 5);

- finally, the third drawing is the true shape of the conic, which can be drawn thanks to the diameter and the *latus rectum* after having measured its length (fig. 6).

In this short essay, it is not possible to examine all the three-dimensional graphical constructions described by Apollonius in *Book I* of the *Conics*; we will, therefore, limit ourselves to the construction of the conic in the case in which the cutting plane meets two sides of the axial triangle and, therefore, all the generatrices of the cone, which is the case of the ellipse, and which, in my opinion, is also the simplest. This examination will be conducted from a particular point of view, that of the architect who admires a building through its representation, as though it were a project.

The drawing of the cone and the ellipse as geometric locus

Proposition 13 begins with a discursive description of the cone and of the relationships that relate it to its section. The text between quotation marks ("…") is the original text; I have added, between square brackets ([…]), the letters that allow us to reconnect the text with the drawing. Apollonius does not do so, which demonstrates the literary nature of this description. We are in the context of an *ekphrasis* (figs. 4, 5) [13].

"If a cone is cut by a plane [*ABG*] through its axis, and also cut by another plane [*EZH*] meeting both sides [*AB* and *AG*] of this axial triangle (fig. 4), but is neither parallel to the base of the cone nor parallel to the opposite [section] [14]; and if the plane the base of the cone belongs to and the cutting plane meet in a straight line [*ZH*] perpendicular to the base [*BG*] of the axial triangle or to it continued [15], then any straight line [*LM*] drawn from the conic section to the diameter of the same [*ED*], so that it is parallel to the intersection [*ZH*] of the two planes [16], squared, will be equivalent to some rectangle [*EMXO*], applied to a straight line [*ET*] [17] to which the diameter [*ED*] of the section has the same ratio as the square of the segment [*AK*] drawn, parallel to the diameter, from the cone's vertex to the triangle's base, with respect to the rectangle contained between the segments [*KB*

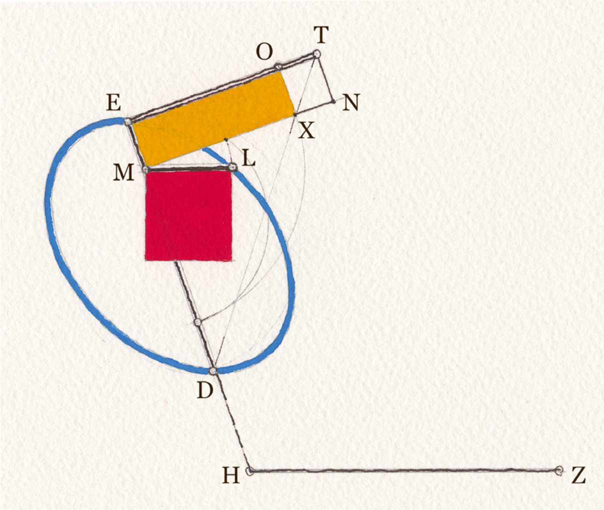


Fig. 6. The third drawing described in the enunciation of Proposition 13. The length of the diameter ED is obtained from the first drawing. The length of the latus rectum ET is calculated graphically by means of the nomogram (fig. 5). By varying the position of the point M on the diameter ED so that the square of LM and the rectangle EX are equivalent, the point L describes the ellipse. The segment EO will always be smaller than the latus rectum ET, which therefore assumes the role of a parameter. And the segment OT is what the parameter lacks to reach the length of ET. 'Lack' is indeed, in Greek, the name of the ellipse.

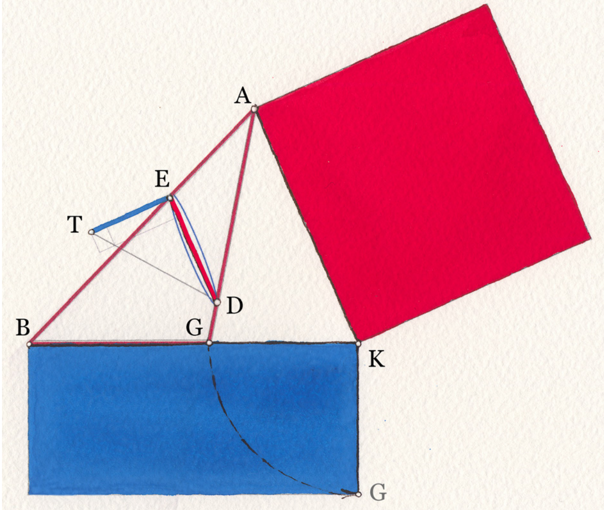


Fig. 7. In this drawing, the cutting plane, which contains the latus rectum ET, has been superimposed on the axial triangle, leaving the position of the latus transversum ED unchanged. Here the colors highlight the corresponding elements in the relation (2).

and *KG*] cut off on the base of the triangle by the aforementioned segment" [Apollonius Pergaei 1891, pp. 48, 49, translation by the author] (fig. 6).
Here the reading is particularly difficult precisely because ekphrasis lends itself well to describing shapes, but is not suitable for talking about relationships between geometric figures. Summarily, Apollonius, referring to the two drawings above, states that (fig. 6):

$$LM^2 = (EM \times MX) \qquad (1)$$

and that (fig. 5):

$$ED : ET = AK^2 : (KB \times KG) \qquad (2)$$

an expression that establishes the length of the *latus rectum ET* in relation to the axial triangle *ABG* (fig. 7).
It is now a matter of tying together the two previous relations, thus the enunciation goes on to define the rectangle (*EMXO*) in relation to the *latus rectum ET* (fig. 6): "And this rectangle applied to the *latus rectum* [*ET*] will have, as its breadth, the segment [*EM*] cut off on the diameter beginning from the section's vertex [*E*] to the point [*M*], in which the diameter is cut by the straight line [*LM*] drawn from the section to the diameter, while its area [*EMNT*] will be diminished by a figure [*OXNT*] similar and similarly situated to the rectangle contained by the diameter and the *latus rectum*. […] Let such a section be called an *ellipse*" (fig. 6).
Therefore, as we shall see (fig. 8), the ellipse generated by that cutting plane can be drawn by arbitrarily choosing any point *M* of the diameter to then construct the geometric locus described by the relation (1).
At this point, all that remains is to graphically calculate the length of the *latus rectum* by means of the relation (2), in which all quantities, except for the unknown *ET*, can be measured on the drawing of the axial triangle (fig. 4) [18].
The relation (2) is given as true, *a priori*. Its validity is proven in the subsequent demonstration, which also justifies the relation (1).

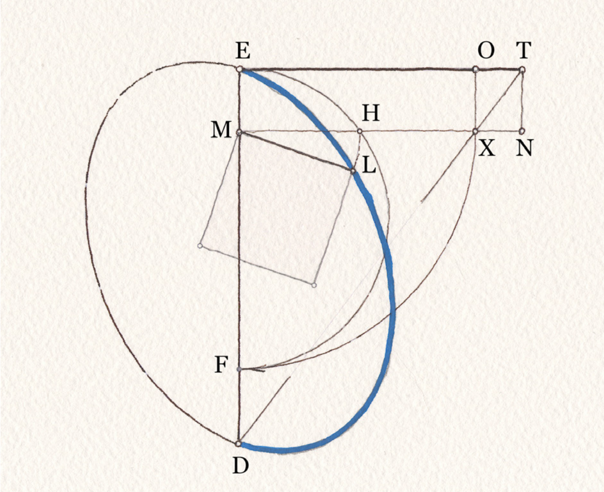


Fig. 8. The construction of the ellipse given the diameter (latus transversum) ED and the latus rectum ET.

The nomogram that measures the *latus rectum*

The demonstration is developed in a dozen steps, for which I refer to the original text [Apollonius Pergaei 1891, pp. 48-53] [19], since what we are interested in here is the three-dimensional model as a whole, evoked by the drawings present in figures 4 and 8 connected by the nomogram in figure 5, which links the orthographic projection of the cone to the true shape of the section by means of the *latus rectum ET*.
The correspondence between the equation (2) and the drawing in figure 5 is direct: assuming that the yellow rectangle *GS* [20] and the red square AK^2 are equivalent by construction (see Note 18), the yellow rectangle is to the blue rectangle as the diameter *ED* is to the *latus rectum ET*. Therefore:

1. on the base of the axial triangle (fig. 4), the line segments *KB* and *KG* are measured, and a rectangle (in blue in fig. 5) is constructed, in which the two sides are equal in length to the abovementioned segments;
2. a segment *KH* equal in length to *KG* is marked on *KB*;
3. a segment *KA*, perpendicular to *KB* and equal in length to *AK*, is raised on *K*;
4. the circumference that has its center on the prolongation of *KB* and passes through *H* and *A* is constructed. This circumference cuts the prolongation of *KB* in *S*, and thus the rectangle having *KG* and *KS* as its sides has an area equal to that of the square of *AK*. In fact [Euclid 1970, VI, 13, p. 379], *AK* is the mean proportional between *HK*, which is equal to *KG* by construction, and *KS*, so that:

$$KG : AK = AK : KS$$

And that is:

$$AK^2 = KG \times KS$$

Therefore, to construct the *latus rectum ET* it is only necessary to find a line segment that satisfies the proportion:

$$ED : ET = KS : KB$$

In fact, rectangles of the same height are to one another as their bases [Euclid 1970, VI, 1, pp. 361-363], and thus the base *KS* of the yellow rectangle, which is equivalent to the red square (AK^2), is to the base of the blue rectangle *KB*, as the diameter *ED* is to the *latus rectum ET*.
It will suffice to put *ED* in relation with *KS*, for example, by constructing any triangle (such as *BSV* in fig. 5) and then cutting it with a straight line parallel to *BS*, so that the resulting segments *ET*, *ED*, have the desired relationships.
Having obtained the *latus rectum ET* as above, one can generate the curve on the cutting plane in true shape (fig. 8).

The drawing of the ellipse

1. The right triangle *EDT*, which has the diameter *ED* and the *latus rectum ET* as its catheti, is constructed;
2. any point *M* is chosen on the diameter *ED* and *MN* is drawn through *M*, parallel to *ET*;
3. this straight line meets the hypotenuse of *EDT* at point *X*;
4. with a compass, *MX* is marked on the diameter as *MF*;
5. the semicircle whose diameter is *EF* is constructed and cuts the straight line *MN* at point *H*;
6. the chord conjugate to the diameter *ED* which is parallel to the intersection *ZH* of the cutting plane with the base of the cone, is drawn through point *M*;
7. with a compass, *MH* is marked on the abovementioned chord as *ML*.
8. *L* is a point of the ellipse, in fact:

$$MH^2 = EM \times MF$$

But given that $MH = ML$ and $MF = MX$

$$LM^2 = EM \times MX$$

Obviously, varying the choice of M, all the points on the curve are obtained (fig. 8).

Conclusions on the purpose of this study

I realize that the fragmentary reading of the text by Apollonius I have referred to, which has, furthermore, been stripped of all or most of the logical steps of the demonstrations, may appear detrimental to the author's greatness and therefore unacceptable. But it must be remembered that this study does not look at mathematics, but at architecture and drawing.
How did the ancients realize the grandiose buildings they have left us, intended as constructions of stone, but also understood as constructions of thought, without the support of scientific representation as we know it today? Hinting at a possible answer is the purpose of this study to show that:
- when Apollonius of Perga deals with solid figures the text can be read as the *ekphrasis* of a three-dimensional model capable of representing space not only allusively but with operational capabilities; this analysis can be extended to many other passages by the same and perhaps other authors;
- in the case of the difficult propositions of *Book I* of Apollonius's *Conics*, this reconstruction can provide the reader with a map for his orientation, moving from an enunciation to a demonstration and then to the final outcome as one moves from a plan to a section when studying a representation of architecture, and then reconnecting the drawings in the space of the mind and finally in reality.

It is well known that mathematicians have an innate difficulty in recognizing the role of graphic models in the elaboration of geometric thought, but there are also other authoritative opinions, and among all of them, Lucio Russo's is worth quoting in full: "Today we consider as independent three activities that were inseparably connected in Hellenistic mathematical practice: deductive reasoning, calculus and drawing" [Russo 2023, p. 59] [21]. And speaking of independence of activities and, I would add, of disciplines, it should also be noted how the scholastic habit of naming courses as being of 'analysis', of 'geometry', of 'drawing', and so on, has induced a separation that not only does not exist in reality, but is detrimental. If we look at the History of Representation, today we find Histories of Perspective, Drawing, Geometry and many other disciplines all separated from each other, whereas they are interdependent. On the other hand, I believe that Christian Wiener [Wiener 1884, pp. 5-61] was ahead of us and on the right track when, in 1884 he outlined a short history that moves with continuity from the perspective of the ancients to optics, topography, descriptive and projective geometry, pictorial and three-dimensional perspective and photogrammetry, and finally to the theory of chiaroscuro. A path that, as we know, certainly did not end with the advent of computer techniques.

Notes

[1] As Girard Desargues said [Desargues 1639].

[2] The genesis of this famous theorem is narrated by Adolphe Quetelet [Quetelet 1867, pp. 144-147] and shows how tortuous the road to a result of such limpid simplicity can be. A result that, although being the result of the collaboration with Quetelet, was published by Germinal Pierre Dandelin in 1822 and earned him admission to the Belgian Academy of Sciences.

[3] The Italian edition of *Anschauliche Geometrie* (1932) was published in the *Universale scientifica Boringhieri* in 1972. Quetelet himself, noting the importance of this theorem, observes that the first to make use of it was Jean-Nicholas Pierre Hachette, in 1828 [Quetelet 1867, p. 145] (fig. 2), precisely in the second edition of his treatise on Descriptive Geometry [Hachette 1828, pp. 51-53], the first being published in 1822, and that Théodore Olivier, in 1847, had devoted a special study to it, which is included in the complements of his treatise [Olivier 1847, pp.V-VIII].

[4] He lived from 262 to 190 B.C. [Boyer 1980, p. 166], and Gino Loria writes of him, "So little is known of his life that up to now it has not been possible to decide whether or not he is to be identified with a contemporary astronomer of the same name. A later commentator describes him to us vain and bumptious, in strident contrast to Euclid, who was modest and always ready to acknowledge the merits of others. Of the improvements he suggested to the *Elements* of the great Alexandrian, we know little more than their existence; of his work on irrational quantities, a supplement to Euclid's *Book X*, we know only what an Arabic writer tells us about it; so of his work on the problem of constructing a circle touching three others situated in the same plane (a matter still designated by the name of 'The Problem of Apollonius') we only know the general

plan" [Loria 1930, p. 17]. The most important commentator among those mentioned by Loria is Pappus of Alexandria [Pappo 1560].

[5] Here I use the same adjective proposed by Gino Loria in his small volume on *Metodi matematici* (Mathematical Methods) [Loria 1919, pp. 77-83] to define this potentiality of geometric construction in general.

[6] On this subject there is an extensive multidisciplinary bibliography already cited in José Antonio Ruiz de la Rosa's essay [Ruiz de la Rosa 1987]. On the temple of Apollo at Didima, see Lothar Haselberger [Haselberger 1985]. The layout of the tympanum of the Pantheon has also been studied by Carlo Inglese [Inglese 2000, 2013].

[7] Apollonius' text is presented as an *ekphrasis* not unlike literary ones. Among the most famous examples of *ekphrases* there is Pliny the Younger's description of his Villa Laurentina, while writing to his friend Clusinius Gallus [Pliny 1973, pp. 314-329]. The reconstruction of the villa attracted the interest of many designers and scholars, from Vincenzo Scamozzi [Scamozzi 1615, pp. 265-268] to Karl Friedrich Schinkel (1833-1835) [*1781-1841. Schinkel*… 1982, pp. 158-161] to the competition announced in 1982 by the Institut Français d'Architecture [Porphyrios 1983, pp. 2-7]. A further and even more pertinent example is Leon Battista Alberti's *Descriptio Urbis Romae* [Alberti 2005], where the drawing is replaced by an alphanumeric code, just as in texts on geometry. The *Conics* originally comprised eight books, written in Greek. The first four have come down to us in the original language. The next three, from *Book V* to *Book VII*, have come down to us in an Arabic translation. The eighth book has been lost. The seven surviving books have all been translated into Latin, and almost all of these editions are illustrated. We recall the main editions, with particular reference to the first four Books. See Memmo 1537 [Apollonius Pergæi 1537]; Commandino 1566 [Apollonius Pergæi 1566]; Barrow 1675 [Apollonius Pergæi 1675]; Halley 1710 [Apollonius Pergæi 1710]. In addition, among the more recent editions: the critical edition by Heiberg [Apollonius Pergæi 1891; 1893]; the slightly abbreviated one by Thomas Little Heath [Apollonius of Perga 1896]; the excellent one by Paul Ver Eecke [Apollonius Pergæi 1923]; and, finally, the one by Robert Catesby Taliaferro and Micheal N. Fried [Apollonius of Perga 2013].

[8] To illustrate this paper, I elaborated the figures on the computer, as I have done for years now. But despite many attempts to alleviate the coldness of these drawings, I could not create images capable, in some way, of evoking the relationship between logic and drawing of which Lucio Russo speaks at length in his study of Greek scientific thought [Russo 2023]. In the end, I preferred to use a ruler and compass, and also having to distinguish some areas with colors, I imitated the graphics of Oliver Byrne [Euclid 1847] to whom homage must be paid for having translated into vivid images a luminous thought that is usually mortified by skeletal line drawings.

[9] "*Les propositions XI, XII et XIII, dont la lecture est assez ardue, sont les plus importantes du premier livre*": Paul Ver Eecke in Apollonius Pergæi 1923, p. XIII] ("The propositions 11, 12, and 13, whose reading is rather difficult, are the most important of the first book"). But already in the edition edited by Jesuit Father Claude Richard in 1655 we read, in one of the introductory chapters, entitled *Warning to the Reader who is a Scholar of Geometry*: "Section XIX – If and why the *Conics* of Apollonius are difficult. If Pappus of Alexandria, who excelled in the matters of geometry judged that, in order to understand the *Conics*, all his lemmas were necessary, in addition to the ninety by Apollonius himself, will they not be difficult?" [Apollonius Pergaei 1655, *Sectio XIX. An et cur difficilia sint Apollonij Conica*, without numbered pages, translated from Latin by the author].

[10] According to Apollonius's *Definition I*, the axis is the straight line passing through the vertex and the center of the circular base of the cone. Care should be taken not to confuse this segment with the straight line that belongs to two of the planes of symmetry of the cone and is perpendicular to the third, as in today's usage. The axis of Apollonius is, in general, distinct from the axis of symmetry: the two lines coincide only if the cone is straight. The term "axial triangle" comes from the original Greek "*ἄξονος τριγώνον*", which others translate [in Italian] as "triangolo per l'asse," from Johan Ludvig Heiberg's Latin edition "*triangulum per axem*". In the original text, in Greek, the definitions are not numbered; Heiberg distinguished them in Latin with the numbers 1 to 8. Here, for clarity, I have used Roman numerals.

[11] Note that, as reiterated in the caption for figure 4, the axial triangle does not, in general, coincide with the apparent contour of the cone itself with respect to the normal direction; this condition occurs only if the axial triangle belongs to a plane perpendicular to the base. Hence the non-projective nature of this image.

[12] In the case of the parabola, whose diameter has infinite length, the *latus transversum* is replaced by the distance between the vertex of the curve (defined in *Proposition 4*) and the vertex of the cone.

[13] It is surprising to note that there is no Italian translation of Apollonius of Pergas's *Conics*, a lacuna that is not so painful because of the language as because of the lack of a suitable iconographic apparatus. In fact, historical editions, as well as others, are all lacking in this respect. The translation into Italian of the reported passages is by the author of this paper.

[14] Every quadric cone, whatever directrix is used to generate it and, that is, a circle, ellipse, parabola or hyperbola, possesses two infinite arrays of circular sections. Apollonius is aware of this and constructs an opposite section in *Proposition 5*.

[15] The required condition of perpendicularity between the two intersecting lines of the base of the cone with the cutting planes, that of the triangle and that of the ellipse, might appear to be a constraint limiting the generality of the construction, but this is not the case, because what determines the shape and size of the ellipse is only the cutting plane, and therefore the axial triangle can be freely chosen.

[16] That is, the cutting plane and the base of the cone.

[17] That is, the parameter or *latus rectum*.

[18] Eutocius, in his commentary on *Proposition 11* of *Book I* [Apollonius Pergæi 1893, p. 217] explains how one can graphically represent the equation $BG^2 : (BA \times AG) = TZ : ZA$ which is analogous to the one we are interested in. And this concern of his is confirmed in the hypothesis that the drawing used by mathematicians of the time had operational significance. Adapting Eutocius's writing to the relations concerning the ellipse, namely to *Proposition 13*, we obtain the following reasoning (fig. 5): "Let $AK^2 : (KG \times KB) = ED : ET$ and what has been said is shown to be true, until proven otherwise. Let the rectangle ($KG \times KB$) in blue in the figure] be [drawn]. Let us apply to the side [KG] a rectangle of area equivalent to the square of side [AK] [in red] and let [KS] be the width of that rectangle [in yellow]."

Let us interrupt, for a moment, our reading of Eutocius to explain his argument in detail. In the scientific jargon of the time "apply to" stands for "build on"; therefore: let us build on that segment a rectangle whose height is KG, like the rectangle ($KG \times KB$), and which is equivalent to the square of side AK, that is, has the same area. This rectangle will, therefore, have KG as its height and a segment KS, as its base, the length of which must be calculated graphically. The two rectangles BKG and SKG, thus generated, have the same height and therefore their bases have the same relationship as their areas [Euclid 1970, VI, 1, p. 361]: ($KG \times KS$) : ($KG \times KB$) = $KS : KB$. Recalling, now, that AK^2 is equivalent to ($KG \times KS$) by construction, we may write that: AK^2 : ($KG \times KB$) = $KS : KB$, and since AK^2 : ($KG \times KB$) = $ED : ET$ it follows that $KS : KB = ED : ET$. This relationship simply indicates that the segment ET, that is, the *latus rectum*, is to the diameter ED as KB is to KS. Therefore, Eutocius concludes in this way: "Let $KS : KB = ED : ET$ and thus we have obtained what we wanted and in fact, since $KS : KB = ED : ET$, it will be, on the other hand, [Euclid 1970, V, 7 coroll., p. 318] $SG : GB = ED : ET$, and it is, also, [Euclide 1970, VI, 1, p. 361] $KS : KB = SG : GB = AK^2$: ($BK \times KG$) [as was to be shown or demonstrated]".

[19] The Italian translation of the first thirteen propositions, annotated and illustrated as in this essay, is available at <https://www.migliari.it> (accessed 15 May 2024).

[20] When Apollonius has to indicate a rectangle he does not use four letters, but only the two he associates with the vertices of a diagonal.

[21] The pages that Russo devotes to drawing all deserve careful reading because they make clear what importance drawing had in the formation of Hellenistic geometric thought and how it assumed the value of an existential demonstration [Loria 1919, pp. 77-83].

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Paper Models for Science Dissemination and the Study of Drawing

Alessio Bortot, Annalisa Metus

Abstract

This contribution concentrates on a peculiar category of analogical models made of (movable) paper already present in scientific treatises from the 13th century onwards. If the first animated pages, capable of showing three-dimensional models, initially supported various fields of knowledge (gnomonic, perspective, astronomy, cryptography, the art of memory, anatomy, etc.), from the 18th century they became objects of entertainment, more markedly recreational, however for an adult public until the late 19th century. Paper models that could be folded to form volumes mainly concerned areas of knowledge related to geometry and gnomonic, as if to denounce how the written word and drawing were insufficient for the description of complex entities in space.
One of the movable techniques, the pop-up, was the subject of a workshop, partly inspired by the experiences of Origamic Architecture. The didactic experience will be described using two approaches: first emphasising the importance of being able to obtain a not entirely predictable model through cutting and folding operations and, secondly, describing the subsequent representation of the same model through the methods of drawing and surveying. The experience indirectly created links with the subject of design, ideally moving from the abstract form made of paper to its materialisation in the construction field.

Keywords: movable books, descriptive geometry, folding; cutting, paper engineering.

Introduction

The relationship between model and drawing, as well as that between drawing and survey, has accompanied the evolution of representation methods both in the domain of abstraction and in building practices. Since antiquity, the study of surfaces and their related curves –consider, for example, Apollonius' cone– has required first of all the use of a physical model and only later its representation through drawing. This contribution aims to offer some observations on the use of analogical models aimed not so much at the figuration of a work to be constructed, but as in the case of the Apollonio's cone, at materialising abstract models to subsequently observe their 'behaviour'. Massimo Scolari observes how: "the model seems to reverse its theoretical sequence and pass, with respect to drawing, from generated to generating. If it is true that the model brings to light the image of the building fantasised, conceived and turned over in memory, it is also true that it is only from this that the drawings of its fantastic elevations and sections seem to branch out" [Scolari 2003, p. 138]. According to some authors, the evolution of representation methods over time is partly linked to the observation of physical models, sculptural elements used to communicate a mental image of an object (architectural or otherwise) preferable to other media for its immediacy, but also for economic reasons (consider, for example, the cost in ancient times of drawing tools such as parchment). The analogue model has not only fulfilled the function of a scaled-down clone of something unrealised, but has often embodied an

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underlying idea of design: "architectural scale models have been employed as mechanisms of thought, used not only to design future buildings, but also as models for understanding and testing concepts of invisible things in general. In other words, scale models were used to define what was considered absolute truth or, typically, the work of the divine" [Smith 2004, p. 3].

Movable books as tools for scientific and artistic dissemination

What we prefaced is well represented by the so-called movable books –fascinating works for their modernity– that have enriched scientific literature in various fields since the Middle Ages. The term 'movable books' encompasses, in its generality, a series of subcategories of literary works characterised by specific techniques and delicate mechanisms, sometimes combined with each other: paper or parchment elements capable of rotating on themselves, folding, lifting and animating themselves to gain the third dimension. Those among scholars [Crupi 2016; Connolly 2009; Wilkins 1997] who have dealt with these peculiar literary objects recognise in the *Chronica Majora* (1240) by the benedictine monk Matthew Paris (about 1200-1259) one of the earliest and most refined witnesses. Starting from the city of London and passing through major European cities, the book suggests routes to the two Christian pilgrimage destinations, Jerusalem and Rome. The dynamism of the narration is guaranteed thanks to folded parchment flaps capable, when necessary, of expanding the space of the sheet, guaranteeing the description of the traveller's routes. A further invention is linked to the temporal dimension, this time using rotating concentric disks (*volvelles*) as a technique for calculating Easter: "Matthew transformed the Paschal Table at fol. v of MS 26 into an ingenious thirteenth-century 'computer' by attaching the large circular table of lunar cycles, epact [1] and other computational data, taken from another sheet of parchment, to the page by means of a metal pin, so that it could be rotated" [Lewis 1987, p. 11]. In the centuries that followed, this system of concentric wheels for calendar use would become a combinatorial model supporting other knowledge, for example astronomy, which in ancient times was not dissociated from astrology. These are dynamic cosmological representations to describe, for example, combinations of astronomical events, as in the case of the sumptuous *Astronomicum Caesareum* produced by Petrus Apianus (1495-1552) in 1540. Close in content and historical period is the *Dess Menschen Circkel* by the physician and alchemist Leonhard Thurneysser (1531-1595), a paper astrolabe that is part of the eight-volume work *Archidoxa* (1575), [Crupi 2019, pp. 30-32]. The peculiarity of this text, conceived in such a way as to allow the reader to calculate his or her horoscope or predict nefarious events, is the possibility of making the configuration of the concentric disks three-dimensional: a paper mechanism, consisting of a wire that acts as a tension rod, allows the structure to be lifted, effectively converting it into a *maquette* (fig. 1).

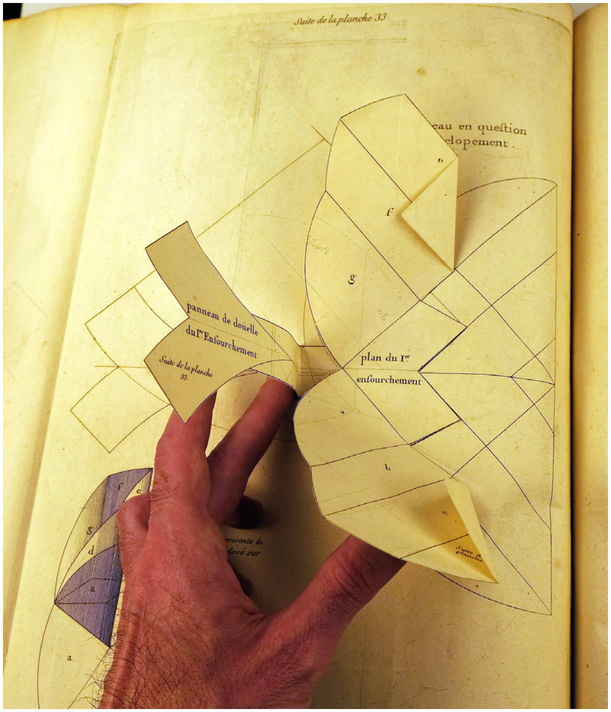
Fig. 1. Thurneysser 1575, fol. 641.

Fig. 2. Billingsley 1570, fol. 314.

The more usual two-dimensional applications of concentric disks rotating thanks to a pivot found useful uses in the art of memory starting from the medieval period thanks to Ramon Llull (1232-1316): concentric disks, visible for example in his *Ars compendiosa inveniendi veritatem seu ars magna et maior* (1274), subdivided into text boxes allowed the creation of logical associations of concepts to achieve knowledge. In the Renaissance, as the art of warfare and cryptography evolved, similar mechanisms allowed for the encryption of messages, which could be deciphered by combining wheels with letters, symbols or other letters [2]. Folded fragments of parchment were not only used to enlarge the surface of the page, as in the case of the *Chronica Majora*, but also to reveal hidden elements overlapping one another: through a sort of paper autopsy, Andreas van Wesel (1514-1564) in his *De humani corporis fabrica libri septem* [Van Wesel 1543] unveils the organs of the human body to the reader.
Moreover, the flap technique was also used to move from the two-dimensional space of the page to the representation of entities in space in the form of paper models: in an English edition of Euclid's *Elements of Geometry* (1570), the printer John Day decided to turn over the faces of some polyhedrons in the form of paper elements that, once folded, could show the model of the solid: the aim was obviously to make the study of Euclidean geometry more popular and comprehensible (fig. 2). A further area in which folded elements were used to reconstruct paper volumes, leaning on the pages, is the treatise on stereotomy, as can be seen for example in *planche 33 bis* of the *Traité de la coupe des pierres* [De la Rue 1728] by Jean Baptiste de la Rue (1697-1743). In the treatise, characterised by rather clear textual explanations as well as refined illustrations in orthogonal projection, perspective and cavalier axonometry, the author states that he considers these graphic-representative methods insufficient to show the morphological complexity of certain stone blocks and therefore resorts to the use of flaps. In the explanatory text of *planche 33 bis*, De la Rue declares to be against the approximation of the intrados surfaces of hemispherical vaults by means of cones, because in many cases: "the length of the surface […] is not sufficiently elongated" [De la Rue 1728, p. 61], as demonstrated by the folded paper flake in the said table that bears the caption "Proof of the error of the model shown through its development" [De la Rue 1728, p. 61] [3] (fig. 3).

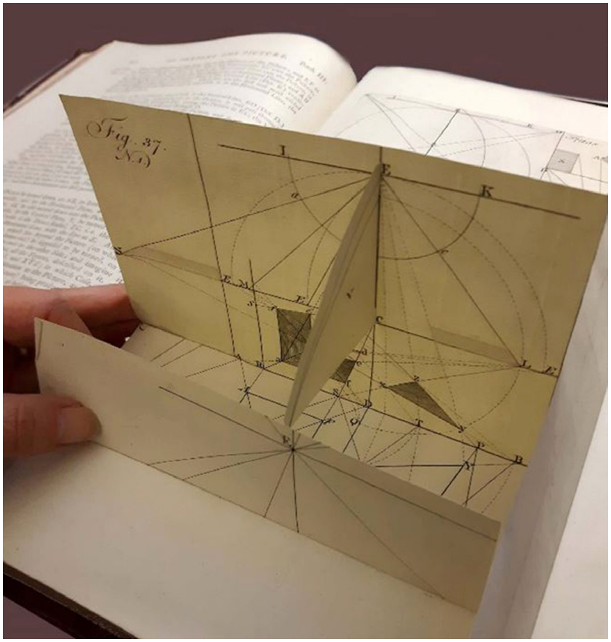
Extensive use of flaps can be found in treatises on the subject of perspective, generally employed to fix the observer's point of view by means of a liftable paper element from which the reader can verify the coherence between what the eye sees, and the image constructed according to geometrical methods. Cristina Candito [Candito 2018] reminded us some famous examples of this practice, such as the *Traité des pratiques géométrales et perspectives*… by Abraham Bosse (1611-1676) [Bosse 1665] or *A compleat treatise on Perspective*… by Thomas Malton (1726-1801) [Malton 1775] (fig. 4). The paper models in the latter's work are not only intended to demonstrate the correspondence between *perspectiva naturalis* and *artificialis*, but also to explain the reasons for the method of perspective through its spatial genesis and thus, through the overturning of geometrical entities, the construction

Fig. 3. De la Rue 1728, planche 33 bis.



of the image alluding to the third dimension of objects on the drawing sheet. "The result is a real device, similar to the mechanical instruments that, in the allegorical repertoire as in experimental practice, became one of the symbols of the scientific revolution that characterised the social and cultural history of the modern able to reproduce a model of the natural phenomenon, observable and operable as in a craftsman's workshop" [Zoerle 2017, p. 94], states Stefano Zoerle analysing the flaps in Salomon de Caus's (1576-1626) treatise on perspective [De Caus 1611].
It is only in the 18th century that the movables for popular or entertainment purposes appeared and the ones for children are produced in the first half of the 19th century, in parallel with the development of children's literature. In the years in which peep shows were fashionable, in the form of voluminous constructions used as popular and street attractions, dioramas –scenes developing in depth like a small theatre– and panoramic representations of landscapes or architectural works became widespread: the purpose in this case was not didactic but rather popularising, as a tourist guide or a view album might have. Jean-Pierre Brès, with *Livre joujou avec figures mobiles* (1831), is the first to have the idea of transforming illustration for narrative purposes: an asterisk inserted in the text indicates when to act out the transformation of the page, changing, for instance, the panorama seen through a window or the subject of a painting on canvas. In 1860, the firm Dean and Son in London created the first automatic three-dimensional books (pop-ups); in the same years fading images appeared, i.e. two images that intersect each other, decomposed and printed on a special paper.

Fig. 4. De la Rue 1728, planche 33 bis.

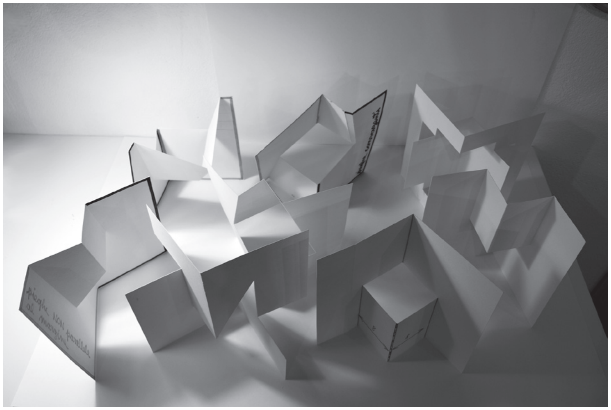


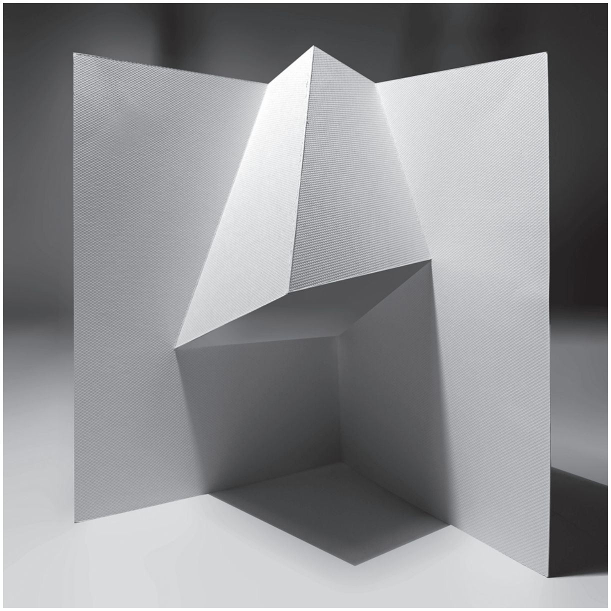
Cutting and folding in paper models

Beyond the techniques and the great number of movables applications in scientific treatises, what seems to be emerging is the need to confront a physical model in the path of knowledge. Today, in the field of didactics and popularisation, the possibilities of abstraction and narration on multiple levels, offered by a skilful and creative application of paper engineering, are in continuous development and are experiencing a parallel fortune with the diffusion of digital animations. Potentialities of these tools are evident if we think of how digital models and applications of augmented reality can offer unprecedented resources precisely for the study of ancient treatises by digital pop-ups [4]. However, we believed that these technologies should complement analogue models, especially in the context of architecture and engineering schools, where 'seeing with the hands' remains an indispensable practice for learning building practices.
In the process of realisation using a movable, it is necessary to reduce the object, which must be simplified according to the limitations of the chosen technique. Schematically speaking, we can identify two methods for placing an object in traction on a page and building it three-dimensional: exploiting the lever in the centre of the page and arranging the load-bearing sides at an angle (*V-fold* technique) or positioning the load-bearing sides parallel to the central fold (parallel fold). The choice of technique influences the positioning of the object on the page, the behaviour of the object in the time of the page opening, the consumption of the page surface and –in its most basic applications– the sacrifice of one of the three dimensions. Some applications of paper engineering in the field of architecture

Fig. 5. Pop-up made during the workshop through cuts and folds technique.

Fig. 6. Pop-up made during the workshop through cuts and folds.





were experimented by us in a workshop dedicated to the relationship between model and drawing [5].
A first round of exercises focused on the figure of the cube, precisely to highlight how the choice of technique (V-fold or parallel fold) influences every other decision concerning the pop-up in the economy of a page of constant dimensions. A second application was explored in a more creative context abstractly related to the study and conception of form through the cutting and folding of the sheet, among other things reflecting two of those operations of composition identified by Franco Purini [Purini 2010] [6]. These models, constructed by freely tracing some cut and fold lines on a single piece of cardboard subsequently folded in two, once opened at 90° reveal shapes that are not easily predictable, defined by generically inclined planes able of stimulating the imagination in abstract space (figs. 5, 6). The exercise is inspired by the technique known as Origamic Architecture (OA), which is often used today in so-called pop-up books, referring to the experiments conducted in the 1980s by a Japanese professor of architecture, Masahiro Chatani (1934-2008) (fig. 7).
The creative process involves a few simple steps: some straight lines are drawn on the rectangular sheet, possibly in different colours for greater clarity, to represent the traces of the cutting planes, the convex and concave folds, which are then marked with a tracing tip. The unpredictability of the shapes, once the sheet was opened to 90°, was of

Fig. 7. Akihiro Higarashi, pop-up model of the Golden Mile Complex in Singapore.

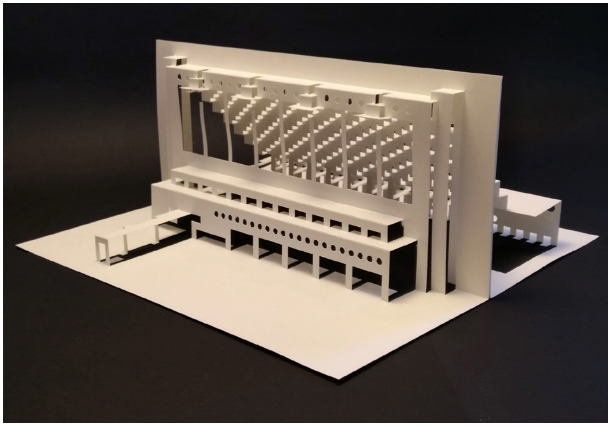
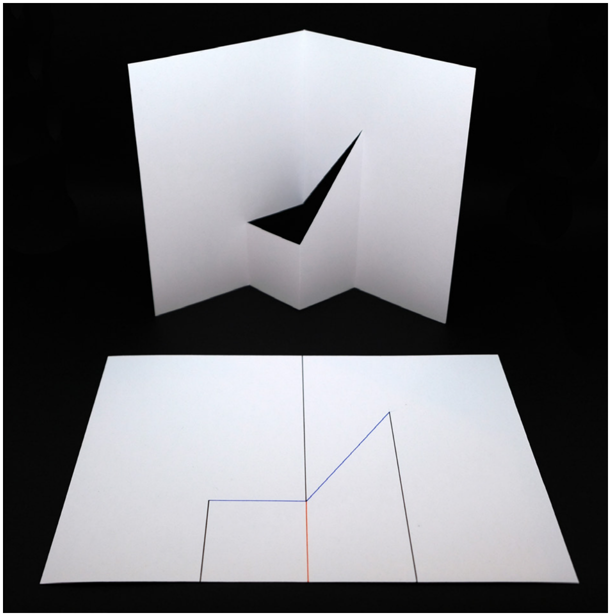
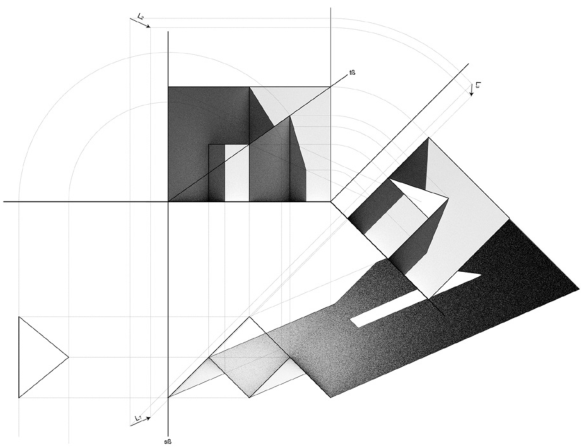


Fig. 8. Pop-up made during the course. The colored libne of the drawing identify cuts and concave and convex folds.

Fig. 9. Orthogonal projection drawing of the previous model after its survey.



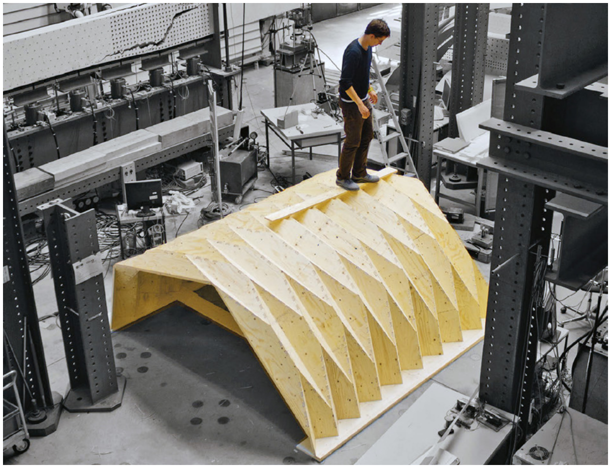


great importance within the seminar, it was then asked to the student to survey and then represent the model on paper in Monge's method with the relevant overturns to obtain the true shape of the faces belonging to inclined planes and, finally, to draw it in isometric axonometry. In a subsequent step, having assigned a light source with a centre at infinity, it was asked to represent in orthogonal projection the shadows through the intersection with secant and tangent light planes (figs. 8, 9).
From the model to the drawing then, that is, having a paper maquette constructed geometrically, trying to imagine it but without foreseeing it in detail, letting the three-dimensional form generate itself in space thanks to the tension generated by folds and cuts. These spontaneous forms, through survey and drawing, then underwent a process of engineering, inviting the student to imagine them as a concept for a design object [7], a building element (fig. 10), an urban furniture, and so on.

Conclusions

Paul Jackson states: "the transformation of a single flat sheet of paper into a three-dimensional structure without the

Fig. 10. An example of an Origamic Architecture prototype made at the ETH Zurich [Weinand 2017, p. 208].



addition (or loss) of material is a contemporary form of 'paper alchemy' that never ceases to fascinate and impress the public" [Jackson 2014, p. 8]. An attempt has been made to highlight how analogue paper models have been a privileged tool for transmitting knowledge since ancient times, enclosed in treatises that, like treasure chests of science, once opened immerse the reader in another space. Moreover, pop-up, conceived in abstractly geometric shapes, have proved to be effective teaching tools for the development of spatial imagination through simple cutting and folding operations. Finally, we could say that the analogical models described here, despite their diversity, represent an idea rather than an object, or possibly a process, the one that from the conception of form leads to its realisation through the tools of drawing, in this case generated rather than generator.

Notes

[1] The epatta of the year is the number of days to be added to the date of the last new moon of the previous year to complete the solar year.

[2] Among many possible examples, consider the treatise by Giovan Battista Della Porta (1535-1615) [Della Porta 1563].

[3] To deepen the representative strategies in De la Rue's treatise see Bortot, Lopez 2020.

[4] On this topic, see e.g. Bortot 2020; Bruschi, Grimaldi 2019.

[5] The workshop From model to design. The cut and fold in paper structures, edited by Annalisa Metus and Alessio Bortot, took place within the Drawing and Surveying workshop of the degree course in Architecture in Gorizia (23 October 2023).

[6] On the subject of cutting and folding in architectural composition, see also Zanni 2010.

[7] On the use of paper models, obtained by folds and cuts, as a source of inspiration in the field of design, see for example: Razani 1993; in the field of architecture and engineering: Weinand, 2017.

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Paper City Tales: Paper Models for Retelling Italo Calvino's *Invisible Cities*

Francesca Ronco, Giulia Bertola

Abstract

The work presented here involved the creation of paper models of Italo Calvino's The Invisible Cities *[Calvino 2009], using different paper cutting and folding techniques to invent sets, forms, structures, and backdrops.*
In the book's introduction, the author emphasizes how a layering of many elements characterizes cities. This characteristic led to the creation of models through different levels, which go to define a 'microcosm', a city in miniature perceptible through the senses, which becomes an object "to be thought, to be touched, to be looked at" [Croset 1987, p. 48].
From a technical point of view, the procedures adopted refer to research on paper folding, carried out by Joseph Albers [The Public Paperfolding History Project 2023] at the Bauhaus, those of Japanese master Masahiro Chatani [Chatani 1984] and British paper artist Paul Jackson [Jackson 2014].
Cuts, folds, linear divisions, and symmetrical repetitions make it possible to move from the two-dimensionality proper of paper to the three-dimensionality of the model. The research and related practice presented here converged in the Paper City Tales *workshop at the* Politecnico di Torino, *held in the MODLab Arch model laboratory, developed by the authors, and coordinated by Prof. Marco Vitali. This experience saw third- and fourth-year students from Piedmont high schools try to construct Calvinian invisible cities.*

Keywords: invisible cities, Italo Calvino, model, paper, imaginary cities

Introduction

The research presented here focuses on creating paper models to make Italo Calvino's invisible cities visible. The development of the theme, already dealt with from a semiological point of view by Fabrizio Gay [Gay 2015] and from a graphic/representation point of view by Mariagrazia Cianci and Daniele Calisi [Calisi 2016], has its formal and methodological roots in the thematic studies and workshops of Coca Frigerio and Alberto Cerchi [Cherchi 2010] and the board games of Bruno Munari. Architecture and the city are thought of as a large laboratory of experimentation in which Calvinian imagery overlaps with personal imagery. Just as in Munari's *Labirinto trasformabile in mille altri giochi*, these models represent "journeys into unknown territories" and "ever-changing landscapes" [Frigerio, Cerchi 2010, p. 4].
Invisible Cities are characterized by structural, spatial, and temporal nonlinearity, so they represent an open field of experimentation [Panigrahi 2017; Cavallaro 2010].
The fifty-five cities of the book are divided into nine chapters, comprising 11 sets of five cities. Their streets, squares, and stone arches are like "words or phrases stretching out in a vast network, where the inside and the outside blur" [Vrbančić 2022, p.40]. The author takes the reader on a journey between the real and the unreal, where cities contain the image of what one wants and does not have. He describes cities through relationships and exchanges, providing

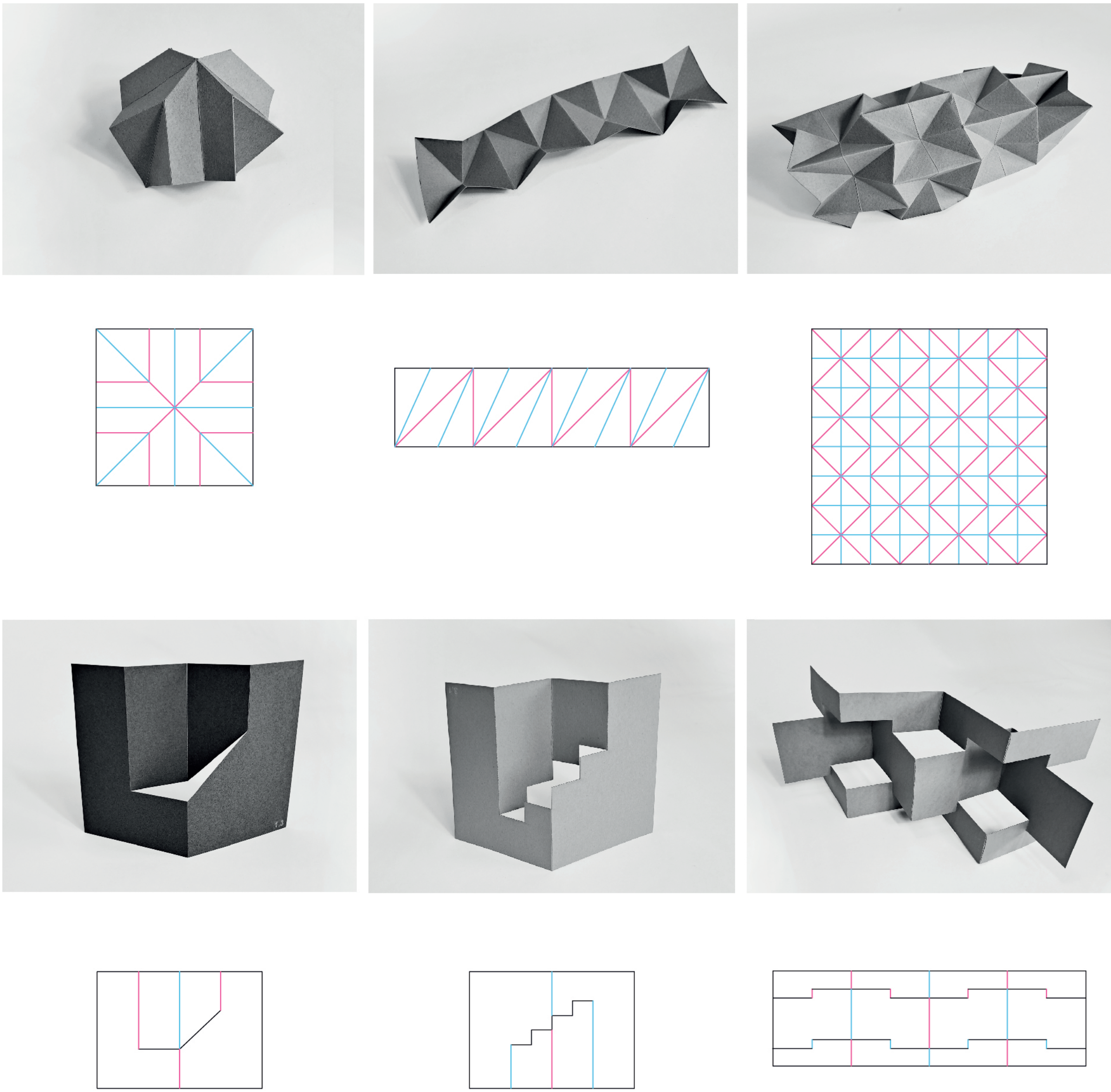

Fig. 1. Folds and cuts: in cyan and magenta the downstream and upstream folds, in black the cuts (photographs, models and drawings by G. Bertola).

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few and concise details, which leave endless possibilities for interpretation.
To this day, this text remains a landmark that has often inspired artistic and visual productions and is part of the bibliography of many university courses, including those in architecture.
Maps, cities, and narratives are always interconnected elements. Cities represent a palimpsest, a whole of intersections, points of view, intentions, and desires that form different planes and structures.
Calvinian cities are dynamic, challenging to schematize, and interconnected. Indeed, entanglement, latticework, constitutes one of their dominant topological structures (Smeraldina, Zora, Fillide, Ersilia, Armilla) [Barenghi 2009]. Each city contains the another one; maps and themes interconnect to constitute an imaginary geography. The catalog of forms is infinite: "until each form has found its city, new cities will continue to be born" [Calvino 2009, p. 140]. Each city in Calvino's text produces a narrative and logical restlessness that is impossible to read one-dimensionally.
In the attempt to transform invisible cities into visible cities, we also drew on Kevin Lynch's study, *The Image of the City* [1960], in which the author identifies the urban fabric of the main elements that define the objective public image and the multitude of individual, subjective images of its citizens.
From this basis, paper models were constructed to represent the stratifications described by Calvino and the elements we find in Lynch's work.
The following sections address the issues of the role of the model as a visualization tool, the use of paper models and techniques for moving from two-dimensional to three-dimensional space, and the *Paper City Tales* educational workshop into which these studies have converged.

The model as a tool for visualization and exploration

The model is understood here in its plastic sense, as defined by Tomás Maldonado [Maldonado 1987], a physical construct that can be modeled in a sculptural sense. This open-ended process is determined over time through continuous retouching and progressive rethinking.
Architects and designers have always used models differently as a design and prefiguration tool.

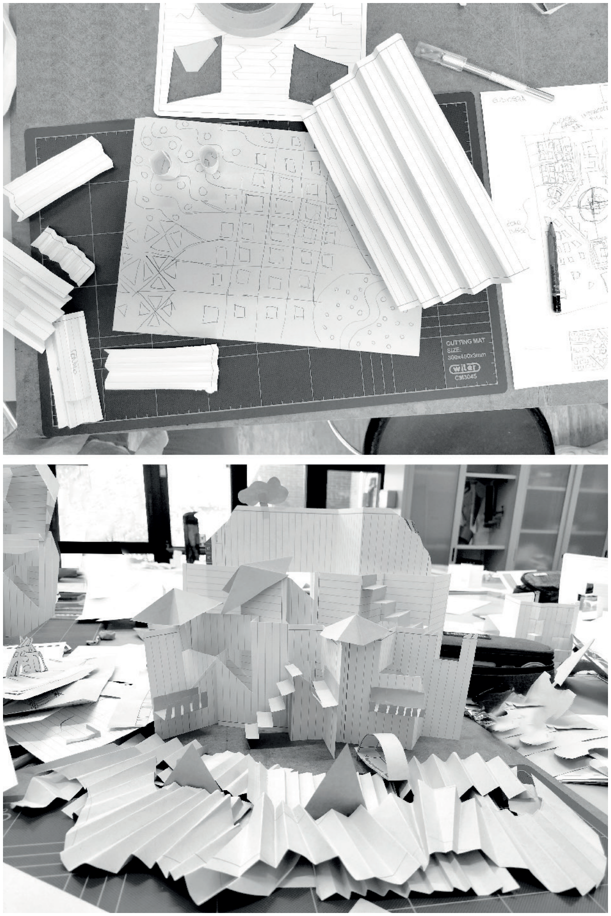

Fig. 2. Paper City Tales workshop: study and experimentation phase of papermaking techniques (photo by F. Ronco).

Fig. 3. Paper City Tales *workshop: stage of project progress, selection of paper and first tests of composition (photo by F. Ronco).*

Fig. 4. Paper City Tales *workshop: final models (photo by G. Bertola).*

Since the Renaissance, the client has been increasingly interested in 'seeing ahead', and it is this need to communicate the design that is at the origin of the profession of the architect. Indeed, the architect was born as a visualizer.
Architects use preliminary models to test and make visible ideas through simple three-dimensional forms. Because of their simplicity, these make it possible to quickly and easily study changes in the primary configuration of spaces, volumes, and masses. The activity of cutting, folding, and marking modeling materials makes the experience vivid in memory [Mindrup 2019].
French architect Le Corbusier used various materials, including paper and cardboard, to create fragile, flimsy, approximate three-dimensional models. Despite their imperfections, these models allowed the architect to study and evaluate the dimensions of spaces, the relationship of mass to other buildings, and the rhythm of openings as an idea before making final decisions.
The model is also used similarly in the design field, and this feature is particularly significant among children's products. The relationship between the child's body and physicality is strong; the user is invited to wear-ride the object.
Another essential reference for the work presented concerning the creation of spaces are the thematic workshops by Coca Frigerio and Alberto Cerchi [Cerchi 2010], inspired by the analysis of form according to the observation and practical knowledge of materials and tools and the ateliers of the *Basic Space* project promoted by the Extra association [Extra 2016, 2018], focused on paths of architectural awareness and pedagogy of making.
Starting from these examples, architecture, the city, and contaminations with different artistic expressions can become an excellent laboratory to experiment, listen, and observe history and build solid foundations and utopias for the future.

Paper model: state of the art

As is well known, physical objects result from the combination of matter and form.

Fig. 5. Paper City Tales workshop: Detail image related to the city of Isaura (model by A. Bulai, photo by G. Bertola).

The material to be modeled is usually selected basing on its ability to represent a form or emulate the material characteristics of the proposed structure.
For an architect or designer who wishes to explore how extrinsic forces can be a source of inspiration for new formal and structural solutions, the modeling material is no longer a passive receiver of form but rather an essential actor in the process of morphogenesis [Höfler 2010].
In the age of digitization, contrary to the often-imagined scenario of loss of matter to the digital, current discussions of form in design and architecture begin precisely with the study of matter.
This paper focuses on creating three-dimensional formal experiences performed on paper and cardboard by exploring their technical and aesthetic qualities. Through cutting and folding operations, one can test the performance of paper subjected to stresses of tension and pressure, obtaining prismatic, fluid, and organic figures and different perceptions of solids and voids. Numerous examples of architects, designers, and artists have been confronted with the three-dimensional paper model.
The didactic experiments performed in the 1920s at the *Bauhaus* by Josef Albers and aimed at studying the stability, load-bearing capacity, and strength of paper [Albers 1928] and those of artist, mathematician, and designer Ron Resch, inventor of geometric models for three-dimensional tessellations and undulations [Callens 2017] are particularly interesting. There are also the works of German architects Michael Hensel and Achim Menges aimed at promoting a paradigm shift toward the re-materialization of form through the development of parametric models [Hensel, Menges 2008] and those of EPFL architects Sion Hani Buri and Yves Weinand and of engineer Tomohiro Tachi based on the production of complex structures using origami technique [Buri 2010; Mindrup 2019; Tomohiro 2010].
Further references on using paper as a plastic tool of prefiguration can be found, as anticipated, in some projects dedicated to childhood and design. Paper, whether fine-grained or thick, textured or colored, white or written or even drawn, is often the medium between the user and the artifact. Examples are Bruno Munari's *Prelibri*, twelve small books of various materials bound differently, and the animated, or pop-up, books by Matthew Reinhart and Robert Sabuda.

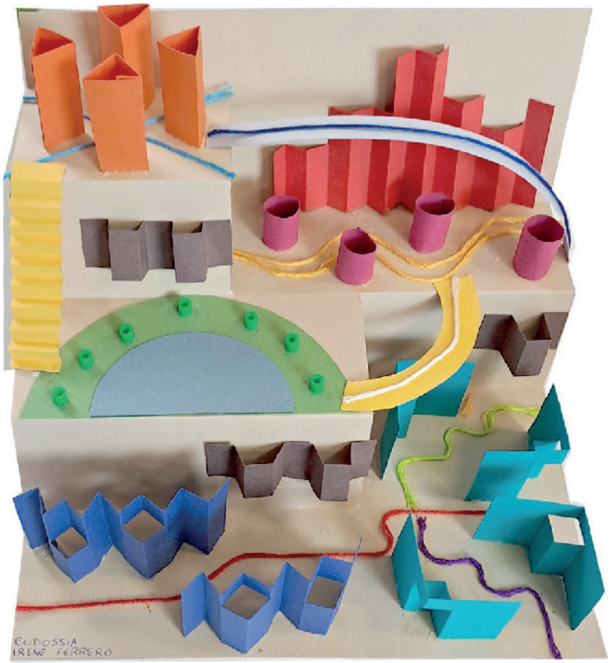

Fig. 6. Detail image related to the city of Eudossia (model by I. Ferrero, photo by G. Bertola).

Also by Munari [MunArt] are the *sculture da viaggio* (travel sculptures), while in the *Me Too Collection* by *Magis* (2012) [1], we find cardboard animal figures by Martì Guixé.
In other cases, paper and cardboard become the vehicle and support of learning methods of design processes that, starting from drawing, develop into a composition of figurative narratives, into collages, into making maps, paper models, or small shelters.
Liya Mairson, for example, with her project *My Space*, composes a series of pop-up mini-scenographies that define real spaces. Marie Compagnon, with *Habitadule*, invites, with sixteen large cardboard panels, the creation of large three-dimensional structures that are always different, giving rise to various architectures and sceneries.
Therefore, the paper asserts itself as a valuable tool for experimenting, learning, manipulating, and composing. It allows one to project from the two-dimensional plane to the third dimension and develop primary geometries or complex shapes through simple gestures.

Methodology: paper cutting and folding techniques

The proposed activity was based on two papermaking techniques: cutting and folding to make three-dimensional pop-ups.
The choice of paper varies depending on the size of the final model and must have a good balance between strength and flexibility. For example, for models of size 20 x 30 cm, the ideal paperweight is 160 and 200 g/m² and can be of different types (smooth, rough, glossy, matte, recycled paper); alternatively, thin plastic (polypropylene type) can be used. Such materials can be worked with simple tools such as 2H-type pencils, plastic and metal rulers and squares for cutting operations, bone folders, cutters, scalpels, protractors, compasses and curvilines, adhesive tape, glues, and self-healing cutting mats.
The technique used is that of pop-up, generally regarded as a three-dimensional object that takes shape when a folded sheet of paper is opened 180°; the objects inside are usually cut and glued together.
For the case study, the 90° opening pop-up technique was adopted instead, a typology popularized in the 1980s by architect Masahiro Chatani [Chatani 1984]

and called *Origamic Architecture*. This type of metamorphic operation allows, during the transition from 2D to 3D form, no loss and no addition of material: the single rectangular sheet of cardboard is initially folded in two and then opened at 90°. Attractive visual effects arise from the cutting and folding operations: each negative space is matched by a positive one, which increases visual complexity [Jackson 2014]. Pop-ups can have greater or lesser degrees of complexity depending on the number and position of cuts and folds, which can be symmetrical or asymmetrical and performed on papers of different shapes. The paper can be divided into various lengths and angles, with the help of a ruler and pencil, or even manually by performing progressive divisions (into halves, quarters, eighths, etc...). During folding operations, it is necessary to consider the downstream and upstream folds and the four basic types of two-dimensional symmetry (translation, reflection, rotation, and glide reflection) [Jackson 2011] that can be used, as well as their modifiability through the different pleating operations (fig.1).

The case study: the *Paper City Tales* workshop

Paper City Tales is the title of the workshop included within the program of *Percorsi per le Competenze Trasversali e l'Orientamento* (PCTO) for high schools, conceived and coordinated by the authors of this contribution, in collaboration with Prof. Marco Vitali, scientific referee, and with the support of the Department of Architecture and Design (DAD) and of the ModLab Arch of the Politecnico di Torino.
From a didactic point of view, the main objectives and skills to be acquired concerned the following aspects: to know how to combine humanistic, scientific, and technical-practical knowledge; to stimulate design thinking, that is, to facilitate the creative process through a sequence of phases (brainstorming, design, and prototyping); to promote a learning-by-doing approach that allows learning by using direct experience on the subject; to bring students closer to the culture of maker, digital and manual fabrication; to bring students closer to the techniques and the design language of the architect and designer; to learn how to transpose the contents of the written language through

Fig.7. Detail image related to the city of Dorothea (model by V.Togni, photo by G. Bertola).

different means of expression such as geometry, representation and three-dimensional manual modeling.
Eleven students from different Piedmont institutions of both scientific and humanities backgrounds participated in the project and were involved in the activity for eighteen hours. The first edition of the course was held in June 2023 at ModLab Arch.
On that occasion, *The Invisible Cities*, described in Italo Calvino's book, were transposed onto paper using the previously outlined processing techniques.
The proposed workflow included choosing paper, instrumentation, and presentation of the leading folding and cutting techniques and composition operations.
Students were equipped with a series of cutting and folding patterns that led to drafts on commonly used paper (fig.2) to make some compositions and evocative structures containing fragments of real cities. During the workshop activity, a great deal of freedom was allowed to go beyond the proposed techniques to experiment freely by fully exploiting the three-dimensional potential of paper in the autonomous discovery of new forms and new imagery (figs. 3-7). As Calisi stated: "representing Calvino triggers a continuous circle in which those who read imagine, those who imagine draw images, and those who look have their visions in turn" [Cianci, Calisi 2016, p. 1388].

Conclusions

The experience presented here is one of the possible applications in the field of representation for generating imagery and settings from written texts. The result was three-dimensional collages that created evocative scenarios from a few simple models. The origami architecture models provided initially facilitated the creative process, avoiding the embarrassment of the blank sheet of paper. Interestingly, starting from the same initial elements, completely different architectures and landscapes can be generated by making simple scale changes, rotations, and compositional variations.
The diversity of solutions and visions that can arise provides a counterpoint to the complexity of *The Invisible Cities* narrative. Bauci, Despina, Dorothea, Eudoxia, Isaura, Maurilia, Octavia, Smeraldina, Sofronia, Zenobia, and Zora are the cities read and interpreted, creating new pieces of the story and a new image resulting from the encounter between words and imagination.
In the field of image creation from written texts, Artificial Intelligence (AI) hints at a possible development of this work. Indeed, the rapid rise of generative AI has opened new horizons in architectural design, causing a paradigm shift. The current resurgence in interest in AI, as Mario Carpo argues, is justified due to the immense memory and processing power of today's computers [Carpo 2023].
AI makes it possible to move away from the conventional Cartesian framework, leading the viewer into the uncharted terrain of latent [Abdal, Qin, Wonka 2019] and multidimensional space told through generative models [Huang, Wang, Jiang 2023].
In this way, it becomes possible to bring previously unknown images to life from structured text segmentation and keyword identification.
This application could be helpful in the workshop context presented here, allowing for easy creation of images that could be used as a cue for the work, combining manual and virtual practice.
Calvinian cities, due to the descriptive richness of spaces, landscapes, architecture, and dimensional scales, could be well adapted to such a workflow.

Note

[1] Guixé, M. (2012). *Me Too Collection, cardboard animal figures*, Motta di Livenza: Magis 2012.

Acknowldgements and Credits

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‘Two-Dimensional’ Models. The Maquette in the Design of Architectural Façades

Piero Barlozzini, Manuela Piscitelli

Abstract

Since the 15th century, the model was used for the representation of design proposals to be submitted to the client, presented at competitions, and exhibited to the citizens to inform them of future urban transformations. We therefore find, alongside models of entire buildings, models related to individual portions object of the competition, such as domes, architectural details, façades. Representation by model allowed clients to express themselves after a critical-comparative reading facilitated by a greater familiarity with reality. The article contextualizes in the historical period and analyses examples of design models of architectural façades, a particular typology defined in the title as ‘two-dimensional’ since the possibility of relating the representation of the façade to the internal or otherwise overall spatiality of the building, which normally characterizes the model, is denied. However, they are certainly classifiable as models, both for the materials used and for the three-dimensionality of the detailed elements and the consequent effects of light and shadow that can be perceived, as well as for the modality of use that is not constrained to a single point of view as occurs in the elevation drawings, and therefore allows showing the corner solution. The analysis is carried out through the presentation of emblematic examples and their comparison with the corresponding drawings.

Keywords: façade models, prospects, design competitions, wooden model, Renaissance representation.

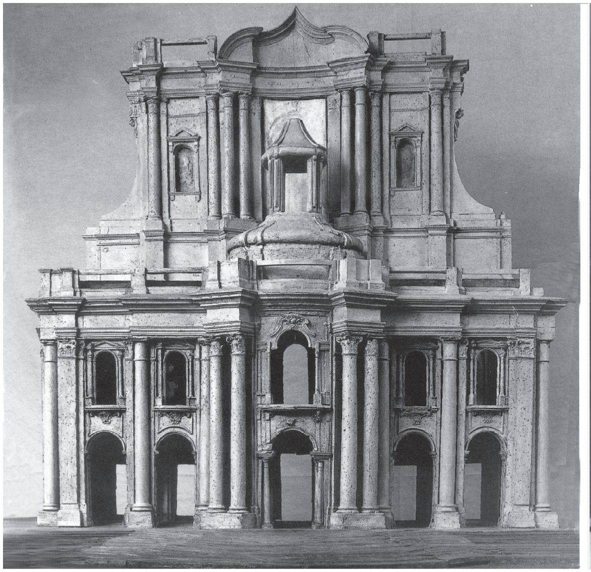
Introduction

The idea of using a material model as a vehicle for transmitting ideas has ancient origins. Indeed, Aristotle discusses this technique in his political work *The Constitution of the Athenians* [Aristotele 1999], as does Appian of Alexandria in his *Roman History* [Appiano 1972]. In his work on architecture Sebastiano Serlio also mentions the use of this mode of expression in antiquity: “The use of models is very ancient, as mentioned by Vitruvius in several places, and Cicero writing to Marcus Caecilius who wrote to Antonius” [Serlio 1584, p. 51].
With the fall of the Roman Empire came a new historical era for the European populations, terminating at the end of the medieval period, during which daily uncertainty dimmed the light of reason and sentiment. Little is known about the representation of architectural projects in this period; indeed, we can only sense an underlying continuity with the earlier expressive system given that written evidence on this subject and on the model only returns in the second half of the 14th century. It is particularly interesting to note that this occurs in detailed form during the construction of Santa Maria del Fiore in Florence [Pacciani 1987], a concurrence that the spirit of observation almost inevitably associates with the return of masonry vaults in the roofing of large buildings, in place of timber trusses [Metz 1938]. Therefore, continuing in the logic of this discussion, we may presume that the return to the model as part of a process of research and project delineation is, fundamentally, due to its specific formal and

Fig. 1: Cutaway model of the dome of Sant'Ignazio of Loyola, Rome. Author's photograph.

Fig. 2: Model of the Basilica Minor of Santa Maria Addolorata of Castelpetroso, Isernia. Author's photograph.

spatial particularities that facilitate the understanding of construction solutions. As regards when it became part of the dialogue between architect and patron/client we suggest that it was due to a change in the latter's attitude: at first work on such commissions could take a great deal of time, even lasting beyond the lifetime of the individual client, therefore it was impersonal on many levels, while from the Renaissance onwards the client wished to add a personal touch to the commissioned building, and was increasingly interested in being able to view the building 'in advance'; for the latter, drawings were still a sort of shorthand composition.
Pausing to observe the models of the great ecclesiastical buildings, housed in museums of the Italian Renaissance, it is evident that this mode of expression was used in a wide field of application. Filippo Brunelleschi, perhaps in order to keep control over his work, used plain, simple models [Manetti 1976], Antonio da Sangallo the Younger and Antonio Manetti Chiacchieri distinguished themselves for the completeness and large scale of their representations in some of their projects, while the models made in the Baroque period to give form to project proposals were distinguished by the importance given to details as well as the building as a whole.
In addition to direct experience, the opinions of other architects who worked in this historical context can be learned from reading archive documents and the treatises on architecture, which from the Renaissance onwards began to be written again, for example: Filarete held models to be useful in the dialogue with clients [Averlino 1972]; Philibert de l'Orme urged the making of partial models of an architectural work [de l'Orme 1567]; Leon



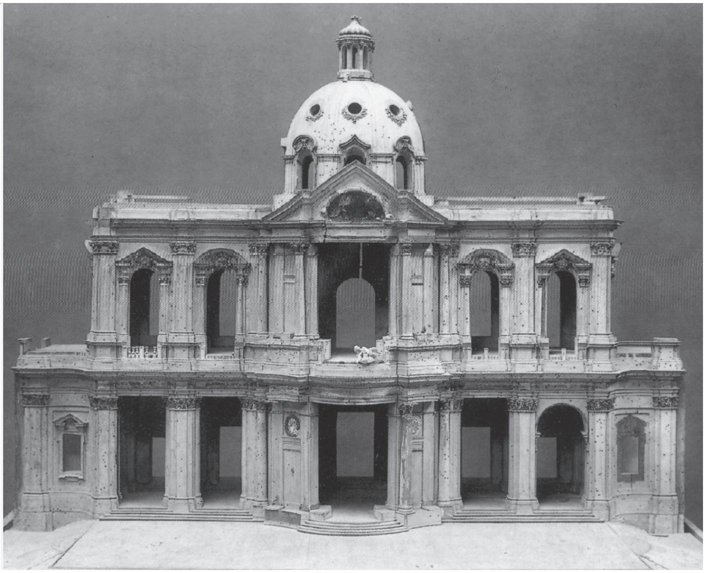


Fig. 3: Model of the façade of the church of San Giovanni in Rome: a) L. Rusconi Sassi 1732; b) G.A. Bianchi 1732 [Contardi, Curcio 1991, pp. 17, 98].

Battista Alberti better than any other author illustrated the utility of models in the education of young architects [Alberti 1989].
Bearing in mind the various points of view of the Renaissance architects and continuing with the concept that sees the reasons for which graphic representation was flanked by the plastic expressive synthesis as the only parameter of judgement, it is possible to observe various typologies of model each with their own physical characteristics and different roles in the designer's creative journey. They are isomorphic miniatures, with regard to the reality they aim to represent [Maldonado 1987], made not only for the visual and formal control of the architectural appearance or for showing the clients the results of a conceptually completed design procedure, but also for studying the most complicated building solutions [Ackerman 2005] (fig. 1). Furthermore, due to the model's appeal to the average person and the fact that its image can be contained within the visual field and, therefore, more easily explored than the actual built structures [Arnheim 1981] –in this case as Claude Lévis-Strauss observed, "knowledge of the whole precedes that of the parts" [Lévi-Strauss 2003, p. 36] overturning the process of learning– models were also commissioned as educational tools, in situations in which the active participation of the population was required during the development phases of the structure, and publicly displayed near the building site (fig. 2).

The material model as a tool for comparing design proposals

Among the patrons and those responsible for the most important communal and ecclesiastical projects in the Italian peninsula during the 15th, 16th and 17th centuries, it was traditional practice to evaluate the design solutions necessitated by the dynamics of the construction site by comparing models representing the ideas, presented by architects, painters and sculptors, either by invitation or spontaneously [Goldthwaite 1984].
In these three-dimensional representations we find the expressive power of detail that often produces a surprising and pleasant 'Gulliver' effect, an optical illusion

Fig. 4. Michelangelo Buonarroti, wooden model of the façade of San Lorenzo in Florence, 1518. Author's photograph.

produced by the dimensional disparity between observer and model. In our suggested classification such objects find a place alongside teaching models despite being partial expressions of the architectural organism; Philibert de l'Orme, as we have seen above, was a staunch supporter of this *modus operandi* [de l'Orme 1567].
Such models were almost always made of wood and were large-scale in order to show the smallest architectural details, including the artistic apparatus where planned, and in some cases even the polychrome designs for the wall decoration. Such expressive characteristics gave the chosen models normative value for the foremen working on the construction site because, as their exterior showed all the design information that was latent or hidden in the iconographic folds of the design proposal, these simulacrum of architecture *in nuce* meant that there were less details to be decided and fewer elements to study and model at life-size. Additionally, they met the needs of the citizens who were called upon to supervise the construction, but were not always capable of recognizing its actual significance just from the drawings.
As is known, drawing is the most ancient and valid mode of expression that Man has for communicating. Drawing can express thoughts and images in an instinctive or coded manner, independently of whether belonging to the real world or an imaginary one. Indeed, the line is that which joins and separates, it is the mark *par excellence*. With its variations in direction, the line can transform itself, without a break in continuity, from an outline into the image of a concrete object, narrow or defined by numerous graphic marks to then return to being an outline, shadow, fissure, or whatever else fantasy and technique permit, but all of this is only possible on a flat surface.
For people who were not educated in the reading of a project drawing, the lines positioned with erudition and dedication by the architect still represented an incoherent fabric, without logic or form. On the contrary, the model being a three-dimensional form allowed them to observe the project proposal from many angles on different eye-lines, requiring less technical competence for understanding the artistic thought. Therefore, the primary task of the models, presented in order to facilitate comparison between design proposals, was that of persuading and seducing the interlocutors, as does a teaching model. Before them, the patrons and members of the selection committees were called on to express their opinions in a phase when it was still possible to make

Fig. 5. Michelangelo Buonarroti, elevation of the façade of San Lorenzo in Florence, 1517 [Millon, Smyth 1988, p. 43].

Fig. 6. Model of the façade of Florence Cathedral: a) G.A. Dosio (1580-1590); b) Don Giovanni de' Medici (1580-1590). Author's photograph.

changes at the actual construction site. In addition, these three-dimensional models were sometimes used for estimating construction costs, as indicated by Alberti [Alberti 1989] and as a guide in the stipulation of contracts.
The models commissioned by the Comitato di Santo Spirito as aids in solving the problem of the entrances into the Florentine church of the same name, designed by Brunelleschi, are an example of this working practice [Goldthwaite 1984]. So too are the examples illustrating the proposed designs for the façade of Florence cathedral [Millon 1994], Michelangelo's 1:1 scale model made to show Pope Paul III the cornice for Palazzo Farnese in Rome [Gotti 1875, pp. 309, 310] and those commissioned by the Senate of Bologna in order to decide on the form of the vaults to cover the central nave in the church of San Petronio in that city [Millon 1994].
With the affirmation of the Schools of Arts and Crafts, during the 16th and 17th centuries designers continued to make models in order to give a form to the plasticity of their architectural ideas. Indeed, we may even suppose that in architectural competitions the use of this mode of communicating ideas even became essential, as can be deduced from the detailed account written by Francesco Velasio regarding the competition for the façade of the Basilica of San Giovanni in Laterano in Rome (fig. 1), dated Monday 14th July 1732; "This morning, the commission appointed to choose the designs for the façade of San Giovanni Laterano is to be held, and as a letter came from the Palazzo (the Vatican) stating that Galilei's drawing was to be chosen unanimously, absolutely. The experts were 6, that is two painters Concia and Ricciolini, two sculptors Rusconi and Maini, two architects Antonio Valeri and a Frenchman. They asserted to have picked Vanvitelli's drawing as their first choice, and in second

Fig. 7. Giambologna (1586-1589), model of the façade of the Florence Cathedral. Author's photograph.

Fig. 8. Model of the façade of the Florence Cathedral: a) B. Buontalenti (1587-1589); b) B. Buontalenti, small model (1596). Author's photograph.

Fig. 9. Model of the façade of Florence Cathedral: a) Academy of Art design (1633-1635); b) G. Silvani (1635). Author's photograph.

place that of Galilei, which was most plain and ordinary. Because of all this, the commission resolved that Vanvitelli should make a model with some alterations, thus remitting the outcome to the Pope's will" [Velasio 1916, p. 338].

The models of architectural facades

The typology of the façade model fits into the broader theme of models made for architectural competitions, of which it represents a specific case. Its origins are to be found in the Renaissance, in response to the need for "a language that, at its various levels, both client and craftsman could understand. In Florence, it consisted of models and drawings" [Goldthwaite 1984, p. 515]. It is from Florence, therefore, that we must start to analyse the examples that have been preserved and today constitute, together with archive documents, a precious testimony of the role they played in the design process, in the presentation to the client, in the dialogue with the craftsmen who executed them.

'Michelangelo's model for the façade of the church of San Lorenzo in Florence is emblematic in this regard. In 1516, Michelangelo was commissioned by Pope Leo X to design the façade of the church. The pontiff expressly requested the execution of twin models: one of which would be used on the building site in Florence and the other sent to Rome to allow the client to understand the details of the work, make an estimate of costs and follow the progress of the building site [Barocchi, Ristori 1965]. The pope's request was in line with his education in Lorenzo il Magnifico's architectural tradition founded on the use of models. On the other hand, for Michelangelo the model was a more suitable representational

tool than a two-dimensional drawing to convey the plastic effects of his composition. On 19 January 1518, the contract was signed in front of the model for the execution of the sculptures and carvings according to a composition "ordinata et seguita ad exemplo et proportione del modello di legname" [Bardeschi Ciulich 2005, p. 129]. It was a wooden model that included figurative and decorative wax reliefs, probably smaller than the only model that has survived, currently in the Museum of Casa Buonarroti (fig. 4). The latter, made of poplar wood and other species, has imposing dimensions: 216 × 283 × 50 cm, corresponding to a scale of 1:12 [Mussolin 2006].
It is interesting to reflect on the relationship between drawing and model. After several failures to produce a model to send to clients, Michelangelo drew executives in full-scale orthogonal projections, including the profile of a column intended for turning [Hirst 1993]. These were therefore drawings that had no specific relation or utility with respect to the realization of the architectural work but were exclusively addressed to the craftsmen for the execution of the model. The latter would then assume the role of the main executive tool for the construction of the final work. The façade was never realized, so the model, the only evidence of Michelangelo's project, was drawn in successive periods by various architects, including Giovanni Battista Nelli in 1687 and Giuseppe Ignazio Rossi between 1724 and 1730, following the custom of studying architecture through drawing and survey. Michelangelo also produced a series of sketches of the marble blocks required for the façade, complete with dimensional indications, which can be considered executive to the point of enabling James Sloss Ackerman to make a comparison between the dimensions that the façade would have had and those of the wooden model [Ackerman 1961]. As for the complete façade, a drawing by Michelangelo of the final project has reached us (fig. 5), from which the large wooden model was probably made [Millon, Smyth 1988]. Even from this comparison it is evident how the role of executive representation was delegated to the model. The drawing is in fact a perspective sketch, lacking metric indications, which seems to refer more to a design study phase than to an executive drawing. Further confirmation comes from the support, a sheet of paper with an underlying drawing and other sketches for studies of anatomical parts [de Tolnay 1975], which does not suggest a representation to be presented to the client or used on the building site. Lastly, about the effectiveness of the representation, the superiority of the model over the drawing should be noted, not only due to the clients' lack of education in reading the work in orthogonal projection and the better perceptive effect of the plastic aspects of the decorations, although not present in the preserved model, but also due to the inclusion of the corner solution. The models of the architectural façades, defined in the title as two-dimensional due to the prevalence of plane dimensions over thickness, are in fact three-dimensional models. In particular, the model of the façade of San Lorenzo is thicker than other examples, making it possible to show the side portion used as a connection with the church behind it [Ackerman 1961], the existence of which can only be perceived from the profile of the column in the drawing. It therefore allows a reading and understanding of the work unconstrained by the frontal viewpoint of the elevation drawing, which reveals the relationship with the side portions that in orthogonal projection would have required further drawings.
The importance of the design theme of the architectural façade in the 16th century debate on the aesthetic categories of religious buildings becomes most evident in the episode of the new façade for the Florence cathedral, which was a battleground between "rulers and archbishops, architects and courtiers, administrators, theorists, academics, and an embryonic 'public opinion', all naturally sensitive to the final and most representative element of the city's greatest sacred monument" [Bevilacqua 2015, p. X]. Here too, the use of the model to represent the façade played a central role, as demonstrated by the seven large wooden models now on display in the Opera Museum, which were used to present the same number of design proposals between 1587 and 1635 [Morrogh 1994]. The reason for which such models, although ephemeral because they were destined to be evaluated by the client, have survived until today, is in the length of time in which the debate and the consequent comparison of proposals remained open, without finally leading to the realisation of the proposals submitted. Leaving aside for reasons of space the well-known story of the demolition of Arnolfo di Cambio's unfinished façade [Pomarici 2004] and the projects and provisional façades that followed until the realisation of Emilio De Fabris's project in the 19th century [Zuffanelli, Faglia 1887], the focus here is on models as tools for representing design proposals. Specifically, the attribution,

Fig. 10. B. del Bianco, Prospect and painting of the façade of Florence Cathedral (1635). Author's photograph.

date and size of the seven models on display (figs. 6-9) is as follows: Giovanni Antonio Dosio (1580-1590) 258.3 × 242.5 × 41.5 cm; Don Giovanni de' Medici (1580-1590) 234 × 248 × 37.5 cm; Giambologna (1586-1589) 147.5 × 135 × 32 cm; Bernardo Buontalenti (1587-1589) 238 × 241.5 × 36.5 cm; Bernardo Buontalenti (1596) 113 × 95.5 × 19 cm; Accademia delle Arti del disegno (1633-1635) 256.5 × 241.5 × 38 cm; Gherardo Silvani (1635) 248.8 × 219 × 23 cm [Opera di Santa Maria del Fiore]. As can be seen from the dimensions shown, three of the 16th century models and the two 17th century ones are about the same size as Michelangelo's for San Lorenzo, while the other two 16th century ones are realised in a smaller scale. The level of detail is almost always very high, including the meticulous modelling of decorative motifs and in some cases the chromatic aspects obtained through painting. For all these models, the role of executive representation of the project to be submitted to the clients is evident, a role that assumed even greater strength than in the example previously treated due to the long period over which the debate lasted, the alternation of clients with different tastes, the intervention of public opinion in the debate, and the possibility of comparing the projects through the same type of complete, detailed and immediately comprehensible representation for all. They therefore stand as evidence of a design practice that assigned a primary role to the three-dimensional model over the graphic work.
The comparison with the 16th century drawings shows a clear superiority of the model as level of definition and attention to details, leaving no doubt about its function as final elaboration. Regarding the corner solution, among the models made for the Cathedral, Giambologna's provides the most information. In fact, the thickness is the greatest in proportion to the size of the façade, allowing the sides of the church to be shown to analyze the relationship with the existing side façade, which was lacking in previous projects. His design included three connections: "between the upper entablature of the model and the cornice of the nave; between the cornice of the main entablature and the balcony; between the collar of the capital below and the denticulated stringcourse" [Morrogh 1994, p. 583]. Once again, it would not have been possible to represent this information in a single drawing in orthogonal projection, and the reading on different drawings would have been difficult to interpret by clients and citizens. The connection with the side façade is also analyzed by the model of the Academy of Art design project, which also has a suitable thickness to show the sides. Of this project, we also have two graphic works (fig. 10): a drawing and a painting from 1635, attributed to Baccio del Bianco [Opera di Santa Maria del Fiore]. We can see how in this case the elevation drawing an orthogonal projection is rigorously drawn to scale with an abundance of detail. To indicate the dimensions of the overhangs, it was necessary to add a view from above with the representation of the front steps and the profile of the façade, an elaboration that was probably difficult for the clients to interpret. On the other hand, there is no indication of the connection with the side façade. This is shown instead in the painting, executed with a central perspective that leaves the main façade undistorted on the plane, but allows the depiction of the depth of the decorative motifs also thanks to the shadows and above all supports a perspective view of the side part that, although not very detailed compared to the main façade, enables to read the continuity in the steps and in the ground connection, and above in the balustrade flap. The inclusion of the characters and the hint of the urban context lend realism to the representation, making it suitable for public understanding. Strangely, the painting does not dwell on the chromatic aspects of the façade, which are instead present in the model through painting. In the comparison of the three works, the model is still the most accurate description of the project, also due to its much larger size.
The last example presented here confirms how the practice of using the model for the representation of the façade was consolidated to the point of continuing into the 18th century, a period in which there was greater graphic competence, both in the execution of the designs and in the education in reading. The model of the Trevi fountain (fig. 11) illustrates Nicola Salvi's design that won the competition in 1732 for the southern façade of the Palazzo Poli [Schiavo 1956]. The model is an exact reproduction of the graphic drawings, executive drawings in orthogonal projection, to scale and complete with every detail. In particular, the water-colored elevation also shows the chromatic aspects and the perceptive effects of the shadows. The model, on a scale of 1:15 with dimensions 339 × 184 × 67 cm, originally included the sketches of the statues and sculptures. It can once again be considered the most

Fig. 11. a) Model of N. Salvi's design for the Trevi fountain, 1732. Detail of the corner solution. [Contardi, Curcio 1991, p. 75]; b) Solution realised without flap. Author's photograph.

Fig. 12. J. Barbault, View of the Trevi fountain, 1763. Bibliothèque nationale de France.

effective representation of the project, as "by developing three-dimensionally, the model shows an important aspect of Salvi's project that the two-dimensional drawing cannot reveal, namely the continuation of the façade beyond the corners, in two side wings formed by two spans that develop in depth" [Pinto 1991, p. 70]. It is interesting to note that, although the side wings were not realized, they are present in several 18th century engravings (fig. 12), which evidently used the model and not the building as source.

Conclusion

The theme of visual representation as an expression of the design process is a structured argument in which most of the reflections written in the West found their inspiration in Renaissance documents.
Indeed, from this historical period onwards a vast literature has discussed orthogonal projections and the alternation between parallel projections and central projections in the design process. However, less attention has been paid to representation in the form of three-dimensional models [Scolari 2005], although it was already clear to the ancients that the volumes represented by drawn marks or by models are not the same given that the variations in the direction of the light offer different levels of resolution, or better: in one case movement is irrelevant, in the other the light models the volumes by highlighting solids and voids, the protrusions and recesses, through shadow play. It is precisely this effect and the abstraction of a whole series of qualities belonging to the actual phenomenon that facilitate the task of those who observes in order to understand.
The great architects we have mentioned above knew that the fruit of their labors would become a construction of enormous dimensions, seen and used by small individuals, and the model offered them an extraordinary opportunity for visual verification of the mental images given that, due to the qualities shared with the construction site, it objectively defined what on paper was only the design intention. Therefore, the making of the model represented a phase of experimentation and reflection on the design project, while for the patron, the citizen, and today the scholar who is about to analyze that extraordinary architecture, the model is the best expression for understanding the design intentions for its development on the three Cartesian axes that is closer than other methods of representation to the usual manner of perceiving reality.

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From Three to Two to Three Dimensions: Exercises for Architectural Knowledge

Paola Raffa

Abstract

The search for the spatial and formal quality of architecture still finds its best referent in the physical model. Reproducing the material texture of built architecture communicates the idea of form and volume that is presented in real space. Models, in the construction of image sequences, reproducing existing or designed buildings, fulfill the task of tools for knowledge.
The underlying rules of architecture materialize, deconstruct and reassemble in a dialectical process in which thought takes form and becomes space.
Representing an architecture by separate parts, selectively describing its characteristics, reducing them to fragments of compositional units, and then reassembling them in their configuration, becomes a useful cognitive exercise in the investigation of architecture.
A tool of study, investigation and interpretation, the model represents an intermediate figure between the imaginary and reality. In the form of ideation it is anticipation of spatial organizations; in the form of representation of the existing it becomes a process of control and analysis.

Keywords: physical model, simulation, figuration, observation, architecture.

Simulation and figuring

The model is a tool for visualizing and controlling space, a step of technical and theoretical knowledge of architecture. An intermediate figure between the imaginary and reality.
In the *Preface* to issue 32 of the 1987 review *Rassegna*, editor Giovanni Vragnaz writes that: "The model is an instrument of representation […] an instrument of verification, often temporary and partial […] an instrument of poetic declaration" [Vragnaz 1987, p. 5] [1] a vehicle for the transmission of ideas. In the way of ideation it is anticipation of spatial, constructive, syntactic organizations. In the way of simulation, representation of the existing or unbuilt, it becomes a conceptual process of control and analysis, capable of defining and communicating character and content of architecture in a continuous dynamic of dimensional and relational connections.
The model "thus evokes the notions of measure, norm, rhythm, mode, limit, until it assumes the Platonic sense of 'ideal form' of paradigm on which material existences are regulated" [Croset 1987, p. 47] [2].
Through the model, architecture is conjugated by two instances of the triad with which Vittorio Ugo articulates representation: *mimesis* and *metresis*. The 'imitation' as physical correspondence, the 'mesurement' as compartability. The model is thus an artifice that through simulation, participates in the process of figuration of architecture and expresses the theoretical value of its compositional parts. An object that mediates between the abstract and reality,

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between imagination and figuration. As one of the possible forms of representation, the physical model constitutes an instrument of visual simulation, which, however, represents only part of the properties of its referent.
During the 2008 Venice Biennale, *Out There: Architecture Beyond Building*, director Aaron Betsky, argues that architecture is not the building, it is instead the way of thinking and talking about buildings, it is the way of representing them, of giving them form. The architecture of a possible world is expressed in physical models to offer concrete forms and seductive images. In the Australian Pavilion titled *Abundant*, 300 models built to a scale of 1:100 are exhibited (fig. 1). Some two hundred participants including professional studios, academies, artists and students were involved in developing models that interpret the aesthetics of Australian architecture, past and present. A forest of yellow aluminum pedestals, supporting discs and celebrating, in their diversity, the hybridity of Australian architecture in the twenty-first century. The models are not all completed, but the materials are homogeneous and the colors coordinated. This was intended to emphasize the conceptual approach from which the meanings of Australia's heterogeneous architecture are derived. The form of architecture lies not in the actual built configuration but in the concept it expresses.
In the same exhibition, Alejandro Aravena proposes *Elemental*, the outcomes of workshops conducted together with residents of the Quinta Monroy neighborhood of Iquique, Chile. Each family designs and colors its own house, based on an essential typological model that is repeated (fig. 2).
The theoretical level of the model lies in the dialectical mechanism between being the object of representation and the self-representation [Holtrop, Princen et al. 2011]. In the 1976 exposition *Ideas as Model*, Peter Eisenmann reformulates the meaning of the model in terms of an object capable of opening up reflections on the design process. A tool for study, investigation, reading and interpretation capable of establishing new forms of balance between representation and reality [Eisenman 1981].
Eisenman's experimentation with card-board houses (1967-1975) represents an example in which the role of the model and its potential is clearly discernible: "starting with the geometric datum, the foundation for architectural construction, he proceeds to its deconstruction, through deformation first and decomposition later" in a spatial dislocation "implemented by moving from one sense, one direction, one meaning, one plane, one space, to another, to the apparent non-sense, non-direction, non-significance, non-plane, non-space" [Ciucci 1995, p. 8] [3]. The model

Fig. 1. Abundant, 2008. Exhibition of the Australian Pavilion at the 11th Venice Architecture Biennale (photo by the author).

of House X (fig. 3), is realized by moving from the space of construction and axonometric representation, to the space of the image: "The axonometric model denies the rotation of both the object and the observer, forcing this and that to the immobility of the one determined point of view" [Ciucci 1995, p. 9] [4].

Representation and critical observation

The transposition of an architecture from its two-dimensional extension to a new material configuration becomes a process for knowledge and analysis [Florio 2020, p. 123], it represents in fact, a privileged means of understanding, as it assumes the role of foreshadowing the quality and theoretical conception that supports it.
The scale of representation of the model expresses the general structure and form of the architecture, the composition it takes on in space, but also the quality of the space, such as its exposure to light, its plastic body, "the figure in short that architecture takes on in manifesting itself" [Cellini 2006, p. 93] [5] and, when one "scaling the scale of representation" the syntactic composition of languages emerges in a theoretical synthesis of historical and cultural orientations.

In the transition from drawing to model, the passage from a mathematical dimension to a physical dimension induces a comparison between two entities, belonging to different realm and placed in relation. The mathematical dimension belongs to the world of scientific exactitude, the physical quantity belongs to the real world of approximations. Measurement in architecture is understood as synonymous with dimension and "assumes great importance especially because of the relations that the various metric systems have […] with the definition of the dimensional scales typical of the different compositional poetics" [Sacchi 1994, pp. 73, 74] [6]. Moreover, measurement, in architecture, is not an exclusively technical datum, but tends to the definition of relationships between parts, thus of proportions, and not least, to the configuration of images that delimit a portion of built space.
The repetitive formulation of the measurement defines a purely mathematical relationship that, while being related to the configuration of the architecture, e.g., the score or rhythm, expresses above all "an invisible rationality of the building" [Sacchi 1994, p. 85] [7] in which the qualitative dimension of the measure implies a proportional structure.
In the model, the algebraic reduction deduced from the drawings is transformed into empirical simulation in which all "the expressive capacities of the scalar dimension"

Fig. 2. Alejndro Aravena, Elemental, 2008. Exhibition at the 11th Venice Architecture Biennale (photo by the author).

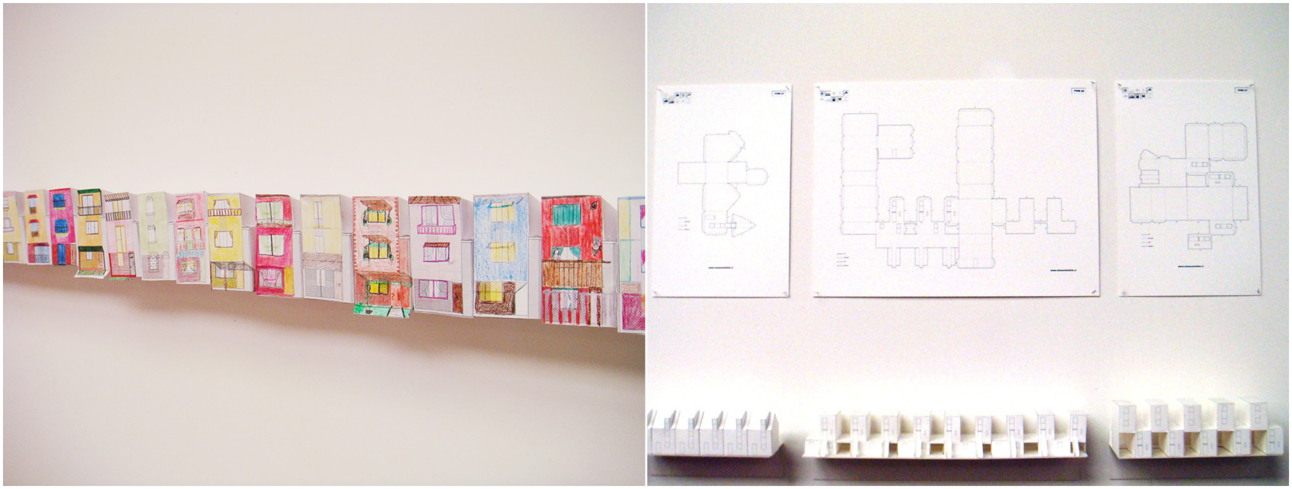
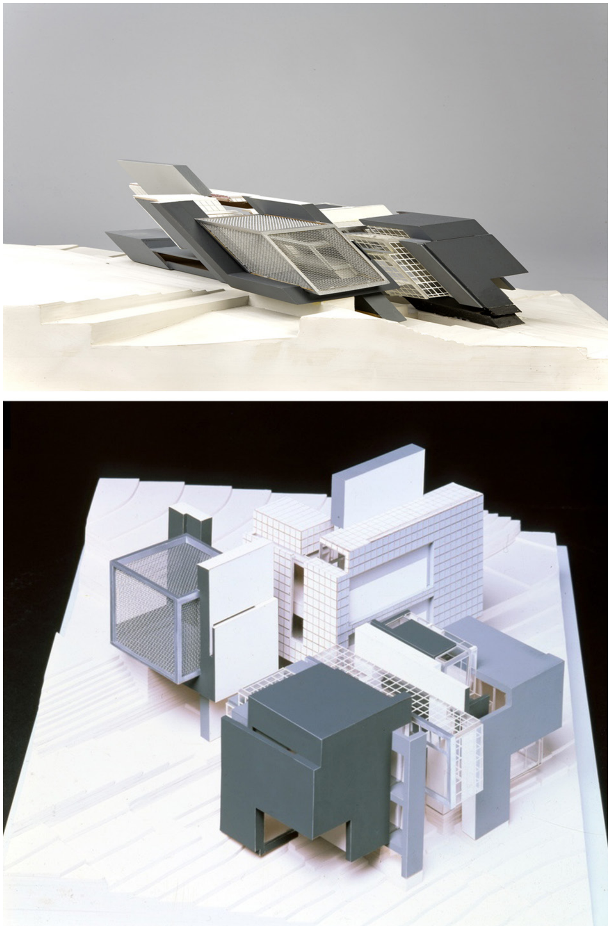


Fig. 3. Peter Eisenman. House X, 1976: <https://eisenmanarchitects.com/House-X-1975> (accessed 30 April 2024).



[Pacciani 1987, p. 9] [8] are concentrated, highlighting the formal relationships, between dimension and proportion.
The model is revealed as a system of signs and forms drawn from the construction, or the field of representation, aimed at defining a configuration of signs and forms belonging to another system of signs and expressive codes, organized in sequences in which a continuous relationship must be established between drawing and physicality. A perennial relationship between the physical world and the world of signs given by the progressive intermediation to which our experience unites us [Florio 2020, p. 126].
The model is thought as a composite set of morphological units in homogeneous sequences. The function of representation applies simultaneously as deduction and as configuration [Croset 1987, p. 48].
Thus, it is not the act of imitating the form or reporting the exact dimensions, but it is about activating all those processes of aggregation of parts for the purpose of reproducing certain aspects and values of the represented architecture. It is about programming knowledge, rationality, technique, procedures and tools to reproduce a series of configurations outcome of the cognitive process of analogical thinking or deduction of graphic tracing. The purpose of the model will take into account reliability and similarity "playing in the artifice the role of the artifact" [Guillerme 1987, p. 31] [9].
The model, understood as a reproduction of architecture, thus refers to the concept of similarity [Maldonado 1992]. The observable object is subjected to judgment and critical analysis in direct relation to the gaze, but also to touch. Taken as a perspective representation whose purpose is control over the overall appearance, as a simulation of vision, it expresses issues pertaining to the three-dimensional configuration that architecture assumes in space.
The critique of the gaze is characterized by a logical-deductive process, given by the reduction by parts of the compositional elements, from which result hierarchies, systems of interconnections, relationships and, on the part of the observer, the consequent attribution of meaning.
An observation is a programmed perception that instructs the exercise of understanding through the relations in which the empirical world appears [Arnheim 2007].
The gaze is aimed at directing mental activity toward the attribution of meaning to each element. An extreme abstraction of the parts is useful in understanding how their meaning does not necessarily belong to the form, but can be expressed in the relationships that hold them

together; because the parts of the architecture, which are found in the abstract two-dimensional configuration, are representations of elements of three-dimensional space. The relocation of the parts, from the space of the two-dimensional representation to the three-dimensional space of the model, induces a shift from a two-dimensional control of the elements, almost always in frontal view, to that of "their weighting in a three-dimensional space in which, among other things, of fundamental importance turns out to be the movement, the lack of a privileged point of view" [Pagnano 2003, p. 11] [10] that an observed element takes on in space.
Space is no longer rigidly defined by the rules of projections, perspective or axonometric, and elements assume different positions and can therefore be interpreted differently.
The model gathers a descriptive synthesis of architecture, it in fact allows one to perceive and manage a complex reality through "a cognitive strategy in which the idea of similarity with respect to reality plays a decisive role" [Migliari 2004, p. 47] [11] a system of symbols that, according to Claude Levi-Strauss, unlike the reality one has the power to manipulate.

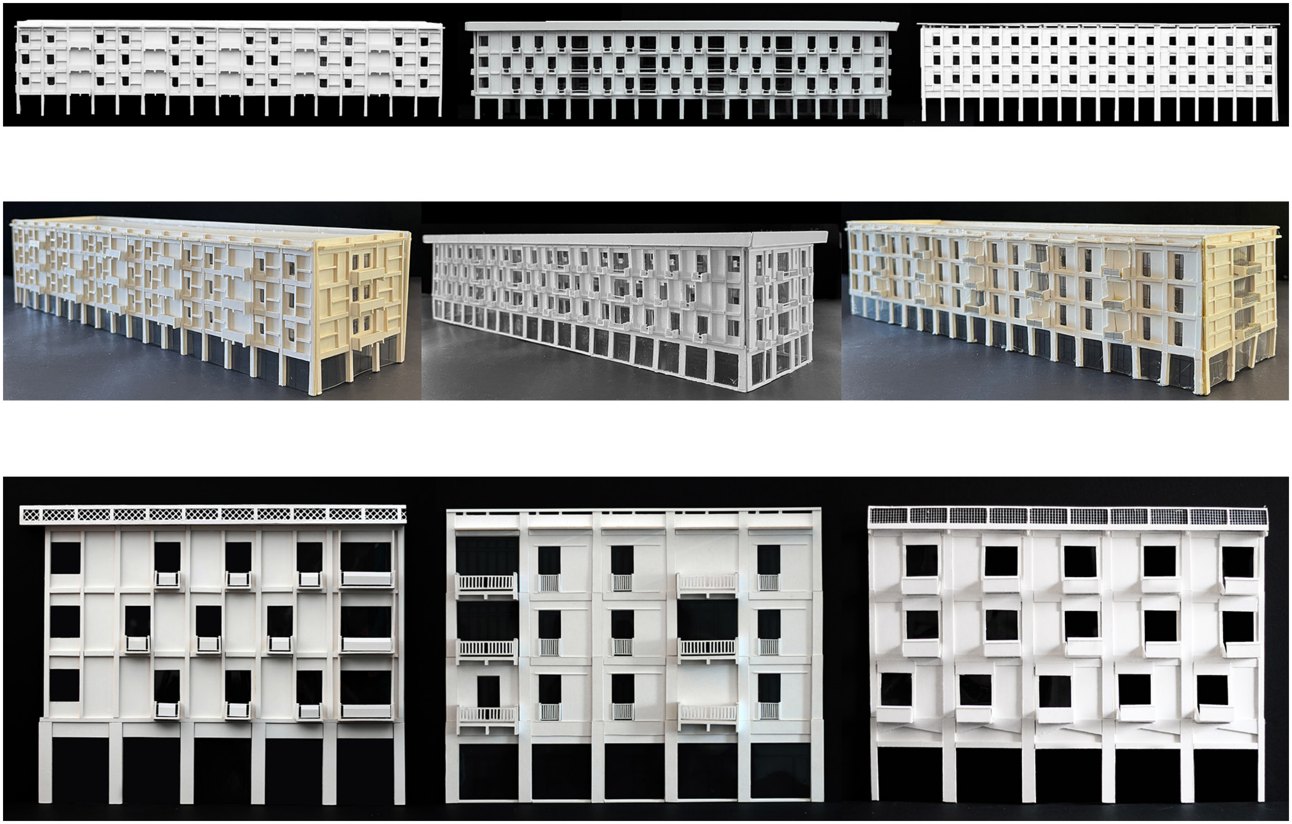
Exercises for knowledge and analysis

In real space, strictly in three dimensions, the vast amount of data is reproduced in analytical schemes that refer to concrete materials. Visual works, Pierre Francastel argues, are acts of figurative language, ordering principles of the process of interpretation and knowledge inferred from the relations of analogy with the real world. The apparent coincidence between model and representation and the full correspondence between the plane of representation and the plane of construction is expressed in the gaze of the observer through physical perceptions, the elements of construction, and indirect perceptions, symmetries, proportional ratios, balances [Migliari 2004].
Programming to construction the physical model, the documentations impose a deductive investigation for the selection of the elements to be reproduced. It proceeds by logical deductions, in which through simplifying processes a reduction of details is implemented, without, however, denying or altering the fundamental characteristics of the referent.
The disaggregation of the elements, into disconnected components and the necessary logical-sequential re-aggregation, leads to a process of knowledge, which through the recognition of the parts necessarily highlights relationships and hierarchies in a volumetric dynamism that gets rid of the 'privileged' viewpoints of traditional representation and allows a simultaneous vision in spatial discontinuity.
The aim of building a physical model, in its visualization dimension, which refers to the field of figuration, is to generate critical knowledge.
The process of model production is aimed at the search for form in space, linguistic syntax, identification of compositional matrices inherent to the design process, geometric ratios, functional relationships, and aggregative logic. The deconstruction of parts into physical conformative elements and theoretical deductive trajectories becomes a tool for learning and analysis.
The exercise of physical reproduction in addition to empirical knowledge of the work brings one closer to theoretical reflection, a critical exercise that connects architecture to compositional theory; the model design becomes a project of subassemblies that will have to be relocated following the theoretical value of the work. The model is constructed, therefore, by discontinuous and partial fragments.
The systemic attitude of rhythm and repetition in the module of the facades of seven of the eleven buildings of the Cortina del Porto of Messina, designed by Giuseppe Samonà between 1952 and 1958, gives the architecture a high unity in the transition from the scale of detail to the city. The dimensional regularity of the form of the facades allows a dynamic relationship of forms and elements to be defined, and allows control of the theoretical input in the configuration of the architecture. The detail of architecture and the urban facade are treated with the same theoretical approach, that of the repetition of an order declined according to the pure geometric language of rationalist architecture. The rhythm of the span has no physical limit. It remains open, undefined, a Miesian 'defining rather than a confining', emphasizing the infinite declination in the combination of parts. The two-dimensional transcription in the CAD environment, of the direct survey of the facades and the realization of the analog model in white cardboard, at the scale of the city, architecture and detailing constitutes an interesting cognitive exercise of the logic-deductive type of architecture.
In the different scales of the model, the configuration of the architecture is shown in the reproduction of the span and finds the character of the urban space in the shape of the blocks and their aligned arrangement. The abstraction of facade models is directed to show the relationships

that hold elements together in the configuration of parts. Transferring the three-dimensional reality to the geometric plane and still transport to a codified three-dimensional level simulates the process of abstraction and conceptual re-composition of the project.
The focus is on the qualitative difference of the span in which the clarity of the compositional character, order and measure highlight the identity of the entire urban compartment.

The modest presence of thickness in Samonà's facades and the modularity of surfaces, emphasizes a vertical building and the pronounced prominence of balconies accentuates grazing shadows. Each building subtends a syntactic order that is repeated in the building that precedes it and in the one that follows it; the alternating composition of the bays and the prominence of the balconies and loggias exclude them from the banal and from that 'linguistic routine' that finds in modernism the academic conventions of architectural identity.

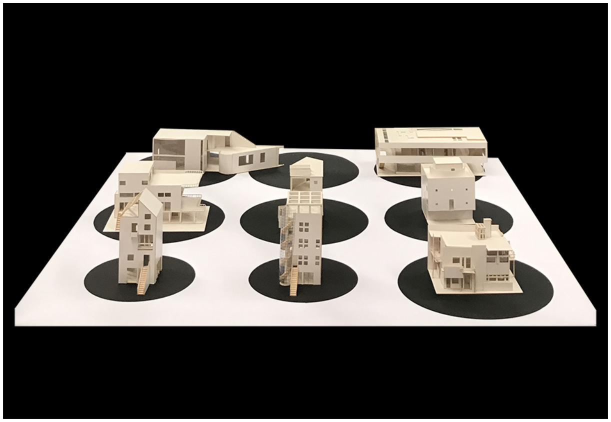
Fig. 4. Cortina del Porto of Messina, models of the facades and urban block, scale 1:200; models of the spans, scale 1:50 (Course of Architectural Drawing 2008-2012, Mediterranea University of Reggio Calabria, Prof. P. Raffa).



To overcome the limits of material physicality, each model made at the scale 1:200 is joined by models of the facades at the scale 1:100 and of five spans of the facade at the scale 1:50 (fig. 4).
"Classical theory assimilates the maquette to a perspective representation whose purpose is to judge the 'overall effect' of the building [...] this does not mean that the maquette can represent all the features of the building" [Croset 1985, p. 48] in order to achieve a deeper knowledge "it is advisable according to Alberti to employ 'numerous' maquettes, in order to reach [...] that point of certainty which is attainable only when each architectural element is precisely defined" [Croset 1985, pp. 48, 49] [12].
The single-family tower houses proposed by Osvald Mathias Ungers for Marburg [Ungers 1977] constitute a variation on the theme of the urban block to the point of total deconstruction into individual dwelling units measuring 6.5x6.5 m for a height of no more than thirteen meters.
The production of 1:100 and 1:50 scale models of the thirteen typological declinations set on a constant grid in plan and volume shows how morphological unity is not given by the homogeneity of formal language but by the mutual interaction between each unit (fig. 5).
The model belies the one axonometric view in which houses are represented as isolated units and highlights the network of relationships established by their different possibility of aggregation, and the definition of different figurative compositions.
In the production of the architectural model whose purpose is that of compositional research and comparison between the parts, the dialectical overcoming of the antithesis between two-dimensional representation and 'spatial construction' is symbolized by the use of white cardboard, an aseptic dimension, of vague Suprematist conception, in which through the simplicity and linearity of the material the theoretical concept prevails over that of the real. And Philippe de l'Orme is of the opinion that monotonic and even imperfect models should be proposed "as long as their proportions and measurements are well respected" [Croset 1985, p. 50] [13] to ensure the relationship between the parts.
The control of the form of an architecture through the model recalls the concepts of harmony and proportion, in which the possibility of deconstruction and re-aggregation of volumes, or of parts in general, allows for the enunciation of geometric, morphological, and dimensional declinations, but also of relationship, perception, and communication [Albisinni, De Carlo 2011].

The International Garden Festival of Chaumont-sur-Loire is a competition that has been held every year since 1992 from November to April with the realization of winning gardens design. Twenty gardens of about 200 square meters surrounded by a hedge with the perimeter of a bell become places of sensory experimentation. A sequence of ephemeral gardens that deal with plurality of languages and symbologies; they are episodes of the gaze and the senses made with temporary and reversible materials not bound to long duration.
The representation of a garden is a issue of signs. Each sign in fact expresses a changing condition that refers to a configuration capable of translating the image of a changing reality. Vegetation must be represented from a process of interpretation and selection capable of highlighting the characters of the plant element, of aggregation with other similar elements, of the formation of space.
For the building of the models of the Chaumont-sur-Loire gardens, it was necessary to describe the individual materials in topological terms and reduce the vegetation types to schematic form. The juxtaposition of different materials and different properties ensured the physical nature of the represented object while leaving out mimetic characteristics.
The model of the gardens (fig. 6) is made at the scale of 1:100 by referring to the design drawings. The relationship between the material and the object represented in the

Fig. 5 White cardboard models for architectural knowledge and analysis, scale 1:00 (Course of Architectural Drawing 2016-2018, Mediterranea University of Reggio Calabria, Prof. P. Raffa).



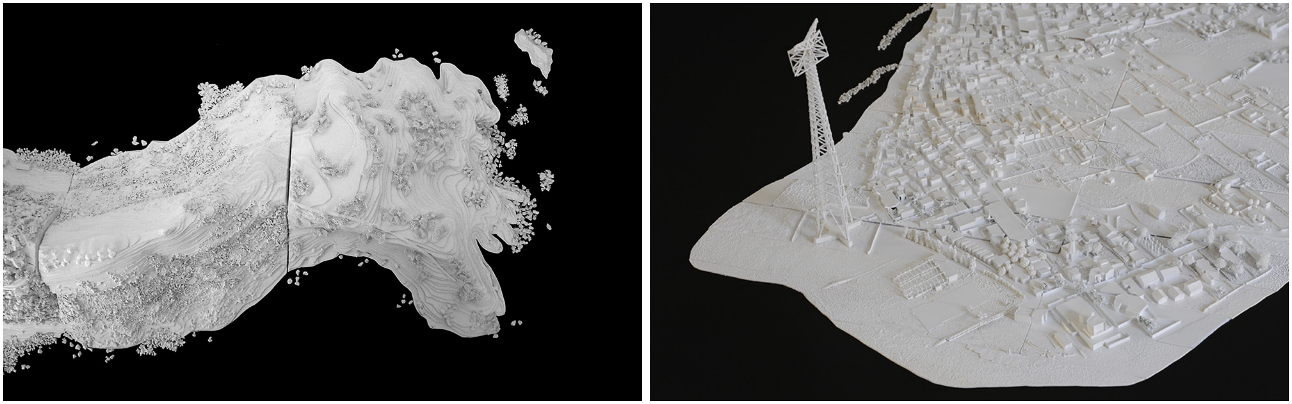
model lies in schematic abstraction and synthesis, in expressive meaning rather than simulation.
For surfaces (paths, lawns, pavements, platforms) and linear elements (hedges, bushes, baffles, benches) the material analogy is reproduced with sheets of colored cardboard of different thicknesses, wooden strips, balsa wood, cotton thread, wire mesh, but also with natural materials such as seeds juxtaposed to reproduce roughness, abrasive papers or sands. For the reproduction of trees, a repertoire of shapes associated with the most common species was created: iron wires shaped in the shape of tree crowns, or coiled into spirals for branches. Textures, textures and colors, respond to tactile and visual needs, to reproduce expressive rather than imitative values of the physical characteristics of each element.
The model for territory knowledge presupposes a high capacity for synthesis and schematization, in which form, size and matter must overcome the mimetic limit and lead each element back to the schematic characteristics that make it recognizable in repetition and juxtaposition.
The scale of representation and the choice of material become the main conditions for the management and reproduction of the lay of the ground, the volumetry of the built elements, the different types of vegetation. The overlapping of sheets of cardboard, the thickness of which should correspond in scale to the value of the equidistance between the contour lines, will serve for the modeling of the terrain, the schematic volume of the buildings will include only the trace of the holes and the roof course, with the same level of schematicity the streets, squares, walls, the lighting system will be made [Colistra 2003]. Important becomes the definition of the themes that the model wants to communicate since the overall finish depends on this, such as treating the entire portion of the area with one homogeneous color or highlighting the different thematic areas with different colors (fig. 7).

Fig. 6. Models of the projects for the Festival of Gardens of Chaumont-sur-Loire, scale 1:100 (Course of Landscape Representation 2010-2012, Mediterranea University of Reggio Calabria, Prof. P. Raffa).

Conclusions

The usualness of virtual models, the abundance of information of intangible places that can replicate visual conditions and simulations of spaces, puts us in a position to associate virtual visualizations with the real world; however, the real, tactile and qualitative conditions of natural light, for example, are confined to two-dimensionality. The search for spatial and formal quality, that is, that portion of space carved out of the physical world that is transformed by the insertion of a new organism still finds its best referent in the physical model.
The model "in its dimension as an object interacts with the physical world through the control of form and the use of the senses" [Migliari 2004, p. 19] [14] reproducing the material texture of built architecture communicates the idea of space and volume that occurs in real space.
Models, in constructing sequences of images that reproduce existing or planned buildings
fulfill the task of tools for knowledge. The underlying rules of architecture are materialized, deconstructed and recomposed in that dialectical process in which thought takes form and becomes space. Representing an architecture by separate parts that selectively describe its characteristics, reducing to fragments of forms, compositional units and then reassembling them in their configuration becomes a useful cognitive exercise in the investigation of architecture.
In order to give figurativeness to architecture, "it is necessary to produce, albeit synthetically, an analytical scheme that allows the functions of design elaboration to be read coherently […] this is made necessary in order to bridge the growing gulf between conception and realization, but also to give the design text a more unambiguous and objective character" [Ragazzo 1996, p. 19] [15].

Fig. 7. Models of Capo Milazzo and Capo Peloro, scale 1:500 (Course of Architectural Drawing 2010-2012, Mediterranea University of Reggio Calabria, Prof. D. Colistra).



Notes

[1] «Il modello è uno strumento di rappresentazione […] uno strumento di verifica, spesso temporanea e parziale […] uno strumento di dichiarazione poetica» [Vragnaz 1987, p. 5] (translated by the author).

[2] «evoca così le nozioni di misura, di norma, di ritmo, di modo, di limite, fino ad assumere il senso platonico di "forma ideale" di paradigma sul quale si regolano le esistenze materiali [Croset 1987, p. 47] (translated by the author).

[3] «a partire dal dato geometrico, fondamento per la costruzione architettonica, procede alla sua decostruzione, attraverso la deformazione prima e la decomposizione poi» […] «attuata spostandosi da un senso, una direzione, un significato, un piano, uno spazio, a un altro, fino all'apparente non-senso, non-direzione, non-significato, non-piano, non-spazio» [Ciucci 1995, p. 9] (translated by the author).

[4] «Il plastico assonometrico nega la rotazione sia dell'oggetto, sia

dell'osservatore, costringendo questo e quello all'immobilismo dell'unico punto di vista determinato» [Ciucci 1995, p. 9] (translated by the author).

[5] «la figura insomma che l'architettura assume nel manifestare sé stessa» [Cellini 2006, p. 93] (translated by the author).

[6] «assume grande importanza soprattutto per le relazioni che i vari sistemi metrici hanno […] con la definizione delle scale dimensionali tipiche delle diverse poetiche compositive» [Sacchi 1994, pp. 73, 74] (translated by the author).

[7] «una razionalità invisibile dell'edificio» [Sacchi 1994, p. 85] (translated by the author).

[8] «le capacità espressive della dimensione scalare» [Pacciani 1987, p. 9] (translated by the author).

[9] «svolgendo nell'artificio il ruolo dell'artefatto» [Guillerme 1987, p. 31] (translated by the author).

[10] «loro ponderazione in uno spazio tridimensionale nel quale, tra l'altro, di fondamentale importanza risulta essere il movimento, la mancanza di un punto di vista privilegiato» [Pagnano 2003, p. 11] (translated by the author).

[11] «una strategia conoscitiva in cui gioca un ruolo decisivo l'idea di similarità rispetto alla realtà» [Migliari 2004, p. 47] (translated by the author).

[12] «La teoria classica assimila la maquette a una rappresentazione prospettica il cui scopo è quello di giudicare l'"effetto d'insieme" dell'edificio […] ciò non vuol dire che la maquette possa rappresentare l'insieme delle caratteristiche dell'edificio» […] «si consiglia secondo Alberti di impiegare "numerose" maquette, allo scopo di raggiungere […] quel punto di certezza che è raggiungibile solo quando ogni elemento architettonico è definito con precisione» [Croset 1985, p. 48, 49] (translated by the author).

[13] «basta che le loro proporzioni e le loro misure siano ben rispettate» [Croset 1985, p. 50] (translated by the author).

[14] «nella sua dimensione di oggetto interagisce con il mondo fisico attraverso il controllo della forma e l'uso dei sensi» [Migliari 2004, p. 19] (translated by the author).

[15] «occorre produrre, seppur sinteticamente, uno schema analitico che consenta di leggere in modo coerente le funzioni dell'elaborazione progettuale […] ciò è reso necessario per colmare la crescente divaricazione tra ideazione e realizzazione, ma anche per conferire al testo progettuale un carattere più univoco e oggettivo» [Ragazzo 1996, p. 19] (translated by the author).

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Models of Structures, Structures of Models

Ingegna Romana.
From Sources to Models, from Artefacts to Reconstructions

Adriana Rossi, Claudio Formicola, Sara Gonizzi Barsanti

Abstract

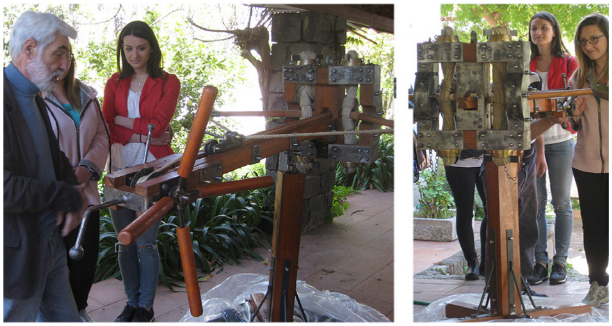
We present an aspect of the research activity shared with the students who approached the topic: Comparative Analyses and Certified Reconstructions for a correct experimental archaeology of Roman artillery. *The occasion seemed useful to reflect on the tangibility of models in which to break down, in the light of current technologies, the configurations between material and immaterial values. For this purpose, we present surveys of physical reconstructed prototypes of catapults from the imperial republican era, based on three types of sources and tested in operation. Moving from the interpretation of the photogrammetric acquisitions to the numerical control of the models based on reality, we look at the dialectical tension between opposing past and present paradigms: survey/design, analogue/digital, tangible/intangible. The transversal aspects of the phenomena related to ontologies that characterize the commensuration of components and building systems, i.e. material, cultural and thus historical, stand out as multidimensional vectors potentially capable of directing cultural policies. Advanced visualizations, based on the rewriting of ancient obsidian histories, promise in the case study to become flywheels for the redevelopment of archaeological areas even of considerable renown.*

Keywords: Roman artillery, digital culture, physical model, virtual model.

Introduction

It was in the 1980s when the School of Architecture in Venice was addressing the 'philological excavation of architecture', while the School of Milan was focusing its attention on the survey for the analysis of urban and territorial problems [Manieri Elia 1983, p. 93]. 'Operational criticism' was spreading in Italy and beyond the Alps to overcome the dichotomy between practice and theory [Tafuri 1969, p. 177]. The themes addressed, laden with the principles that characterized graphic representation in that historical period, focused on the need to appreciate the 'already made' as 'text'. Interpretation, as an intellectual lever [Dal Co 1999], has allowed a host of masters of undisputed calibre (too many to mention without omitting any) to claim an independent space for the elaboration of original and transversal thoughts guided by the acquisition of data and oriented by their graphic processing. Following in the footsteps of Luigi Vagnetti [cfr. Vagnetti 1971; 1972], they claimed, in other words, the disciplinary autonomy of survey and drawing: systematic action aimed at extracting geometric and dimensional properties, proved to be a 'picklock' for raising objectionable issues through repeatable and comparable procedures. 'Designing' (hence the term 'Drawing') went beyond the limits of being a mere tool at the service of Design, qualifying as a 'metaphor' for architecture, recognised as such even by experts in other fields [Lampugnani 1982]. An opportunity to test the criteria underlying the discipline, the adjustment imposed by years of computer revolution. The collection of articles and lectures printed by James S. Ackerman [Ackerman 1991; 2002] offers a framework for the transformations on the way the architectural project is disseminated: in those years, analogue/digital and physical/virtual recurred as recurring oppositions. In the notion of the model, a place was found where the antinomies could be diluted. The anthology of writings edited by Riccardo Migliari in 2004 [Migliari 2004] provides themes for reflection. Several of the authors whose papers are collected in that volume have continued to explore innovative paths, persevering in the challenges posed to the Science of Representation. Towards the current demarcation of concepts/meanings that, in more recent years, the contents of that volume have fuelled a fervent debate on the shift towards digital culture [Brusaporci 2019], the use of the interpretive model and in particular its visualization in the context of cultural heritage [Hodges 2020]. More modestly, the essay intends to draw attention to the multiple dimensions of the model to highlight its heuristic role, based on the ability to understand the content in order to act accordingly. A content that advanced techniques enrich. The case study is, consequently, a pretext chosen for the purpose of bringing research activity closer to teaching experience. The model, even the one that the "ancients built with their hands" [Scolari 1988, p. 137], refers, in fact, to an all-encompassing experience in which the antinomies –old (relief/project), new (real/virtual/tangible/intangible)– are diluted, showing the transversality that is established between the poles of a unitary, cyclic and interactive pathway, by virtue of which the mind perceives, looks, knows, reads and interprets.

Fig. 1. Scorpione. Prototype reconstructed by F. Russo (2014) on the basis of the modiolus found in Ampurias (Spain); LabTAR students (prof. A. Rossi a.y. 2016-2017) visiting the Officine di Archeotecnica.



The practice of constructing 'models' on the basis of technical drawings, which became systematic in the 15th century, had multidirectional uses from the outset: Filippo Brunelleschi used them to convince patrons enraptured by the realistic views of painters [Manetti 1976, p. 117]; Filarete regarded them as an erudite tribute for patrons [Filarete 1972, vol. I, p. 40; p. 207]; Leon Battista Alberti used them to verify the calculation of 'symmetries' [Alberti 1966, vol. I, pp. 860-862] while Michelangelo built them to provide the site with a safe guide [Millon 1988]. Giorgio Vasari, on the other hand, introduces an entirely new aspect, reporting on the precision to the nearest centimetre sought in the construction of maquettes in which the wall textures and architectural mouldings of practicable interior spaces were miniaturised [Millon 2002]. A leap that, manifesting the desire to observe the very small and the very large, demotes the possibility of zooming in on details, navigating not only in space but also in time [De Luca et al. 2023] of faithful copies that, for all their informative aspects, prove to be 'twins' of physicists [Grieves 2011].

Materials and methods

In presenting the case study, we have kept in mind the objectives outlined in the *Introduction*: on the one hand, we wish to persist in reasoning on the ontological identity of the notion of model, which, in its evolution, records the metamorphoses of culture, declining the variation of canons and epochal processes; on the other hand, we wish to give substance to the applications that computer research offers, directing them towards a shared thematic knowledge that is both flexible and inclusive as well as implementable. It is within this argumentative context that the no-contact survey of some working prototypes of Roman catapults, known as 'scorpions' in the military jargon of the 1st century B.C. and A.D. eras, is framed. The reflections that follow are restricted to the aspect shared with groups of students who, at the three university levels, have touched upon or approached the subject in a broader and recently funded research project [1].
Compared to architectural artefacts, the catapults elected as emblems of application are small in scale but for this reason emblematically suited to the understanding of the rules of composition. At the basis of the weapon's proportioning is in fact the measure of the module, based on which Vitruvius imposed the commensuration of the parts

[Vitruvius 1758, III, I, pp. 91-101] and, from the Renaissance to the present day, the exegesis of his passage incisively affected the way architectural organisms are analyzed and designed in the West. Mediating didactic aspects and the interests of students and researchers, we visited the workshops of Archaeotechnics to handle and in some cases test (fig. 1), physical (analogue), fully functional prototypes of Roman catapults reconstructed in full scale (1:1) by engineer Flavio Russo, consultant and collaborator of the Army General Staff. All reconstructions, the scholar explains [Russo 2004, p. 44], are based on:

1. the analysis of artefacts found, identified, and inventoried [2];
2. the study of the few scientific volumes and articles written on the subject [3];
3. the technical translation of fragments of classical works directly interpreted by the Russian in comparison with what is available in the literature [4];
4. the verification of functioning physical prototypes.

Supported by the scientific evidence of the paleo-reliable and transparent sources [UNESCO 2003; 2009; 2019], comforted by the omnipresent quotations of Russo's texts by anyone who has tackled the study of Roman artillery in our times and, last but not least, enthused by the all-round experience offered to the students of the Advanced Representation Techniques Laboratory (Lab/TAR) laboratory activated at the Department of Engineering, Università degli Studi della Campania *Luigi Vanvitelli* since the 2014 academic year, the work phases were arranged in order to transfer technical skills and scientific knowledge. The results were then shared by opening the doors of the laboratories with citizens and technical staff from private public bodies. Building a bridge between the Academy and the area in which the Department is located is now a constant commitment at all levels of the activities undertaken.

Operative phases

The catapults studied were manufactured using technologies and techniques congruent with the period of reference: the structure is made of wood and the armouring is of matt metal. The materials therefore prove to be compatible with the use of the chosen surveying technique. Close-range photogrammetry, Structure from Motion (SfM), made it possible to reconstruct the three-dimensionality of the machines' exterior with millimetric precision and

Fig. 2. SfM survey of the reconstructed prototype of the scorpion by F. Russo (manu balista) on the basis of the archaeological findings in Xanten (2008), (digital elaboration by the Lab/TAR students, prof. A. Rossi a.y. 2021-2022; tutor S. Gonizzi Barsanti). Phases: a. alignment and position of the images around the object during the survey; b. sizing of the bounding box and scaling; c. 3D dense point cloud; d., e. 3D mesh.

3. Blindfolds of the propulsion unit ('capitulum') found in Emporiae Spain, (courtesy of F. Russo).

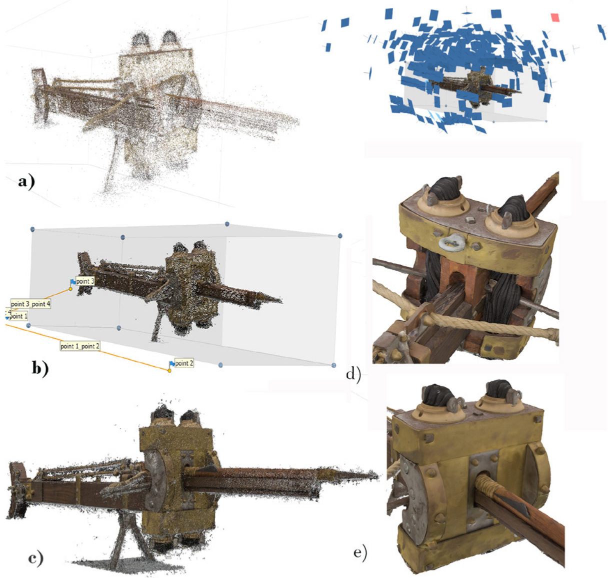
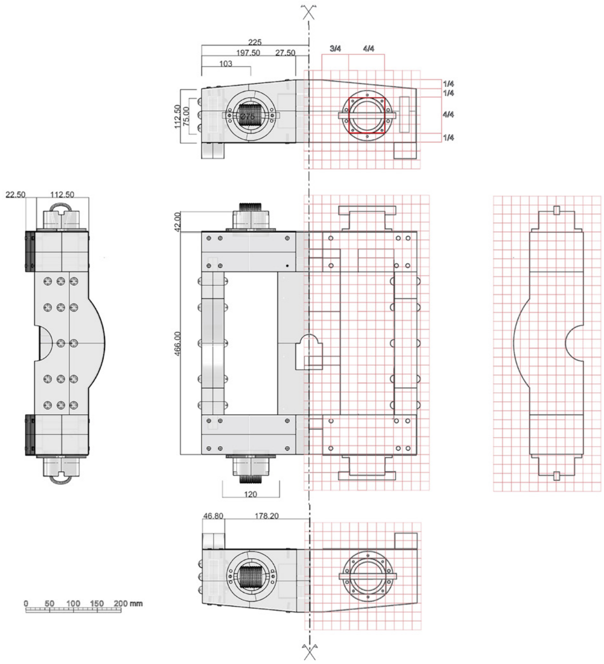


photo-realistic accuracy. For this purpose, the students' mostly SLR cameras proved functional. In dim light conditions and compatible shadows, a series of shots were taken from different angles along a 360° path around the object to cover the entire surface. Good image quality was achieved using an 18 mm lens with a diaphragm set at 9 and ISO at 500. The captured shots, subject to the necessary basic precautions, were processed with *Agisoft Metashape 2.1.1 Professional*. At the end of processing, the software generated a textured polygonal mesh of satisfactory quality (fig. 2).
The orientation process of the individual frames is fully automatic, based on the recognition of homologous points between pairs of stereoscopic photos in which exposure differences are minimal. The intersections of projective beams provided the spatial configuration of

Fig. 4. 'Capitulum eutitone' commisuration [Vitruvius 1758, X, pp. 418 and foll.] on the basis of the 'modiolo' found in Ampurias (digital elaborated by S. Acerra, R. Anzalone, F. Damasco, Lab/TAR a.y. 2017-2018, reconfigured and corrected by the tutor C. Formicola).



the point cloud, an initial approach to the reality-based 3D model. The greatest difficulties encountered concerned the definition of thin parts, such as the arching strings or the cusp of the darts. The triangulated cloud, appropriately scaled, cleaned and decimated with different degrees of detail, was texturized, using the same photographs. The result, overall satisfactory, returns the three-dimensional and photorealistic shell of the 3D model, which can be measured and exported in an .obj or .stl format or other extensions compatible with vector modeling programmes. It is indeed necessary to do a semantic partition of the parts of the surface, producing the trajectories of the contours congruent with the functioning of the components.
To this end, the manageability of the physical prototypes facilitated the task, motivating researchers and students engaged in 'transducing' the characters that identify the continuity of form, from an analogue to an equivalent digital signal and thus referred to the mathematics of the discrete.
Before the construction of the models there is the reasoning on the proportioning of the parts in the meaning given by Vitruvius [Vitruvius 1758, III, I, pp. 91-101]. At the basis, therefore, is the measurement of the '*modiolo*', which in technical jargon identifies the internal diameter of the flanges on which the elastic hank rests. The term, handed down to us by the same treatise writer [Vitruvius 1758, X, 9, pp. 401-405], betrays an obvious architectural derivation. As in classical temples the diameter of the column proportioned the parts and the whole according to '*symmetria*' [Migliari 1991], so the small module (hence the diminutive '*modiolo*') provides the guiding principle for proportioning the parts that archaeological findings make objective and the missing parts that the repeatable and criticizable procedure makes methodologically grounded. The prototype reconstructed by Russo is calibrated on the remains of the artefact from Emporiae, in Spain [5] (fig. 3). All the ratios of proportions of the organs of these weapons are calculated on the basis of the length of the dart they are to shoot, the ninth part of which corresponds to the diameter of the hole in the frame of the *'capitulum'* (the propelling unit) through which the bundle of twisted fibres that support the arms passes' [Vitruvius 1758, X, 9, 1-4, pp. 401-405]. In the light of Vitruvius' passage, it should be reiterated that the unit of measurement of the weapon, i.e. its module, is equal to 1/9th of the length of the dart. Consequently, the same

length and width of the drive ('*capitulum*' for Vitruvius) must be a multiple or submultiple of this module. The axes, upper and lower of the frame, defined peritreti by Vitruvius, must have a thickness equal to one module and a width equal to one module and three quarters [in the middle] and one module and a half at the ends. This is followed in *Book X* by indications that are not always clear, but which, Erwin Schramm's, Dietwulf Baatz's, Eric William Marsden's and other authors' texts [Schramm 1918; Baatz, Feugere 1981; Marsden 1969], due to their substantial concordance, help to resolve, at least in terms of the morphological aspect [Russo 2002, pp. 232-243].
The commensuration exercise proved to be a training ground for researchers and students who, in short, were able to contribute effectively to the definition of 'constructive' designs [see Galiani, in Vitruvius 1758, p. 5]. The results (fig. 4) are in turn a prompt for the formalization of ready-to-use information, which has much in common with the current way of proceeding in standardized production [Gaiani 2006].
Point clouds imported into Rhinoceros 8.0 and placed as the origin of the workflow, guided the vector modelling of the scorpion of Ampurias, so-called because it is calibrated to the size of the *'modiolo'* found near the Spanish town. The views derived from the 3D reality-based model were compared with the executive plans drawn up for the reconstruction of the physical prototype [Russo, Russo 2008] and digitised in the same software environment (fig. 5). The geometric modeling process did not present any executive difficulties (figs. 6, 7). The process was based on the morphological synthesis of graphic primitives and in a few cases, translations or rotations of generators along lines or tracks. Indeed, the characteristics of neuroballistic machines leave no room for free-form drawing [Valenti 2022, pp. 87-102]. Even the reduction of models to parametric form has no reason to be dynamic due to the configuration derived from the tight commensuration of each part to the whole that leaves nothing to subjective arbitrariness. Instead, it is almost indispensable to be able to scale each element proportionally to be able to move swiftly from the configuration of '*maneschi*' (hand-carried) to large, fixed scorpions [6].
That techniques are never neutral with respect to outcomes is a well-known truth [De Simone 1990]. Still relevant today is the use of the 45° square for the construction of the axonometries disclosed by Abbot William Farish in 1840. Even though the procedure was already

Fig. 5. Executive plans (courtesy of Archeotecnica).

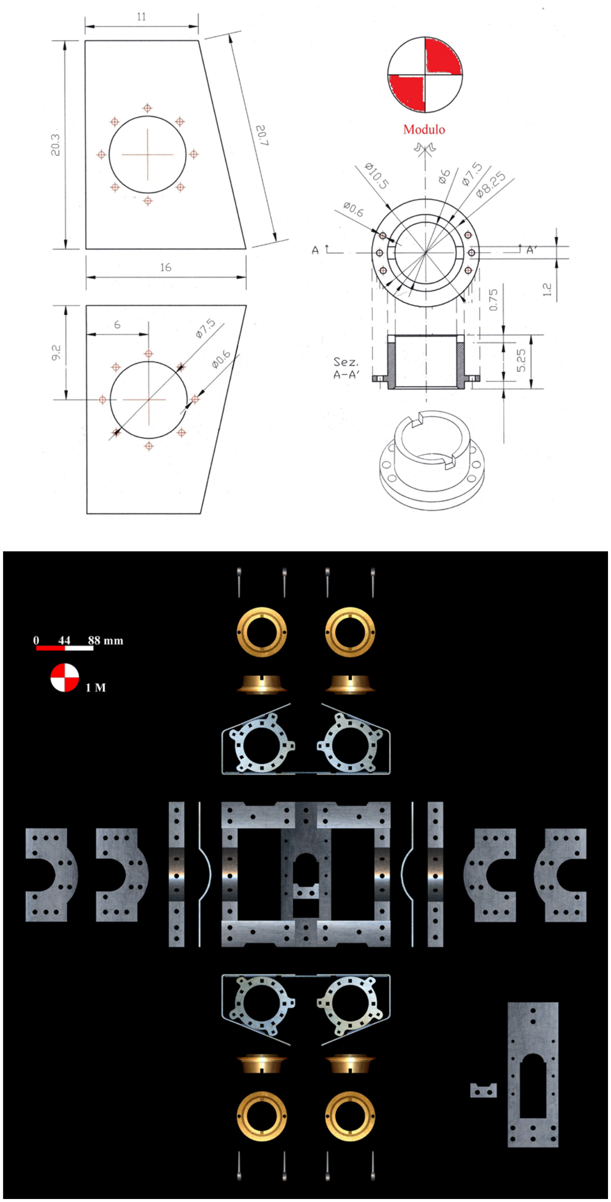
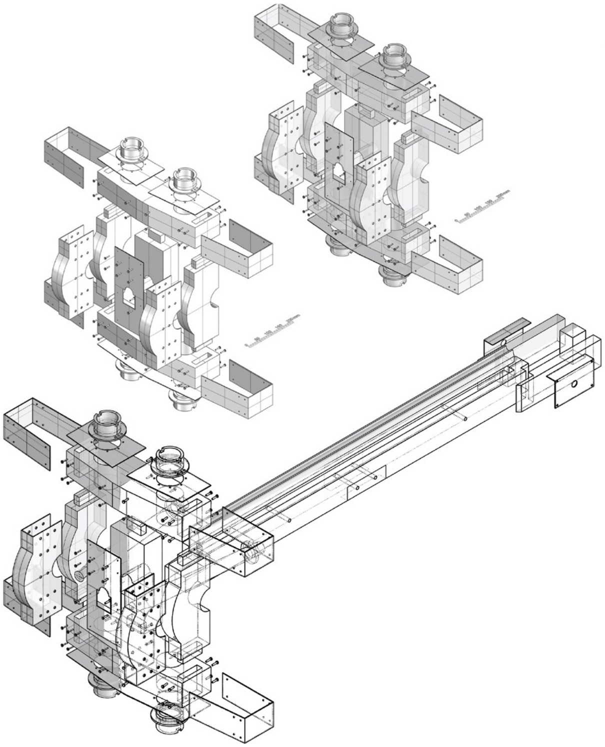


Fig. 6. 'Capitulum eutitone'. Isometric axonometric view of the model (graphic elaboration by the Lab/TAR students a.y. 2017-2018; shaded, semitransparent view reconfigured by the tutor C. Formicola).



known to Luca Pacioli, Nicolò Tartaglia and in France to Oronce Finé, the 'oblique' drawing was shown to renew the way of thinking [Scolari 2005] affecting the industrial production of the time and in the following century the research of architectural forms [Reichlin 1979; Sartoris 1983, pp. 82-93].
The speed of execution, not secondary to formal clarity and immediate measurability, has, in the present case, guided hand and mind to an initial control of the geometric configuration (fig. 8c).
Digital modeling integrates and accelerates the dialogue with one's intelligence, introducing a third element between hand and mind. Pre-set instructions condition the results based on technical ability: experienced critical skill is required to obtain views that have communicative quality. These, in addition to communicating obvious properties, must be able to express attributes; computer design makes transparent readings-interpretations: at each stage the appropriateness of the choices can be compared with the propositions taken backwards. In addition to distinguishing between analysis or project drawings to interact with the forecasting system, the operator is enabled to consult databases and archives.

Objectives achieved and in progress

The models presented, circumscribed to a case selected from the exercises conducted with the *Laboratorio di Tecniche Avanzate della Rappresentazione* (Lab/TAR; Advanced Techniques of Representation Laboratory) students (figs. 8a, 8b), document the convergence of three models: the geometric model that translates the analytical structure into an equivalent figurative system; the mathematical model that makes the problem formulation concrete; and the simulated model that verifies the algorithmic characteristics. The syncretic nature of the construct facilitates the organization of data according to strategic objectives. Although the analogue information provided by the material prototypes (fig. 9) has to date proved to be much richer than that shown by the numerical models, we look at the hardware and software solutions that integrate *Model Theory* [Hodges 2020], Visual Science and Graphic Science in the representative model. The resulting cultural product goes beyond the traditional confrontation-help provided by maquettes, to generate a conceptual space in which antinomies can be broken down and relief/design, signifier/meaning, material/immaterial dialogue can take place. The applications show that they accompany the direct observer with the 'physicality' of a digital construct. There is no deception, but integration in the image of the differently tangible perceiver [Jenkins 2007]. 'Real' and 'Virtual', far from being opposites, identify a problematic field in which the protagonists are the users [Lévy 1995] who are invited to rectify with their imagination the perception of what they have sensitively experienced [Brusaporci 2023]. In step with the times, the experience conducted looks at the advantages contained in the possibility of studying the very small and the very large on the same model that has become the collector of an overlapping and navigable information system, an implementable geography of multidimensional knowledge [Comte et al. 2024]. Valorizing the now recognized archaeological findings of Roman artillery, defining a protocol for the construction of physical and digital artillery of the period, providing

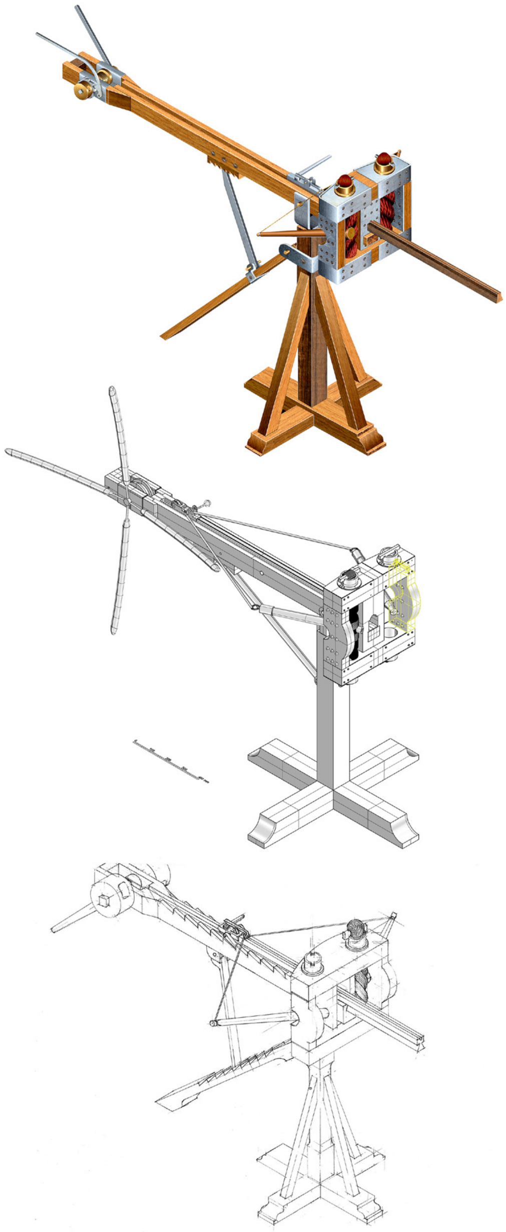
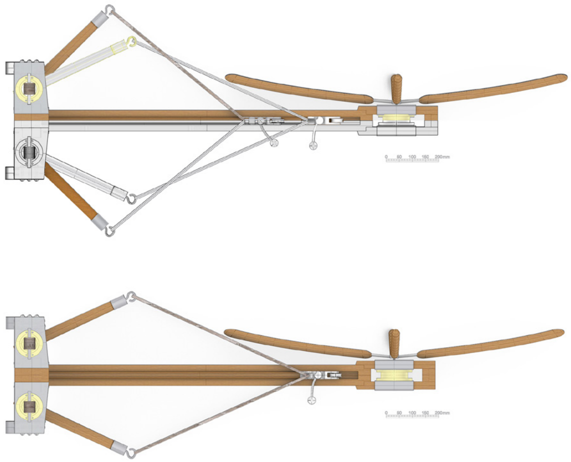


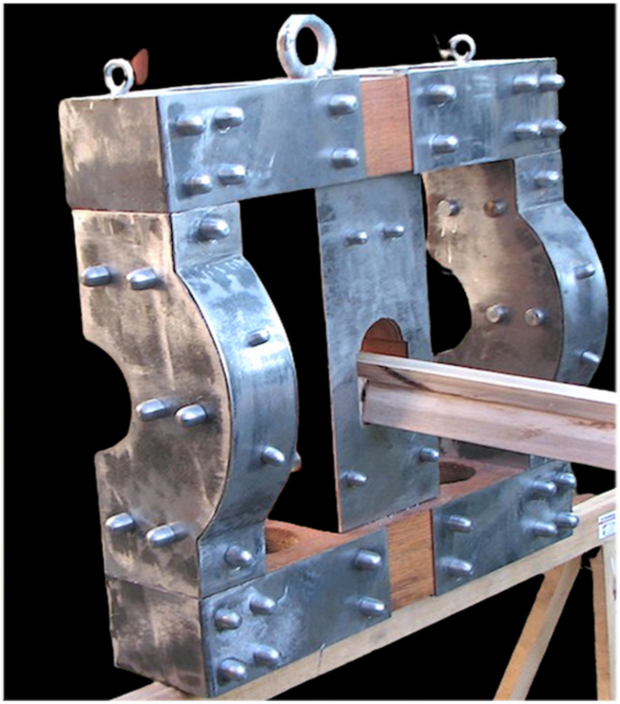
Fig. 7. Horizontal view of the model. Movement of the arms at rest and in loading (Lab/TAR students, a.y. 2017-2018; reconfigured views by the tutor C. Formicola).

Fig. 8. Scorpion of Ampurias. Comparisons of physical models. Form top to bottom: rendered view of the model; shaded view (Lab/TAR students a.y. 2017-2018; reconfigured by tutor C. Formicola according to an optimized swing concept); study isometric view (A. Rossi for Archeotecnica).



details for a better historical understanding of the oxidional investments of archaeological areas, is the final goal approached in stages. To date, the above contents seek the convergence of teaching and research. The sharing of workshop outcomes with secondary school pupils and local administrations has shown on a small scale what is hoped for on a large scale in the field of digitization and technology transfer of the shared and interoperable theme to different user levels: from scientific research to gaming and entertainment, culture and tourism, and services.

Fig. 9. Archaeological outcomes of the 'capitulum' found at Ampurias (courtesy of Archeotecnica). Model used for digital reconstruction.



Credits

Author Contributions: Conceptualization: A. R.; methodology: A. R.; software: C. F., S. G. B.; validation: A. R.; formal analysis:A. R.; investigation: A. R., C.F.; data curation: A. R., C. F. S. G. B.; writing original draft preparation: A. R.; writing review and editing: A.R., S.G.B; supervision: A. R. All authors have read and agreed to the published version of the manuscript. F. S. G. B.; writing original draft preparation: A. R.; writing review and editing: A.R., S.G.B; supervision: A. R. All authors have read and agreed to the published version of the manuscript.

Notes

[1] Project SCORPiò-NIDI. B53D2302210 0006 PRIN 2022 D.D. n.104 /02-02-2022 Prot. 20222RJE32, ERC Area SH5 'Cultures and Cultural Production' admission to funding MIUR D.R.n.10790/2023.24 months, from 1/X/23. P.I. A. Rossi. Members for the UNICAMPANIA unit: Sara Gonizzi Barsanti, Silvia Bertacchi, Claudio Formicola. D.R. 10790/2023. P. I. Prof. Adriana Rossi, University of Campania Luigi Vanvitelli.

[2] Some thirty *modioli*, all of bronze except two; half a dozen arresting harpoons, six hank holders of various workmanship and sizes, one of which was made of bronze; a *kamarion*, several iron and bronze armour plating for catapults and ballistae, a frontal shield and some fragments of a winch.

[3] In chronological order are the texts by Escher 1867; Schramm 1918; Marsden 1971; Garlan 1974; Wilkins 1995.

[4] The indications given by Heron of Alexandria (1st century AD), the dimensioning given by Bitho (2nd century BC) and handed down by Philo (3rd century BC) in the *5th Bok of Mechanical Syntax*, as well as the proportional ratios of the components described by Vitruvius for the catapult [Vitruvius 1758] are fundamental.

[5] Preserved at the Ala Ponzone Civic Museum in Cremona, they were measured and examined by Russo in 2014 by kind permission of the Museum.

[6] '*Eutitone*' if the arms rotate outwards from the fulcrum; 'palintone' if the movement is reverse: Filone, Heron, Marsden [Russo, pp. 86 and foll].

[7] Oronce Finé went so far as to bring back to the angles of oblique figures those '*metriae*' that would give rise to the name 'axonometry', although it would take Ludwig J. Weisbach (1806-1871) and Karl Pohlke (1810-1850) for the method to be codified.

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Stage Space Maquette: Device of Illusion and Theatrical Practice

Massimiliano Ciammaichella

Abstract

Between the Renaissance and the Age of Enlightenment, the theatrical spectacle moves from the static image, of the fixed scene, to the changing image of moving backdrops that simulate the centrality of frontally arranged spaces, evolving them into the Bibienesque corner view. The perspective's theories and methods are progressively absorbed by empirical staging inventions, while drawings of individual apparatuses and machines that reveal their kinematics are often fragmentary. Even more so are the analog models, traces of which remain only in sporadic reconstructions displayed in exhibitions: they are magic boxes suitable for rediscovering the perspective space dimension, evoking the original mise-en-scène *configurations.*
The essay rereads the maquettes by relating them to the iconographic and textual sources that determined their design logic. The burgeoning literature reflecting on the practices of theatricality from the second half of the sixteenth century onward is analyzed to rediscover the fundamentals of relief perspectives and the determination of the optimal point of view, starting with the constructive rules of the stage, evident as in the treatises of Scipione Chiaramonti and Nicola Sabbattini. This makes it possible to trace the real spatial configurations of the contexts in which the performances took place, while also verifying the proportionality relationships of the proscenium arch, which can be inferred from the study of the frontispieces and engravings accompanying the operas' librettos.

Keywords: melodrama, perspective, set design, telari, Venice.

Introduction

Illusione e pratica teatrale is the title of an exhibition held in Venice in 1975, whose main means of communicating the contents offered to visitors –drawings, engravings, documents, and heterogeneous sources– was entrusted to the maquette, understood as three-dimensional analogical restitution of the compositional dynamics of the stage space, between the sixteenth and eighteenth centuries [1].
As a design tool of a double invention, that of first scenography and then 'Italian' theater, with its performances in a melodrama set to music, today we record the few pieces of evidence that have come down to us, mainly attributable only to the wooden prototypes of the instituting building. Yet, it is well known how several artists have used these devices to simulate the spatiality and poses of actors, bringing their settings back to the plane support of the painting. One need only think, for example, of the work of Tintoretto, who created wax or clay models of the characters dressed in *rags* [Grosso 2018, p. 70], and then placed them within "perspectives, composed of boards and cardboards, accommodating little candles in the windows, thus obtaining the lights and shadows" [Ridolfi 1642, p. 8]. However, in this essay what is being investigated is the reverse process.
In the absence of concrete evidence of the theatrical works, the maquettes can house possible reconstructions of the realized sets, because the iconographic sources that have come down to us depict

illusory architecture and landscapes whose perspective restitution allows us to understand their feasible spatial arrangement, confirmed by the dimensions of the stages, most often described in the documents and contracts for the renovation of theaters to be modernized. Unfortunately, many of these have completely disappeared, just think of Venice, which in 1581 inaugurated the first paid public theater –owned by the Tron family near the parish of San Cassan– and by the end of the seventeenth century had some fifteen.
Talented set designers whose work is not always recognized worked in this city: described in the literature as inventors of scenes and machines, architects, engineers, and scene painters, their names appear in opera librettos sporadically [Ciammaichella 2021]. Therefore, being able to prefigure the spatiality and illusory effects of an artfully designed *hic et nunc* means recomposing the fragments of drawn, engraved, and written memories, bringing them together in analog models corresponding to the methodologies through which, at the time, performances were designed.

Musical Intermedi and changeable scene

The Renaissance scenic model tends to recover the centrality of static relief perspectives, keeping the settings virtually unchanged throughout the performance, so much so that Serlio, in rereading the Vitruvian codes in a modern key, offers three possible variants for the tragic, satiric, and comic scene. Of the latter, he delves mainly into the constructive aspects, where the architectures are represented by the high relief structured by moving backdrops and painted telari. But several scholars have expressed not a few perplexities about the small size of the stage that was supposed to locate them, considering that the plan published by the author indicates a precise subdivision into square modules of two feet on a side [2]: the podium measures 60 by 12 feet [Serlio 1545, p. 64] and its horizontally is interrupted by the sloping surface on which the *Casamenti* rest, occupying an area of 22 by 5 feet approx (fig. 1).
This poses a problem for the movements of the actors who would see their action take place, almost and exclusively, in the proscenium. "If, as the dramatic reading of the time suggests, from Machiavelli's *Mandragola* (1521) to Piccolomini's *Amor costante* (1536) or A. Landi's *Commodo* (1539), which requires at least four practicable houses, we considered the 'streets' marked by Serlio on the tilted plane to be practicable, we should arrive at a plan significantly deeper than that of the treatise" [Mancini, Muraro, Povoledo 1975, p. 35]. In any case, the model exhibited relates to the practice he carried out himself, creating the temporary setting of a wooden theater together with the scenes of a play commissioned by the Compagnia della Calza of Vicenza, which took place in the courtyard of Ca' da Porto [3] during the carnival of 1539 [Zorzi 1969].
The Renaissance recovery on the classical amphitheater continues to be orchestrated by the *prince's eye*, seated in the center of the first tier of tiers; therefore, the optimal incline of the stage declivity does not exceed 6 degrees [Chiaramonti 1675]. The gradual abandonment of the fixed scene, on the other hand, is due to the dramaturgical demands of the plays themselves, whose narrative marked by acts is often interspersed with the *Intermedi*: autonomous forms of performance that break into the plot of the main narrative with pantomime, acrobatics, ballet, and singing performances. These impose a rapid transformation of the stage design, given by the movement of flat panels and the painted curtains, activated by the ingenuity of machines and hoists to be hidden in the under-stage and attic.
Specific expedients can be found in the practices described in treatises, from which one of the best ruses, to disguise the house facades and their foreshortened profile planes, is to wrap the telari on two vertical wooden rods. The former is to be nailed to the end of the fronts hidden by the proscenium, the latter is conveniently slid by two or more men moving in the back of the roofs [Sabbattini 1638].
Stagecraft' daring developed in the service of private courts, as was the case in the Florentine where Bernardo Buontalenti, in 1589, showed off his prowess with six Intermedi to be cadenced during the performance of the comedy *La Pellegrina*, by Girolamo Bargagli, performed in the Uffizi Hall to crown the wedding of Ferdinando I de' Medici and Christina of Lorraine.
In this celebration, amazement is fueled by credible illusion, whereby one witnesses the apparitions of mythological subjects suspended in the clouds, simultaneously appreciating the changing atmospheres that echo the semblances of possible spatiality. But by the end of the century what marks the break with the structural static

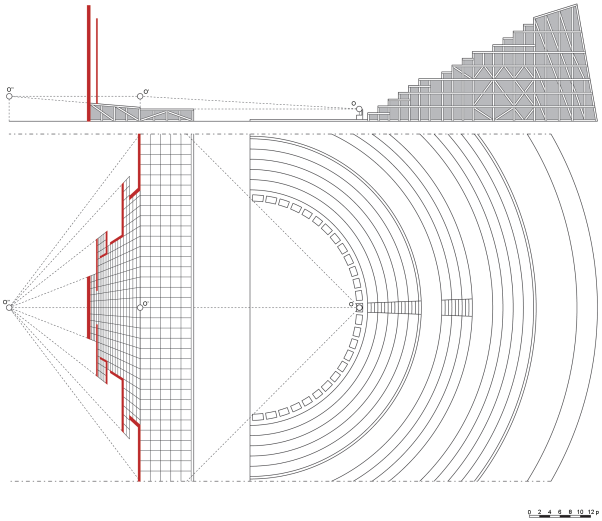

Fig. 1. Reconstruction in plan and elevation of Sebastiano Serlio's temporary theater [Serlio 1545] (drawing by author, 2024).

nature of comedy is precisely the supremacy of the Intermedio, whose inevitable evolution is consequential.
In 1600, in Florence, the Camerata de' Bardi initiated "the rampant fortune of melodrama, the spectacle of music, song and vision that would become the 'important' spectacle, the one on which theater buildings would measure their validity" [Cruciani 2001, p. 24]. Taking up this challenge will be the public pay-per-view theaters inaugurated in Venice, with melodramas in music suitable to qualify their programming.
After the fire of 1633, the San Cassan Theater was rebuilt and four years later debuted with Benedetto Ferrari's *Andromeda*, set to music by Francesco Manelli. This was only the beginning of an intense cultural activity, due to the refinement of artistic impresario systems under which companies rented theaters to owners, also paying the production costs.
The typology of the building, housing the audience distributed in the stalls and over several orders, is confronted with spatial optimizations due to the minimal space of the boxes designed around the horseshoe cavea. Conversely, the stage expands out of proportion, depending on the effects provided by the individual performance.
The Teatro SS. Giovanni e Paolo, owned by the Grimani family, was opened in the carnival of 1639. Also, in the same parish [4], an association of nobles rented an area granted by the Dominican friars, entrusting Giacomo Torelli –then a naval engineer employed by the Venice Arsenal– with the design of the Teatro Novissimo, where he demonstrated his extraordinary talent as a set designer and machines inventor, starting in 1641.
For the staging of *Venere Gelosa* [5], in 1643, the depth of the stage acquired an additional 12 feet, thanks to the agreement made with the friars in renewing the annual lease, amounting to 300 ducats [Bianconi, Walker 1975, p. 415].
Historical sources agree in attesting that the proscenium was 9 meters wide and about 7 meters high, with the last backdrop at least 12 meters away from it [Mancini, Muraro, Povoledo 1995, p. 323]. The models displayed in the above-mentioned exhibition take these valuable pointers into account, focusing on two scenes from the second act [6], relating to the very deep hellish cavern with burning towers in the background and the courtyard of the King of Naxos (fig. 2).
The memories of the melodrama are reported by Count Majolino Bisaccioni with a certain descriptive emphasis, accompanied by Marco Boschin's engravings in which actors are shown at a very small scale, to exaggerate the effects of the central relief perspectives simulated by the layered sequence of painted telari –called *Principali*– pierced in the center and lowered from the ceiling, through complex systems of balconies anticipating the gridiron. Then the setting is lickety-split transformed, with on-sight changes given by the horizontal translation of elements that recompose the king's court architecture. Thus, in a kind of surplus homage to the Torellian 'long scene', it is declared that the square of Naxos "was composed of forty-eight Telari, which the mere thought a so great a multitude, makes one believe marvelous the challenge of back together them in a moment" [Bisaccioni 1644, p. 20].
It is well known that the rapid stage transformation aroused the applause of the audience and was governed by a large winch with counterweights, connected with the under-stage to a large revolving wheel to which all the backdrops converged [Guarino 1992], but the disproportionate number of the latter is not likely. Generally, even the most elaborate and wasteful Baroque sets required a maximum of eight or nine panels per side (fig. 3).

Fig. 2. Models of the scenes for the melodrama in the music of the Venere gelosa, Teatro Novissimo, Venice 1643. [Photographs courtesy of the Institute for Theater and Melodrama. Giorgio Cini Foundation, Venice 2024].

The interpretation of the engravings and the restitutions of the apparatus, traceable to the scale of the wooden models, attests to this. Moreover, from the study of architectural perspectives framed in the redrawing of the proscenium front, the optimal viewpoint can be traced. Since it is assumed that the Novissimo had three overlapping box orders, the tendency is to approximate it to the height of the box of honor, completing the strategic functionalities of a typological model of theater, known as the 'Italian theater', to be exported around the world (fig. 4).

Angular scene and painted scene

The last quarter century consolidates a practice able to extrapolate, from the establishing building, the good rules of proportioning the stage space. The treatises measure the stage according to its length, to derive the slope, which must not exceed the twelfth part, so the number 12 also becomes the regulating module of the entire width of the theater itself [Carini Motta 1676]. Instead, regarding the perspective configuration of the system of backdrops and drop-curtains –converging in the central stage vanishing point, in *O*– Andrea Pozzo mirrors it in the visual pyramid that maintains the distance from the picture framed by the proscenium arch; thus, *PA* is equal to *AO* (fig. 5). This demonstrates how the ideal point of view does not always correspond with that of the unambiguous spectatorship elected by the perpetuated sixteenth-century model, because the 'scenic theater' redesigned in plan places it outside the access to the central box of the first order.
A further problem is posed by a certain seventeenth-century habit [7] of slanting the canals for the slide drop-curtains, which should all be parallel to the stage front [Pozzo 1693]. It can be understood how the level of complexity, to which the Jesuit priest turns his attention, precisely concerns the tracing of the perspectives to be painted in sequence, resolved beforehand in sketches from which to transfer the graticule system directly onto the oblique telari. Thus, all the vertical lines of a backdrop sequence, whether left or right, remain parallel while the horizontals converge to a single vanishing point [Baglioni, Salvatore 2021].
"By placing the 'eye' in an inaccessible zone, Pozzo subordinates the perspective scene to individualized observation and thus superimposes, as it were, on the existing (fixed) perspective arrangement a changing perspective

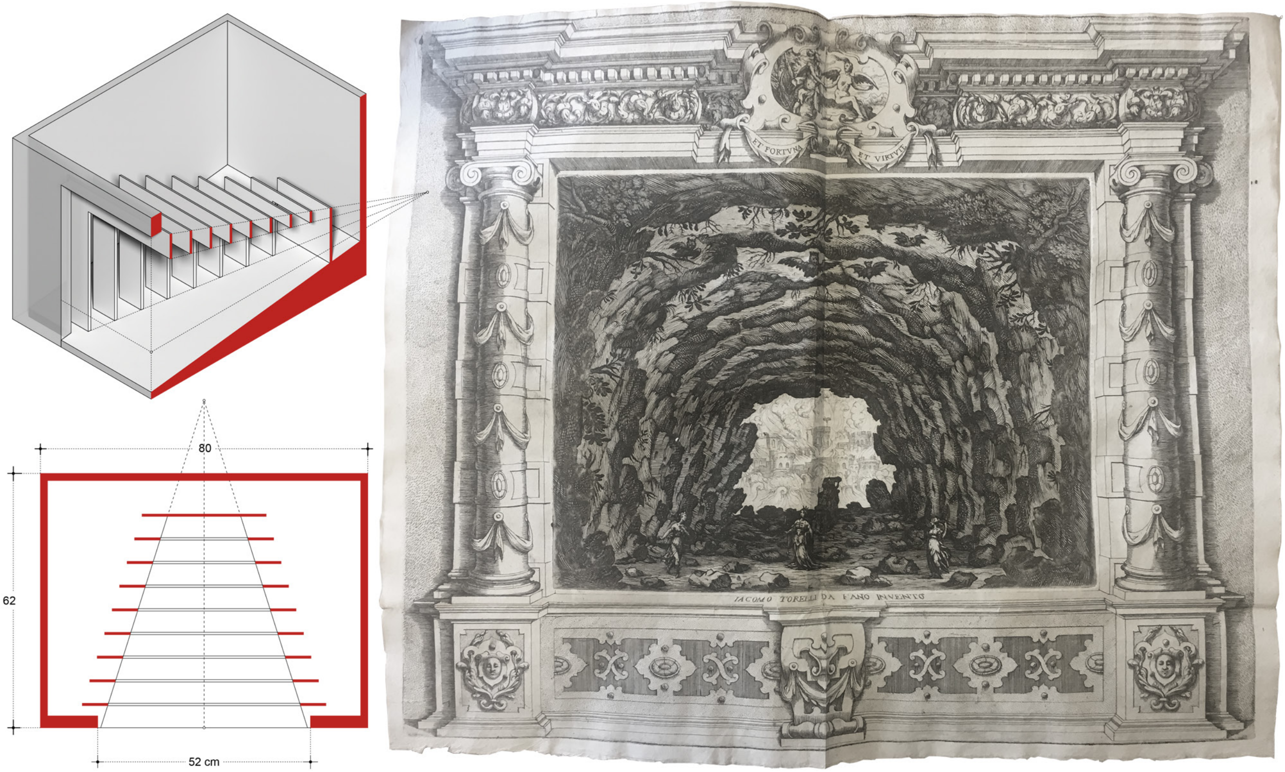

Fig. 3. Reconstruction in plan and axonometric section of the stage set at the maquette's scale (graphic elaborations by author, 2024). Engraving of the scene with an infernal cavern [Bisaccioni 1644].

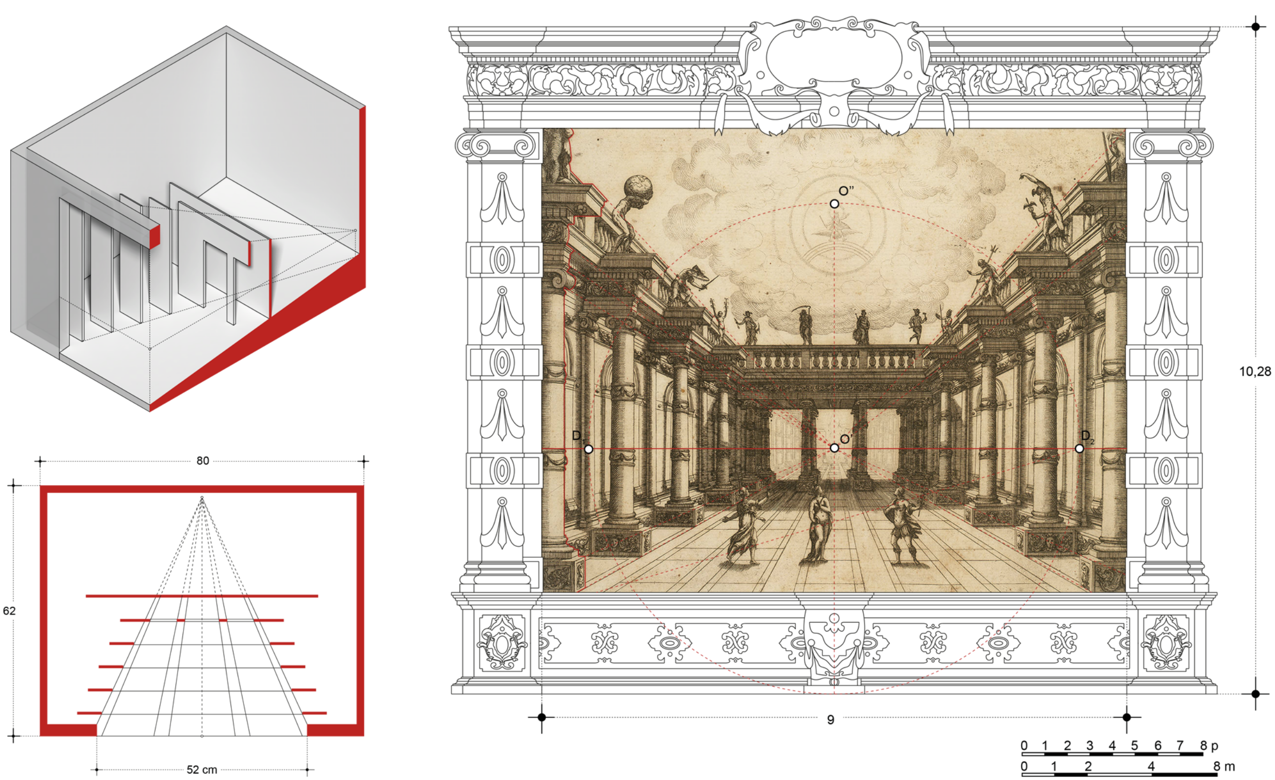

Fig. 4. Reconstruction in plan and axonometric section of the stage set at the maquette's scale (graphic elaborations by author, 2024). Proscenium front and engraving of the scene with a courtyard of the King of Naxos [Bisaccioni 1644].

of vision. This is equivalent to formally postulating the 'objectivity' of the simulated space. Perspective loses its 'illusionistic' character and is set to become the instrument of identification between real space and stage space" [Marotti 1974, p. 85].
Inheriting this paradigm shift is Ferdinando Galli Bibiena, whose work is congenial to a period of decay of the splendor of the machines, until then useful to the spectacle of the mythological matrix, with its rapid appearances and flights of characters suspended in the clouds. The dramaturgy becomes romanticized earthy, and the transformation of melodrama in music already heralds lyric opera.
As the renewed taste for bel canto predominates over the entire staging, the placements of the protagonists –predominantly proscenium or center stage– help its success, which explains the thickening of the proscenium arch wall designed to amplify the theater acoustics. Throughout, the set design continues to change from act to act, but it acts as a backdrop in making up for the abandonment of the symmetrical depth of the height-decreased panels that are no longer needed. It follows that the rhythmic repetition of the painted symmetric telari is interrupted by the off-center monumentalization of the architectural image. The scene becomes autonomous concerning its host site, and the ways to enable it depend on the scientific methods of angular perspective, changing the assumptions of consolidating the uniqueness of a vanishing point that now accommodates other points, far beyond the frame of the proscenium arch, to dilate its perceptual extension and foster the ensemble of the multiple viewpoints of the spectators, seated in the stalls or on multiple orders of boxes.
Anticipations of this trend can already be seen in Lotto Lotti's pseudo-historical drama *Didio Giuliano*, which opened the renovated Ducal Theater in Piacenza in 1687, with music by Bernardo Sabatini. The libretto, accompanied by a figured frontispiece and ten engravings of the sets, contains the author's signature. Some scholars agree that Bibiena sets them "according to perspective axes oblique to the proscenium and with gradually different vanishing points, but always at a measurable logical distance, never to infinity as in seventeenth-century scenography" [Lenzi 2000, p. 41].
It must be pointed out that several engravings still represent central perspectives but with a misalignment of

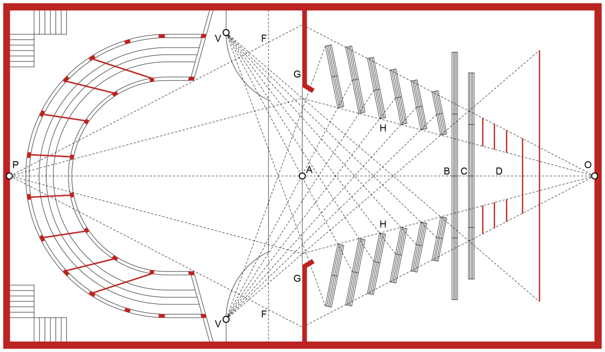

Fig. 5. Plan reconstruction of the scenic theater [Pozzo 1693] (drawing by author, 2024).

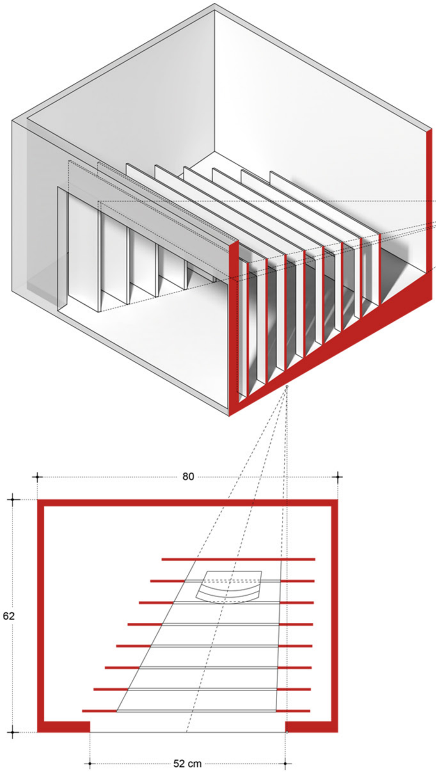

Fig. 6. Plan reconstruction and axonometric section of the stage setting at the maquette scale (graphic elaborations by author 2024). Maquette of Nerone fatto Caesare, Teatro Malvezzi, Bologna 1695. [Photograph courtesy of the Institute for Theater and Melodrama. Giorgio Cini Foundation, Venice 2024].


Fig. 7. Ferdinando Galli Bibiena, Prison courtyard, 1699-1700, Special Superintendence for the Historical, Artistic, and Ethno-anthropological Heritage and for the Museum Pole of the city of Naples. [Maquette, photograph courtesy of the Institute for Theater and Melodrama. Giorgio Cini Foundation, Venice 2024].

the principal point to be moved near the edges of the proscenium. This form of dynamization of the illusory space is replicated by Marcantonio Chiarini in *Nerone fatto Cesare* [8], a drama set to music by Giacomo Antonio Perti at the Teatro Malvezzi in Bologna, in 1695. In particular, the maquette exhibited at the Venetian exhibition focuses on the opening scene of the first act, with Agrippina sitting on the throne in the illuminated hall of the imperial palace (fig. 6).
The composition is structured by seven drop-curtains from the ceiling, a backdrop, and a canopy with semicircular steps shifted to the right, as can be seen from the reconstruction in the plan. We can therefore venture that the imminent invention of the '*scena per angolo*' is suggested by the empirical practice assisted by the Andrea Pozzo rules, well before publishing *L'Architettura Civile* [Bibiena 1711] that follows many of his valuable teachings.
In particular, the well-known plates 22 and 23 of the treatise reaffirm the importance of preparatory drawing, tripartite by the plan of the architecture to represent, by its rotation in conical projection, and by the perspective representation of buildings for which the ground line coincides with the horizon. So, the stage becomes more leaning reaching the tenth part of its length, to agree with the view offered by the middle box of the first order. These expedients allow Ferdinando Galli Bibiena to prepare the apparatuses of the shows, equipping himself with a principal pierced drop-curtain that acts as a sort of proscenium, which can follow at least another parallel and a closing backdrop (fig. 7).
If the end of machines and oblique canals delineate the sunset of baroque opulence, in the mid-eighteenth century the stagecraft simplification process has now reached, combining with musical productions and the economic needs of less expensive comedies.
Returning to Venice, in 1755 at the Teatro Grimani in San Samuele Carlo Goldoni debuted with the playful drama *La Diavolessa*, confirming the solid collaboration with the playwright and composer Baldassarre Galuppi. The scenes are curated by Andrea Urbani, and the engraving that accompanies the libretto shows a dark cellar very faithful to the watercolor sketch by the set designer, from which you can interpret the composition of the entire space, structured by two openwork drop-curtains and a backdrop that recompose a setting with a strong pictorial worthiness. Not that perspective construction is denied, but here the

Fig. 8. Plan reconstruction and axonometric section of the stage setting at the maquette scale, graphic elaborations by author, 2024. Maquette of La Diavolessa, Teatro San Samuele, Venice 1755. [Photograph courtesy of the Institute for Theater and Melodrama. Giorgio Cini Foundation, Venice 2024].

appeal to off-center vanishing points harmonizes with the idea of a credible depth masked by the real distribution of surfaces close to the proscenium (fig. 8).
What stands out is the so-called 'painted scene ' (*scena-quadro*), entirely resolved by painted canvases.? "The roof, now loaded with major tasks such as the vertical change of scenes, is provided with a gridiron or perforated ceiling to which the '*gargami'* (guides) are attached. The new notion of the painted scene resolves the scenography through canvases and backdrops disengaging itself from the perspective convention of telari [...]. It is this traditional yet gradually renewed scene that the nineteenth-century performance will acquire and subject to verification" [Sinisi, Innamorati 2003, p. 139].

Conclusions

The in-depth study of some maquette specimens, exhibited at the 1975 *Illusione e pratica teatrale* exhibition, made it possible to investigate the design methods and rules of a performance-making process that never disregards the spatial context in which it is set. The transition from the semicircular amphitheater to the Italian theater also determines the rules of transformation of a fixed scene dynamized by backdrops with visible change sets, to pander to the baroque expectations of an audience entirely devoted to melodrama in music.
The centuries-old cultural affairs that can be summarized in the individual case studies examined, however, demonstrate how perspective always assumes a central role in devising settings capable of harmonizing with the dramaturgical necessities.
This is evidenced by the opera librettos, engravings, and the few sketches that have come down to us, but especially by the burgeoning development of treatises on scenic perspective, through which reconstructions of the apparatuses and stages that housed them can be conjectured.
The research mainly dealt with the traces of an intangible memory to be rediscovered, to enhance a cultural heritage that still deserves to be studied and enhanced.

Credits and Acknowledgements

The analog models displayed here are the result of rigorous restoration work that engaged the Giorgio Cini Foundation's Institute for Theater and Melodrama in Venice. Today they are exhibited in the Scenography Room of the same institute, documenting the outcomes of many years of research on scenic and stagecraft practices from the 16th century to the late 18th century. We thank the director, Maria Ida Biggi, and the institute secretary (Marianna Zannoni and Linda Baldissin), for their cooperation and for allowing us to share the valuable images accompanying the text.
Finally, it is worth mentioning that the title of the exhibition and the present contribution [9], also evoke the title of an important international conference: *Illusione scenica e pratica teatrale* [Biggi 2016], dedicated precisely to the scholar Elena Povoledo to whom the author owes many of the arguments here written.

Notes

[1] *Illusione e pratica teatrale*, exhibition curated by Franco Mancini, Maria Teresa Muraro, Elena Povoledo, Giorgio Cini Foundation, Venice 1975. Analog models of the scenes on display were made by: Domenico Berardone, Roberto Contenti, Vito Galgano, Pasqualina Jorio, Angela Norvillo, Annunziata Peluso, and Lina Zirpoli, students at the School of Scenography at the Academy of Fine Arts in Naples, directed by Franco Mancini, Claudio Chirivino, Massimo Paragona and Rosanna Piscitelli Mancini.

[2] The Vicentine foot is equivalent to the Venetian foot: 0.348 cm approx.

[3] da Porto Colleoni Palace, in Contrà Porti.

[4] The Teatro Novissimo was in the Cavallerizza area, in SS. Giovanni e Paolo, so called because it housed a riding stable for horse racing.

[5] Libretto by Niccolò Enea Bartolini, music by Francesco Sacrati.

[6] They are 1:17 scale wooden boxes with a base of 80 cm, height of 59.5 cm, and depth of 62 cm. The proscenium measures 52 by 43 cm.

[7] A similar configuration of the stage setting, with oblique canals, can be seen in the drawing by Tommaso Bezzi (1691-1693), depicting the plan and longitudinal section of the Teatro SS. Giovanni e Paolo in Venice. Today it is housed in the Soane Museum in London.

[8] The engravings accompanying the libretto are by Carlo Antonio Buffagnotti.

[9] The article is part of the outcome of the research project funded by the Department of Architecture and Arts, Università Iuav di Venezia (2023), entitled: *Drawing of the Ephemeral. Reconstructions and itineraries of a disappeared theater scene*, scientific coordinator: Massimiliano Ciammaichella.

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Experiences in the Use of Analog Models in Micro-Architectures Design

José Luís Higón Calvet, Mónica Val Fiel

Abstract

The use of analog models in microarchitecture design offers a series of benefits, from detailed exploration of small-scale elements to stimulating creativity and innovation. These enriching experiences significantly contribute to the design process and help develop more robust and effective architectural solutions. Models are tools that enhance haptic perception and play various roles in the analysis, experimentation, conceptualization, and teaching of microarchitectures. Their ability to provide a tangible and accessible representation of design makes them remarkable resources in the architectural design process.

Keywords: design process, analog models, microarchitecture.

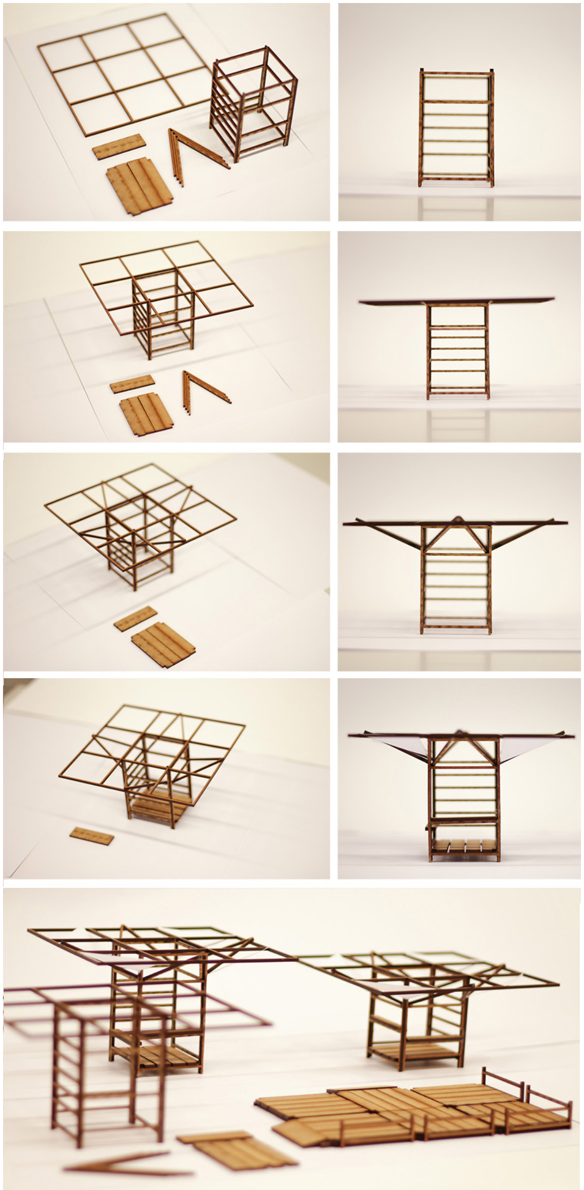
Introduction

The logic of the design and project process demands from the designer the use of various spatial representation techniques in order to conceptualize and communicate the outcome of their work. While the tools commonly used in the project process typically start from sketches and end in representation through plans, elevations, and sections complemented by rendered images from three-dimensional models, there are cases where these resources are not sufficient to properly show and communicate the nature of the projected model, either due to the geometric complexity of the model or the nature of the material used in the design processes.
It is in these cases that the use of the model, understood as a reduced-scale physical model of the object to be represented, proves to be a highly useful tool, both during the project process and as a way to display a final result.

The model as an instrument of analysis and communication: enhancing haptic perception

The model shares withdrawing its analytical capacity. Eduardo Carazo argues for the use of the model as a form analysis tool, "as anticipation of the project or verification of what it is going to be" [Carazo 2014].
In an analysis phase compared to digital models, physical models allow for a more direct understanding. Having a physical and tangible representation makes it possible to

Fig. 1. Assembly process of a tubular structure, corresponding to the ephemeral installation developed by Javier Gómez and David Minton.



immediately evaluate forms, volume, proportions, contextualization, interior distributions, details, and other relevant aspects of the project.
Pallasmaa, in his research, advocates for the importance of all senses in the sensory understanding of space. Immersed in a technological era with clear predominance of the sense of sight, Pallasmaa emphasizes the importance of touch for understanding the world and experience, calling for a multisensory approach in the arts and architecture. "A work of architecture is not experienced as a series of isolated retinal images, but in its full and integrated material, corporeal, and spiritual essence. It provides pleasing forms and surfaces shaped by the touch of the eye and other senses, but it also incorporates and integrates physical and mental structures that grant our existential experience enhanced coherence and transcendence" [Pallasmaa 2022, p. 13].
Pallasmaa analyzes the essential role of the hand in the evolution of skills, intelligence, and conceptual abilities [Pallasmaa 2012]. Models consolidate and refine our ideas to the extent of rendering them constructible. The project defines its existence through an object shaped by hands. "Through our hands, we engage with what is projected. Working with our hands leads us to internalize or externalize something that will eventually become part of the project" [Dorado 2013, p. 197] .
In the context of architectural design and models, haptic perception plays an important role in the understanding and evaluation of spaces and structures. Models, as tangible objects, enhance haptic perception by allowing a complete sensory experience of the project. By physically interacting with a model, either through direct manipulation or by contacting surfaces and materials, one obtains comprehensive information about the proportions, textures, and spatial configuration of the project as a whole. This aids designers, architects, and other stakeholders in understanding, communicating, and making decisions in the design process.
The model as a communication tool not only allows visualizing the final design but also facilitates understanding of the construction processes. Through the analysis of the model, those involved in the project can learn about construction processes, including the installation of structural systems and the integration of facilities. Manipulating and studying the model helps identify potential challenges, clarify construction details, and visualize construction sequences, providing a deeper and more

practical understanding of how the actual construction will take place. In this way, the model becomes a perfect tool to get as close as possible to the reality of construction before starting the actual assembly (fig. 1).

The analog model versus the digital model

The creation of physical models or prototypes to scale has been and continues to be a common resource in the design and development processes of products, despite the enormous possibilities offered by computer-based media to generate and visualize virtual models. When infographics were able to offer photorealistic results of high quality, the relevance of these result models that usually starred in the presentation of any project was questioned. However, professional activity, perhaps guided by the force of habit, demonstrated the effectiveness of using this resource during the project process.
In the field of architecture and design, the so-called 'working model' allows for a preliminary approach to the spatial and formal reality that is being developed, offering unexpected perspectives and revealing possibilities not initially foreseen once the design process has begun and the initial proposals have been graphically defined. It materializes a recreation of the idea being defined, which can be manipulated and transformed at will, providing continuity to the creation process in coordinated alternation with graphic resources. Even in its construction process, the model offers from the outset a series of sensory and material experiences that digital representation is unable to provide.
Architects like Eisenman integrate the use of models as a process of interaction with digital media. Eisenman justifies the dialogue between physical and digital models as a back-and-forth journey between computer models and physical models. He argues that models serve to see how space will be: "With the computer, you can only go around nothing... with three-dimensional models, I can see what is really happening [Mills 2011, p. 144]. "When Eisenman describes his design process, he determines that he always establishes a dialogue between two different models of the project under development. Models are a constant in the process, but always after a conceptualization phase, which takes place on the computer. 'I know what I am trying to achieve theoretically,' explains Eisenman, 'and the models tell me whether I am achieving it or not'" [Val Fiel 2016, p. 143].

The model as a means of experimentation

New materials and technological changes have expanded the ability of the model to articulate ideas [Moon 2005]. These advances have transformed the way models are constructed and offer designers a wider range of tools and techniques to represent and communicate their ideas. In this context, the model is presented as a project in itself. The model as a 'project' to be solved involves approaching its creation with a methodological and creative focus, similar to the architectural design process. This includes clearly defining the purpose, seeking and selecting suitable materials, determining the scale, and planning the construction process, among others (fig. 2).
By directly manipulating a physical model, designers can experiment with different forms, structures, and arrangements in an intuitive manner. This can lead to the generation of new ideas and solutions that may not have been considered otherwise.
In the early stages of the project, the model is not limited to a real representation of the object to be built, but can be an analytical element where information can be extracted to shape subsequent phases of the project, adding value to the creative process.
Furthermore, working with the model demands a process of synthesis and abstraction that contributes to clarifying

Fig. 2. Model of ephemeral installation made with foam board. Author: Saul Rojas Bombal.

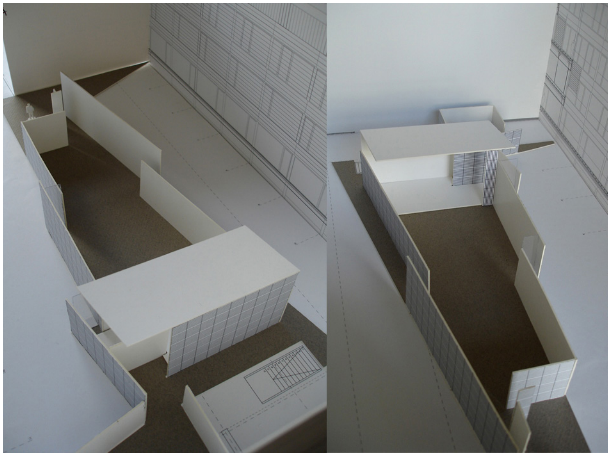


Fig. 3. Test model for a scenic background project. Author: Ignacio Gutiérrez Soto.

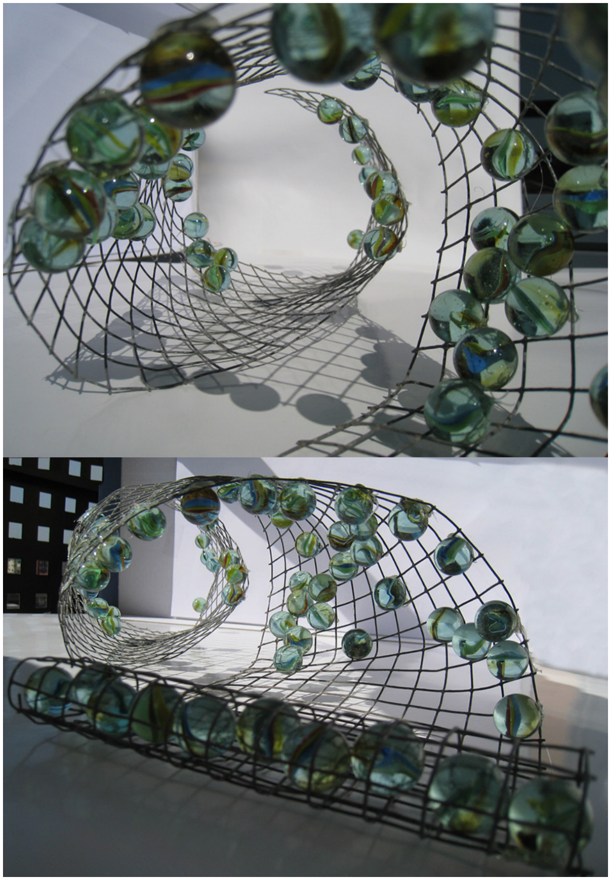
project ideas and how they materialize. A flow is established between the project objectives and their confirmation in a small-scale model, which can confirm its validation or open up other avenues of development.
Contrary to the model as a reproduction of a real project, it is important to highlight the consideration of physical models as part of the design process in any phase of project definition.
At this stage, models are used as tools for exploring ideas, experimenting with forms and volumes, focusing on capturing the essence of the design without reaching the definition of details "they pose problems and formulate hypotheses, understanding and teaching to understand, avoiding that works escape us" [Álvarez 2011, p. 13].
In the project development, the use of physical models enables formal exploration, along with the review and validation of certain ideas. Alternatives are explored on the material itself, with versatility and immediacy being the most significant advantages of this medium in the design process (fig. 3). The model is used as a tool for idea generation, experimenting with a purely formal definition that subsequently evolves and acquires content regarding the development of an idea that later incorporates functional and constructive requirements.
In an initial phase, the model offers the opportunity to test different ideas, concepts, and solutions, and explore the feasibility of innovative or unconventional ideas. The working model allows for the investigation of multiple design options and the quick evaluation of their spatial configuration as a whole, without the need for extensive skills and time management in software usage.
At intermediate or detailed scales, it allows for experimentation with a variety of materials and textures to determine which ones may work best for the project. It enables testing different cladding materials, interior and exterior finishes, in order to find the desired combinations.
Iteration and successive adaptation are among the most notable aspects. Building models enables designers to iterate and continuously refine the design throughout the process. Rapid changes can be made and different options can be compared to enhance the functionality, aesthetics, and performance of the project. A flow is generated between exploration in the process, materialization, and ultimately the realization of the project idea.
In this experimental context, the use of folding techniques for creating three-dimensional forms is remarkable. The fold has been a constant in all artistic periods, the fold as a

resource for ideation and conceptualization. "Multiplicity is not only what has many parts, but what is folded in many ways " [Deluze 1989, p. 11]. "The ideal genetic element of variable curvature, or of the fold, is inflection. Inflection is the true atom, the elastic point" [Deleuze 1989, p. 25]. Not only folding but also bending flat surfaces to generate active surface structures, with self-supporting capacity [Shen, Nagai 2017]. Developable surfaces, generating volume, three-dimensional forms from a flat shape (development) through bending and/or folding (fig. 4).
Experimentation with form allows for infinite possibilities of a plastic nature, but the necessary constructive rationalization to make the object viable or constructible suggests the use of geometric patterns, which do not necessarily have to limit the designer's creativity. Research in this regard has evolved in recent times, so that we have multiple examples and even studies that seek to systematize folding techniques. Through straight folding, it is possible to obtain polyhedral surfaces. Through curved folding or directly curving the flat development, it is possible to obtain surfaces of simple curvature, conical or cylindrical, but also others of greater visual complexity and structural capacity due to double curvature [Jackson 2022].

Specificity in the context of micro-architectures

Micro-architectures, as well as ephemeral architectures, due to their nature of maximum expressiveness with minimal constructive elements or limited material resources, are susceptible to experimentation and testing during the ideation phase through the development of analog models. Micro-architectures projects are characterized by the creation of small-scale structures, shelters, urban furniture elements, or ephemeral installations among others (fig. 5). Due to this condition, because of their specific nature and reduced size, these projects allow designers to innovate both in terms of functionality and exclusively formal approaches. Some notable issues in the use of models in the context of micro-architectures are their integration into the field of action, their relationship with human scale, and the choice of materials.
At a primary level, physical models allow analyzing the influence of the environment. They enable the designer to evaluate the influence of the urban structure on the micro-architecture (views, sunlight, etc.) and more immediately identify the potentialities of the context.

Fig. 4. Working model made with wire mesh and marbles. Author: Ana Blaya Rodríguez.



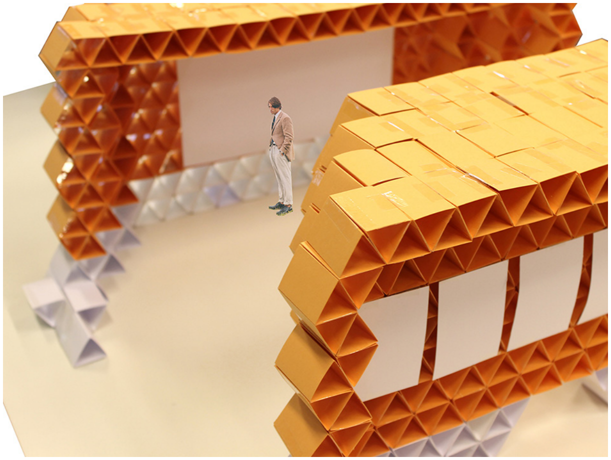
Compared to the definition of digital models, the model presents itself as a highly flexible tool, in which elements can be manipulated and modified within the environment, directly observing the changes they produce in the space in which they are inserted and in the scope of action. The visualization of the result and spatiality is direct and is not reduced to the discretization of viewpoints or the focus to which digital rendering representations are limited.
At a secondary level, physical models allow designers to assess the relationship between space and human scale. This issue is particularly important in the design of small spaces where physical models assist in deciding on ergonomic and comfort-related matters. Designers can simulate human interaction with the built environment and make adjustments as necessary to optimize the user experience.
Finally, research and testing with multiple materials and textures are notable because the choice of material can have a particularly decisive impact on the form and function of the project (fig. 6).

Fig. 5. Model made of wood with textile fastening. Ephemeral installation project developed by Barbara Maestre Fenoll, Jon Maiztegui Etxaniz, and Luis Marques Marti.

Discussion

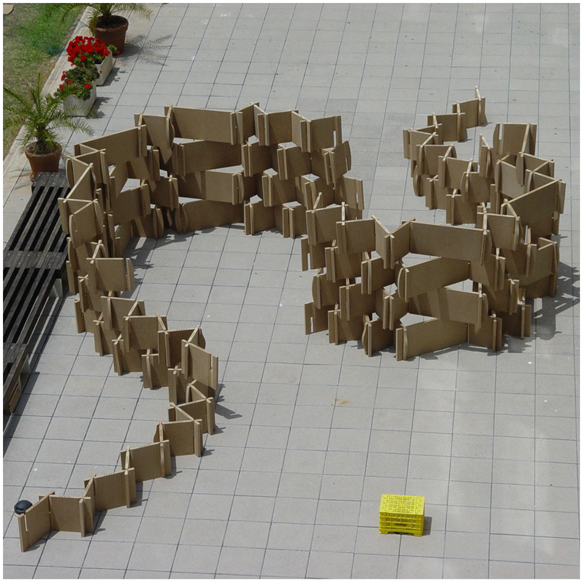
In the educational context, the model compels the designer to adopt an active attitude in the learning process [Álvarez 2011], fostering creativity and teamwork. Additionally, working with models develops spatial and representational skills, including the ability to manipulate three-dimensional objects. From visualizing abstract concepts to simulating construction processes, it is a valuable tool for enriching the learning experience and promoting longer-lasting learning.
Regarding the materiality of analog models, although the tendency in their selection often aims to mimic the represented nature, it is advisable to reflect on whether such materials reaffirm the initial project intentions or not.

Fig. 6. Model made with triangular cardboard pieces. Authors: Rafa Megías Vizcaíno and Elisa Sanz Peris.



Manipulating materials and observing the results in the model provide insight into the inherent characteristics and qualities of the materials, which can be incorporated into subsequent projects.
The development of physical models as a resource for analysis and experimentation in project definition is an enormously valuable tool that facilitates, as we have generally observed in our experience, the process of ideation and formalization of different proposals.
Scale models are constructed and integrated into the project definition process during ideation as working models, with varying degrees of abstraction from the idea being materialized, and coordinated with the usual graphic resources, from freehand sketches to 3D modeling on the computer, as the project takes shape.
Regarding infographics, despite their significant development in recent times and ease of use in producing virtual models, it is important to understand them not so much as an opposing procedure, but as complementary to the use of physical models on a reduced scale. While virtual models indeed allow for more agile management of project modifications, physical models provide information whose quantity and quality enable untrained observers to understand the project without other prior information. It is also worth noting that, for representation purposes, physical models allow for obtaining high-quality photographs from them, whose ultimate purpose is the same as that pursued with rendered images, thus achieving a result analogous to that obtained from a virtual model.
The development of ephemeral installations as examples of micro-architectures provides a valuable opportunity where the project can be materialized with a full-scale model. This culminating stage of the process allows for validating and confirming the materialization of the project idea. Experimenting with a process similar to that of constructing the real project, from material selection and manipulation to resolving construction details, including acquiring cross-cutting competencies such as team coordination and practical skills, allows for confirming the successes and errors that may have occurred during the project process. Additionally, creating a 1:1 scale model serves as a tool that confirms learning about scales. The designer can directly compare the full-scale model with their original design and evaluate the relationship between physical dimensions and previous scale representations.

Fig. 7. Top: General image of the proposed route. Bottom: Partial image of the temporary installation, placed in relation to human scale. Ephemeral installation projected by Mercedes Cepeda Zaragoza.



Conclusion

In certain instances, and due to the complexity of the geometry to be represented, obtaining a faithful three-dimensional digital model of the concept being projected proves difficult to address. This is both due to the inherent limitations of the software used and the significant amount of time required for its development. In other cases, the chosen materiality for the project's development may be challenging to represent and render, as it involves materials whose texture and configuration would require substantial effort to generate the desired visualizations. It is in these cases that the true potential of the reduced-scale physical model is revealed. Such models allow for simultaneous reflection on the logic of the chosen material and provide a good approximation to the final result. In some instances, when budgetary and time constraints allow, these models may be used as a preliminary step prior to the realization of full-scale proposals, thus completing the entire cycle from ideation to real-scale formalization of the project (fig. 8).

Fig. 8. Full-scale ephemeral installation developed with recycled plastic baskets. Author: Ana Mas Gil.

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City Form and Cognitive Model

Francesco Maggio, Alessia Garozzo

Abstract

In 1975, Rosario La Duca published Cartografia generale della città di Palermo e antiche carte della Sicilia *(General cartography of the city of Palermo and ancient maps of Sicily), containing 40 plates and about 100 charts. Among the plates is the* Pianta geometrica secondo lo stato presente della città di Palermo capitale del Regno di Sicilia col suo porto, sobborghi, molo e campagna*, drawn in 1822 by F. G. C. B. De Behrend.*
After a brief note on the model, the contribution presents a recent didactic experience related to surveying and digital representation, in which it was decided to study and investigate the De Behrend cartography according to a procedure that, starting from the redrawing of a historical map, arrives at the construction of a physical model of the structure of the 19th century city, in an optical/tactile dimension. The model is to be understood in its double value of outcome and incipit *for other studies; if on the one hand it returns an image of the city in its entirety, the result of progressive stratifications, on the other hand it offers the possibility of investigating the morphological aspects of the urban fabric to trigger classificatory processes that never neglect the contribution of History.*
The construction of the physical model allows the transition from the abstraction of the two-dimensional representation of the iconographic document to the material concretisation of the building structure of the historic city. Sensory involvement as an amplifier of knowledge finds its concrete dimension in the 'model'.

Keywords: reading, interpretation, survey, redesign, model.

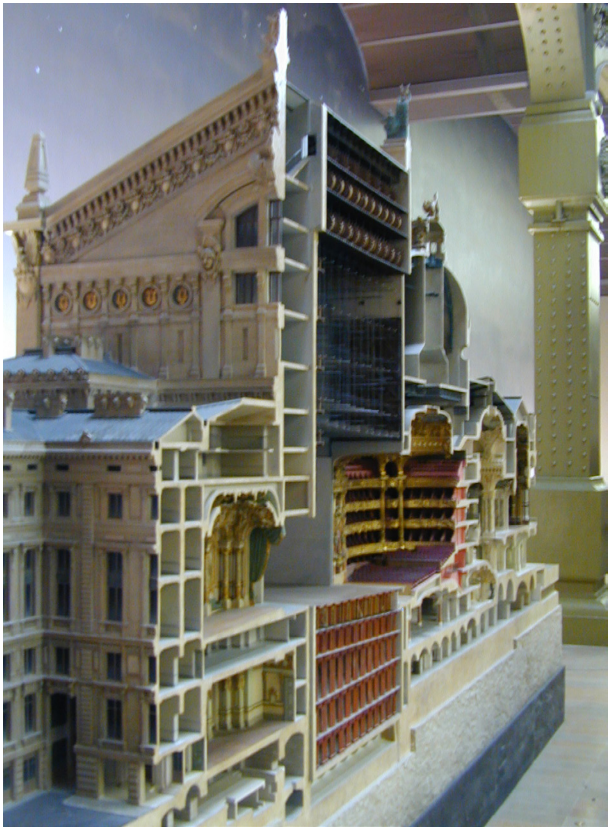
Brief notes on the model

The architectural model has always been a tool for controlling and communicating the design idea. Its ontological role was for a long time acclaimed for its value in the presentation of the project when orthogonal projections and, a little later, axonometry had not yet been codified; the representation of the project found, in this sense, in the construction of the model the most appropriate modalities for the description and presentation of the idea [Giaffreda 2005; Scalzo 2010; Del Pesco 2015].
The term model is thus linked to that of project in an inseparable pair in which the two words complement each other. As Tomás Maldonado has stated, this association is very reductive because "the use of models (which in modern epistemology is known as modelling) does not only concern problems pertaining to design and communication processes, but also a wide range of other issues that have long been the subject of controversy, especially within the philosophy of science. Modelling is certainly a creative strategy, but it is also a cognitive one. And the relationship between creativity and knowledge, as we know, is an issue that is far from settled" [Maldonado 1987, p. 57]. The Argentine philosopher-designer, who is also an Italian citizen, with great lucidity tries not to slip on a definitive affirmation of the concept of the similarity of the 'plastic' by posing some questions about the values of models, from prototypes of industrial design to those relating to

Fig. 1. Scale model of Pompei. Museo Archeologico Nazionale di Napoli (MANN).

historical-archaeological documentation with both didactic and touristic implications.
Think, for example, of the car prototypes by Le Corbusier, Walter Gropius and Buckminster Fuller or the extraordinary instructive model of Pompeii, preserved in the Museo Archeologico Nazionale di Napoli (National Archaeological Museum of Naples, MANN), which represents the archaeological excavations of the ancient city buried by the eruption of Vesuvius in 79 A.D. [1] (fig. 1).
And again, think of the tourist who, visiting the Musée d'Orsay in Paris, discovers, situated at the end of the museum's great central aisle and set up by Richard Peduzzi, the polychrome plaster model of the longitudinal section of the Opera House as it was at its inauguration on 5 January 1875 (fig. 2); the visitor, undoubtedly amazed by the beauty and the large size of the model (1,578.0 x 110.0 x 240.0 cm), meanwhile rests his feet on a transparent floor walking on another 1:100 scale model of the Opera House district, which is still from the year 1914 (fig. 3).
The tool of the model, in the history of architecture, has basically been linked to show the 'magnificence' of the building or, in the purely engineering field, to verify the capacity of resistance to mechanical actions and the structural goodness of the design [Blasi, Coïsson 2015].
The model, as a transmission of knowledge, has also assumed the dimensions of the colossal when its scale of representation has become that of the real 'thing', or of that which no longer exists while still manifesting itself in its 'supposed' metric consistency.
In order to show the architectural ornaments, for example, the model has become a true copy. For this, one only has to visit the *Cité de l'architecture et du patrimoine,* Europe's largest institution dedicated to the promotion of architectural and urban planning culture, which occupies part of the Palais de Chaillot, a majestic architectural complex designed for the International Exhibition *Arts et Techniques dans la Vie moderne* held in Paris in 1937.

Fig. 2. Scale model of the Paris Opera. Musée d'Orsay, Paris (photo by F. Maggio).



La *Cité* has two missions: the first is to enable a dialogue between architecture of the past and contemporary architecture, areas that have long been in opposition; the second is to make the architectural heritage, predominantly French, known to the general public.
Begun by Eugène Viollet-le-Duc, the Museum's collection brings together a selection of monuments that best represent the excellence of French art. Reproduced to scale and in minute detail, or presented in the form of models and drawings, these emblematic buildings of French architecture make up a truly extraordinary collection. The permanent collection is displayed in three galleries: the *Galerie des moulages,* the *Galerie d'architecture moderne et contemporaine* and the *Galerie des peintures murales.*
With more than 350 plaster casts (some more than 10 m high) and sixty architectural models, the *Galerie des moulages* invites visitors to retrace nine centuries of French architectural history. From the Abbey of Moissac to the Cathedral of Notre-Dame, via the famous staircase of François I at the Château de Blois, France's most famous civil and religious monuments are presented (fig. 4).
In 2002, the *Cité de l'architecture et du patrimoine* initiated the *Le Corbusier project,* an extraordinary and unique 1:1 scale reproduction of a housing unit of the *Cité radieuse* in Marseille placed in the museum's *Galerie d'architecture moderne et contemporaine* (fig. 5).
In this flat, visitors can enter, touch the space, and experience for a few moments a house from a housing project considered to be among the most interesting and innovative of the post World War II period.
The exemplarity of this educational project lies in the active participation of 17 vocational high schools in the construction sector; depending on their qualifications, each high school was assigned a work package (carpentry, joinery, finishing, painting, plumbing, etc.). The construction of the model began in 2006 and involved the commitment of the students and their teachers, who used their skills and worked closely together to discover the architecture and its history [2].
The great and extraordinary models of the French institution, therefore, have an essentially popular and, in the case of the Marseilles Housing Unit, by its conception, purely pedagogical character.
But the model is also "an instrument of representation, a vehicle for the transmission of ideas, an anticipation of a constructive reality and of its overall effects, it is also at the same time an instrument of design work aimed at

Fig. 3. Scale model of the Opera district in Paris, 1914. Musée d'Orsay, Paris.

Fig 4. One of the rooms of the permanent exhibition. Cité de l'architecture & du patrimoine, Paris (photo by F. Maggio).

verification, often temporary and partial, along its progress [...] In fact, the origin of the word *maquette* from the Latin *macula* (small stain, sketch, first draft) refers to the technical dimension of the ideational process, made of remakes, corrections, verifications. *Maquette* therefore as an open process where the first encounter between the necessary manuality of research and the world of physical things is realised, and through these, with the necessary, symbolic materiality of architecture" [Vragnaz 1987, p. 5].
The model as a 'contemporary' verification of the design process, and not as a mere 'construction' linked to issues of dissemination or communication to an external public, is a tool [3] adopted, for example, by the firm AM3 Architetti Associati [4] in many of their design works.
In some of these, the close link between the graphic representation of the project and the model is strongly recognisable, as the themes of assembling and composing [5] are in close relation to each other. The wire axonometric exploded views and the perspective views, in fact, seem to be the 'pieces' of the model that, once recomposed in space, tell the story of the project; the perspective views, the result of 3D modeling, emulate the views of the physical model, showing the close relationship between drawing and model (fig. 6). In the case, for example, of the proposal for the competition for the *Enhancement of the northern sacred area of the Sanctuary of Hercules Winner in Tivoli,*

Fig. 5. Scale model of an apartment in the Cité radieuse. Cité de l'architecture & du patrimoine, Paris (photo by F. Maggio).

announced by the Ministry of Cultural Heritage and Activities in 2010, the architects from Palermo, finding in the theme of the 'section' the question of the project, build a plastic model made of vegetal cardboard whose base is made up of 19 pieces equivalent to as many sections that study the orography of the site. The model was built, modified, altered, manipulated in a continuous comparison with the sketches of the project in progress [6]; ultimately the model was the representative system of the project whose graphic results were nothing but the effects of its construction, of its being a project itself (fig. 7).
It seems that certain issues on the subject of the model can, in a way, be reversed; the design becomes an imitation of the model and not the other way around.
But, after all, this is what happened in Renaissance workshops where sketches, pseudo-axonometries and pseudo-perspectives, described the model *in fieri* controlling all aspects of the design idea.
The model, moreover, may concern the shaping of one of the aspects of the design idea and not only manifest itself to show the project in its entirety. This is the case of the model realised for the study of the section of the central hall of the Church of the Immaculate Heart of Mary in Agrigento, built in 2022 by studio AM3. The element characterising the space of the hall is represented by a roof with soft lines, which, like the Virgin's mantle, gathers and protects the faithful. The ceiling seems to be suspended and finds its highest point at the altar, lit by zenithal light.
The comparison between the thematic model and the executive section of the project (fig. 8) recounts a possible declination of the construction of a model that, purged of the 'superfluous', tends to show, in the end, the true form.

A didactic experience. The model to get to know the city and its history

The opportunity to have had, as part of the *Survey and Digital Representation Workshop*, out-of-town and Erasmus students to whom the city was practically unknown, led to work on the theme of knowledge of Palermo through the study of its shape and its transformation over time by means of a rereading of the cartography of the 19th century city and, through comparison, knowledge of its recent history.
In the early years of the 18th century, the cartographic production of the city of Palermo still showed an inadequate

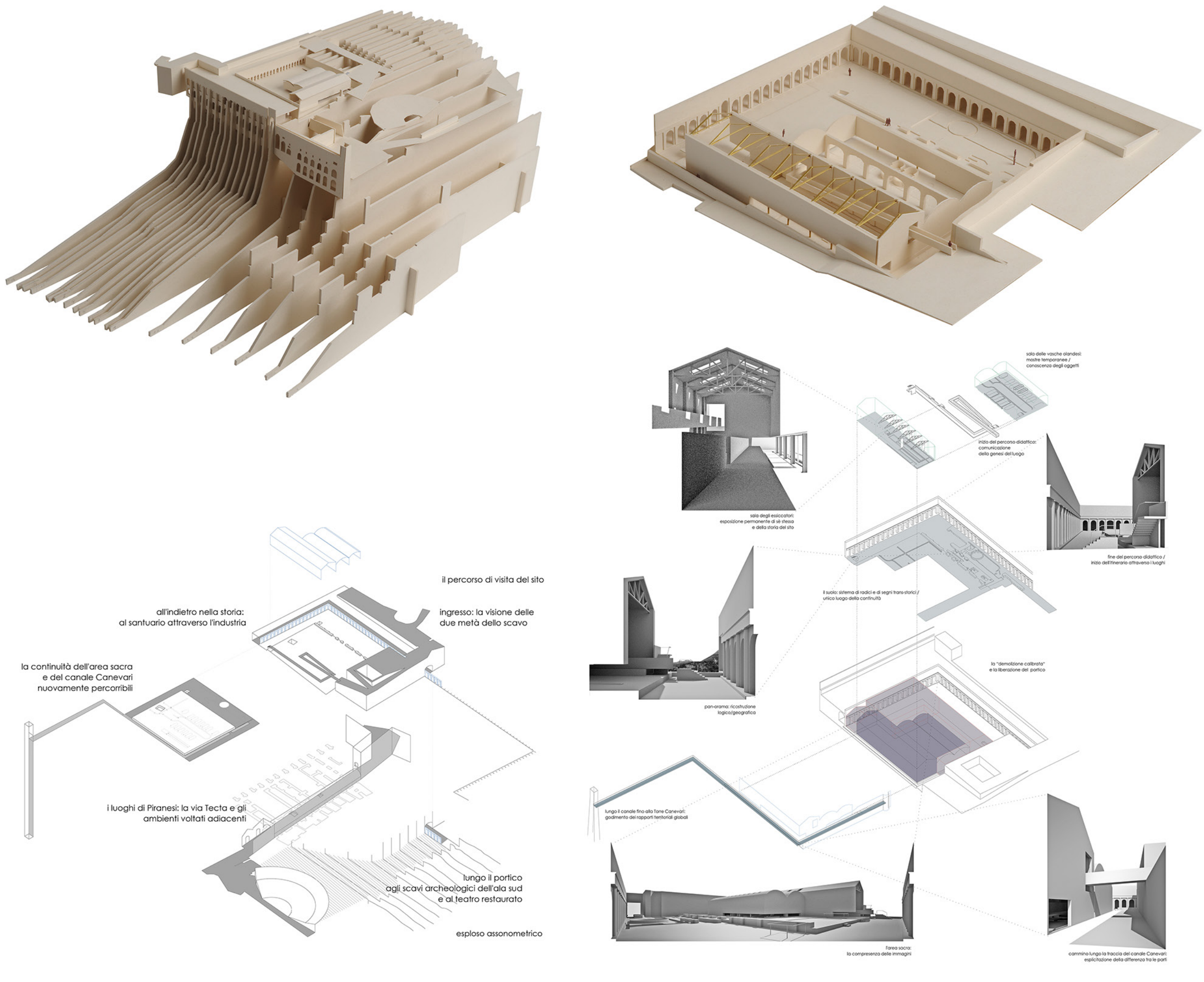


Fig. 6. AM3 Associated Architects. Winner of the competition for the redevelopment of the Sanctuary of Hercules in Tivoli. Scale model and renderings.

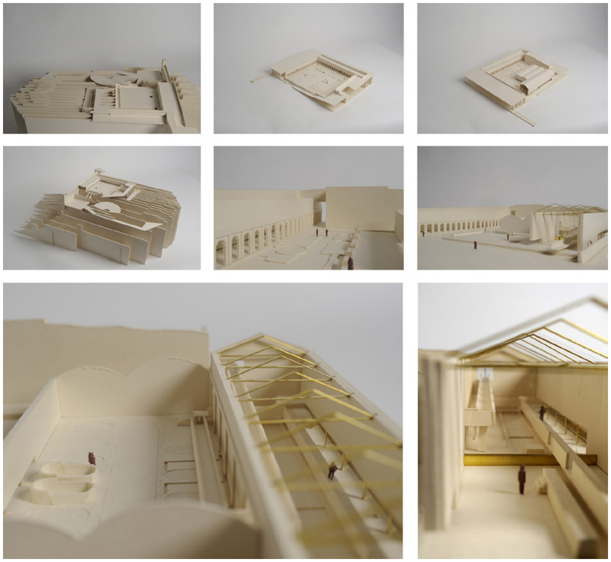


Fig. 7. AM3 Associated Architects. Competition for the redevelopment of the Sanctuary of Hercules Winner in Tivoli. Photo of the scale model.

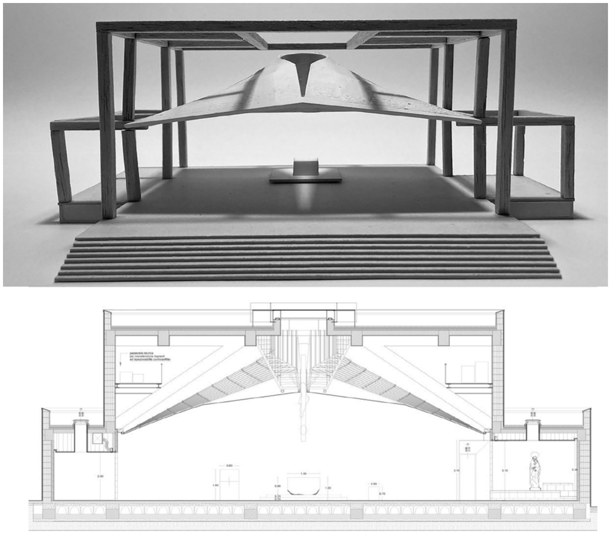


Fig. 8. AM3 Associated Architects. Scale model and section of the church of the Cuore Immacolato di Maria, Agrigento.

level of scientific accuracy due to the lack of topographical updating, which produced representations of the city that slavishly replicated its ancient 16th century layout, completely ignoring the important urban transformations that had taken place, particularly between the end of the 16th century and the following century. Combined with the continued use of the oblique projection method and the frequent absence of graphic scales, this propensity to copy gave an inaccurate geometric configuration of the city's layout and did not allow for a reliable reading of the urban fabric [La Duca 1975].

In 1777, at the request of the Senate of Palermo, the first large plan of the city represented in orthogonal projections and completed through direct survey by the royal engineer Nicola Anito was printed. The *Pianta geometrica e novella secondo lo stato presente della città di Palermo capitale del Regno di Sicilia con l'antico Palermo giacente in essa, e co' borghi molo e campagna* was designed by Francesco Maria Emanuele e Gaetani, Marquis of Villabianca and engraved by Giuseppe Garofalo. Following the four-sided scheme dictated by the orthogonal axes of the Cassaro and Via Maqueda, Villabianca placed, to the left and right of the 'topographical field', references to the notable places and buildings of the Albergheria, Kalsa, Capo and Loggia districts.

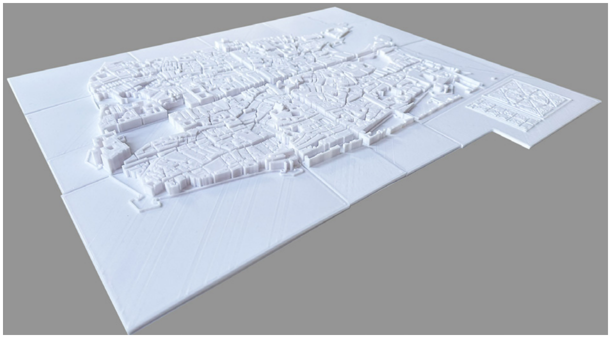
Despite the 'geometric' character of the representation, the general image still reflects a prevalent celebratory function, typical of Sicilian cartography produced between the 17th and 18th centuries, underlined by the presence of decorative trappings such as drapes, cartouches and coats of arms that did not allow for a complete depiction of the areas outside the urban centre [La Duca 1975]. Using the same copper plates, in 1791 Villabianca's plan was updated according to a new survey that showed the interventions carried out in the meantime, including the construction of Villa Giulia and the Botanical Garden, the extension of Via Maqueda, the opening of the perpendicular Via Stabile and the rectification of the 'stradone di campagna', which corresponds to the current Corso Scinà.

The break with the iconic language that had characterised 18th century cartographic production took place in 1818 with the production of the *Pianta della Città di Palermo*

Fig. 9. Plan of Palermo drawn in 1822 by F.G.C.B. De Behrend (La Duca 1975, Table 17).

e suoi contorni (Map of the City of Palermo and its Surroundings), made by Gaetano Lossiex and engraved by Tommaso Lomastro. The plan moves away from previous achievements, definitively abandoning decorativism in favour of greater precision and schematism.
Nineteenth-century cartography, on the other hand, pursuing the goal of scientific objectivity could not concede anything to ornament and allegory [Pagnano 2007] and for these characteristics Lossiex's map represented a model for the cartographic production of the following two decades.
However, only a few years later, in 1822, what Rosario La Duca called 'a revival' was printed, a plan of Palermo that represented a sort of revival of the18th century map of the Marquis of Villabianca. The map entitled *Pianta geometrica secondo lo stato presente della città di Palermo (Geometrical map according to the present state of the city of Palermo),* consisting of four separate sheets (fig. 9), was drawn by Lieutenant Colonel F.G.C.B. De Behrend, who expanded its contents in 1825 by adding what he had missed on his first reading and inserting new data.
De Behrend re-proposes, bringing it up to date, the scheme and ornamentation adopted by the Marquis of Villabianca by inserting, along the outer edges of the four sheets, "out of the picture", more than 1300 references with *descriptions of the Churches, Palaces and main objects and the names of the Squares, Streets, Alleys and Courtyards* of the four quarters that formed the ancient city: St. Cristina, St. Ninfa, St. Agatha, St. Oliva, today respectively the Royal Palace, Monte di Pietà, the Courts and Castellammare.
Despite the fact that De Behrend's plan represents a reversal of the 19th century tendencies to modernise

Fig. 10. View of the model (photograph by A. Garozzo).



ancient cartography, it was decided to use it in education as a basis for studying the form and structure of the historic city and for analysing the urban transformations that occurred over time.
The entire didactic process was conceived through a series of strategic steps, mainly characterised by cognitive and applicative modes. Beginning with the redrawing of the De Behrend map, a study model was constructed to understand the shape of the city.
The teaching activity therefore took place in several stages, including knowledge of the cartography, redrawing, field visits and construction of the physical model.
The model is constructed in pieces that apparently seem to have no logical structure in their composition; in reality they correspond to the number of visits made with the students who, through direct observation, got to know buildings, streets, alleys and courtyards, which they had previously drawn, only to discover them or, very often, not to find them. Each piece of the model thus corresponds to a walk, becoming the story of an experience (fig. 10).
Knowledge of the plan of Palermo of 1822 was explained to the students starting from the assumption that "every representation, even the apparently flattest one, always communicates something else, beyond the things presented and the obvious information, since the same way of transcribing interprets and loads the things drawn with meaning, with the meaning we attribute to them" [Pagnano 2007, pp. 88, 89].
The role of the model in the work with the students was substantial for the knowledge of the morphology of Palermo in the early 19th century; the map, once redrawn and interpreted, is 'elevated' with the model in an optical/tactile dimension (fig. 11).
The extrusion of the polylines of the CAD drawing, and thus the construction of a digital model, would have been an operation that, on its own, would not have achieved the objective of reading the overall shape of Palermo's historic centre.
It is evident that the construction of a model made with a 3D printer presupposes the construction of a three-dimensional digital drawing. But what 'physical' experience, of true optical-tactile knowledge, would the students have had without the aid of the inspections and the construction of a physical model? What subsequent perception would they have had of the overall shape of the city linked to the memory of having experienced it in some way? Would the digital experience alone, delegated to the viewing of

Fig. 11. Scale model superimposed on the redrawing of the map of 1822 (graphic elaboration by A. Garozzo).

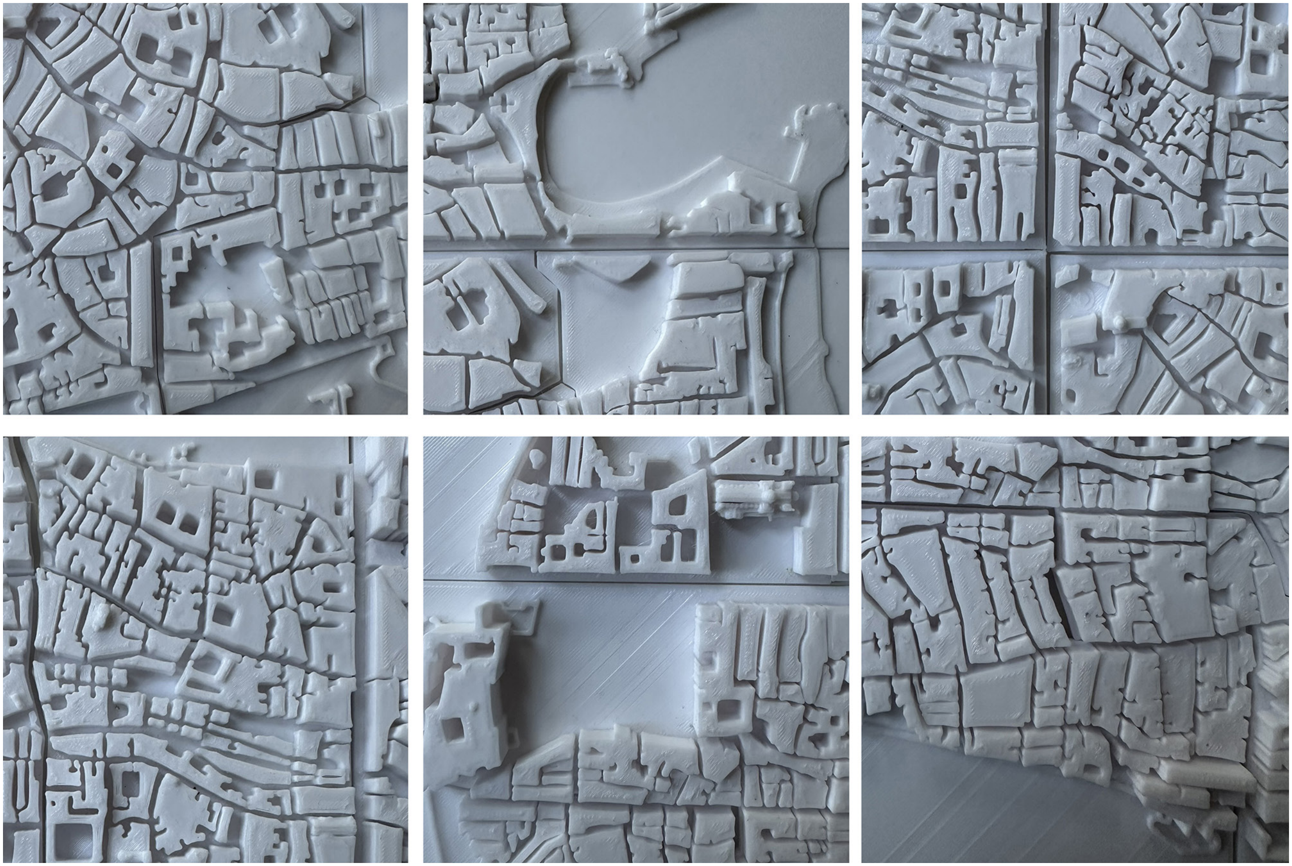


Fig. 12. Details of the scale model (graphic elaboration by A. Garozzo).

a screen, have been enough to know and tell a brief fragment of the history of a complex city?
The realisation of the model was intended, in this sense, as a construction of knowledge, remembrance and memory of the design of a city that was also, to relate it to its present-day consistency.
The static nature of the plastic model, opposed to the dynamic fruition of the 3D model, fixes the design of the urban form and its spatial contents composed of an intriguing system of alleys and courtyards, of streets and squares and the relationships with the coast and the sea (fig. 12).

Conclusions

The construction of the *maquette*, linked to the action of surveying a cartography in the context of a didactic experience, is an act of understanding that takes on, together with redesigning, a formative value. Its perceptive dimension allows a slow observation, an attentive gaze capable of 'entering' the interstices of the form of the city in a vision in which the whole and the part are always in simultaneous relation. This apparently static dimension, referred to the physicality of the model, reverses the theme of dynamism

in the three-dimensional graphic model. The latter is in fact explorable and navigable through the support of the screen or advanced technological instruments in which the investigating subject can, from a still position, scrutinise the object in its details. In the 'reading' of the model, on the other hand, dynamism is entrusted to the subject himself who, moving, "looks, observes and sees" [7].
In the triad 'looking-observing-seeing', in fact, lies the secret of those who do not want to be surprised when faced with the phenomena of reality, which investigated and analysed becomes the heritage of our knowledge. Watching implies educating the senses to the multiplicity and difference of forms, observing grasps the reasons for differences by revealing their rules, seeing traces meanings and values. The 'stillness' of the model refers to the slowness and 'calmness' of observation, a reading procedure induced by the fixity of the *maquette*.
On this theme, the words of Gaetano Cuccia are enlightening: "He who proceeds slowly deliberately distracts his attention, with an oriented intention, from particular points, to focus his gaze, his hearing, his senses all to grasp a nuance, a small vibration, to make an unpredictable, but patiently sought-after connection, to try out another possibility. Slowness is also a way of being present to the world and perfectly present to oneself, attentive to what one sees or hears, to the nuances, to the details, isolated in their small complexity, seemingly unrelated to one another and then quickly recomposed into a single reality. Slowness is a virtue that aids the ability to compose, the will to grasp the unitary form of an articulated reality, whatever it may be; it is the desire to glimpse a structure behind the simple appearance of things" [Cuccia 2007, pp. 11-13].
The Palermitan scholar, always with great intellectual refinement, again writes about slowness, quoting Milan Kundera who, in his book entitled *La lentezza (Slowness),* tells of the protagonist and her lover, that "by slowing down the pace of their night, dividing it into distinct and separate parts, she has managed to transform the brief span of time they have been given into a marvellous architecture, into a form", since, he continues, "giving form to a duration is the need for beauty, but also the need for memory" [Kundera 1995, p. 38], a concept of structure that has never been better expressed, since form itself can be defined as a complex and unitary structure in which the parts –neither juxtaposed nor contiguous– are subject to a law capable of determining the meaning of the parts themselves [Arnheim 1994].
Unlike many hyper-realistic virtual reconstructions, the three-dimensional print of the city represented by De Behrend, eschews the ambition of being a simulacrum of the nineteenth-century *forma urbis Panormi.* Rather, through its physical consistency, it transmits to the observer a subjective vision that opens the way to new interpretations and represents an opportunity, in a time of bulimic assimilation of images, for a profound learning of the form and structure of the city of Palermo.

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Notes

[1] The model of Pompeii, made of cork, wood and paper on a scale of 1:100, was inaugurated in 1879. It was designed by the Neapolitan archaeologist Giuseppe Fiorelli, director of the excavations at Pompeii and the Naples Museum, who entrusted Felice Padiglione with its realisation. It was later commissioned to Nicola Roncicchi in 1908 and took on its final appearance. During the course of the 20th century, it was moved several times between Naples and Pompeii, sometimes even divided into several parts, mainly to protect it from damage caused by the two world wars. In 1950 it was finally placed in the National Archaeological Museum in Naples.

[2] For more information on the *Le Corbusier project* see <https://www.citedelarchitecture.fr/fr> (accessed 10 April 2024).

[3] The model is understood as both a 'device' and a 'system of thought': in Latin *instrumentum* (instrument), just as Heidegger defines 'technique'

as both a means to an end and as man's actual activity.

[4] AM3 Architetti Associati was established in 2011 by architects Marco Alesi, Cristina Calì and Alberto Cusumano <http://www.am3studio.it/index.asp> (accessed 10 April 2024).

[5] The term 'compose' is used slavishly following the etymology of the word: compórre, contracted from the Latin *compònere* –p.p. *compòsitus* comp. –*com=cum* together and *pònere*, place, locate. To put together and mix various things to make one; otherwise and more communem. To form; referring to literary or musical things. To write of one's own conception; in things of art, Modelling, Drawing of one's own imagination.

[6] Alice Franchina and Francesca Mazzola, architects, are the authors of the physical model and design. Between two-dimensional representations, sketches and the construction of the model, they verified the design ideas in a synchronic representative process. The lack of material quality and executive refinement of the model, unnecessary because they were not absolutely necessary, left room for the formation of the project, delegating the development of the design process to the physical model.

[7] Reference is made to Le Corbusier's famous double triad from Carnet T70 of 1963. "The key is this: look, observe, see, imagine, invent, create".

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Models for Thinking about Architecture by Alberto Campo Baeza

Carlos L. Marcos, Andrés Martínez-Medina, Vincenzo Bagnolo

Abstract

The use of models in the design process has been a common practice throughout history that still endures. Despite the development of new technologies and their sophisticated ability to represent and anticipate the appearance of architectural designs, physical models continue to captivate us today. Their materiality, combined with their three-dimensionality and the ability to miniaturize architecture as a physical object, still make them an eloquent and irreplaceable communication vehicle. It is difficult to imagine a significant competition where architects reject to present models or photos of them. Here, we analyse the use of models in the design process of Alberto Campo Baeza, their importance in this process, and even the possible influence they exert on his own work. It is necessary to add that models are used in his studio for many different purposes. A detailed analysis of the types of models used by Campo Baeza and their various communicative, expressive, conceptual, and contextualizing purposes is presented here. Also their use as a vehicle for the creative process, testing lighting effects, or as an eloquent tool to be manipulated in order to synthesise and anticipate various aspects of architecture. Throughout this research, a taxonomy of the types and uses of models by this Spanish architect is proposed, delving into the details of their capabilities as project tools.

Keywords: models, Alberto Campo Baeza, uses, taxonomy, design process.

Introduction

The making of scale models has been a common practice in the civilized world; evidence of their existence dates back millennia [Franco Taboada 2017]. They have been used to reproduce reality; for worship, offering, and representation purposes; as souvenirs or for study [Gercke et al. 1986], or simply anticipating reality and serving as a model for construction. We are interested in the latter because their materiality and three-dimensionality contrast with drawings as a means of architectural representation, without the inherent limitation of their projective reduction. Understanding spatial complexity makes of them extraordinary ideation tools, anticipating the visualization of architecture as a tangible object. Additionally, their physicality allows adding layers of material significance in architectural representation that are notably useful in the case of conceptual models, adding expressive and informative richness to them. Their interest is such that they have been studied for decades [Vragnaz 1987]. Here, we reflect on the quality of models as a tool of architectural thought in its design dimension.

Our case study focuses on the models from the studio of Alberto Campo Baeza –an architect distinguished by the Accademia Adrianea with the Piranesi Award in 2018 and with the Gold Medal of Architecture in 2019 in Spain– with which he works himself; often, reducing their dimensions to miniature. As he writes, "an idea fits in the palm of a hand" [Campo Baeza 2013, p. 10]. This miniaturization, which effectively synthesizes the design idea [Scolari 1988], allows them to be directly manipulated with hands, which are also a tool

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Fig. 1. Monographic exhibition by Alberto Campo Baeza at the Patio Herreriano Museum (Valladolid), 2017.

of our thought [Pallasmaa 2012], serving as an intellectual vehicle equivalent to conceptual drawing, but adding cognitive aspects closed to the latter due to its two-dimensional nature. Thanks to their haptic condition, they ease a spatial understanding impossible to achieve through graphic representation. Moreover, unlike virtual models, physical models are malleable and hand-crafted, a true laboratory of experimentation [Carazo Lefort 2018]. This interactive relationship between the model and hands as tools linked to our spatial invention and as an extension of cognition is characteristic of *homo faber*, of our ability to imagine and build [Llopis Verdú 2013, p. 73]. In a way, it constitutes a place of articulation between architectural theory and practice [Allen, Agrest 2003]. However, reducing the use of models to these aspects does not exhaust the possibilities their professional use entails. Furthermore, Campo Baeza uses them in parallel with drawing as vehicles of architectural thought and ideation during the design process [Marcos, Allepuz 2018].

Methodology and objectives

To address this research, we have thoroughly explored the website of Alberto Campo Baeza's studio to delve into his projects and identify most of the models he uses, both during the design process and those made for more communicative or representational purposes, mainly intended for architecture competitions or to serve as an instrument to convey the project's idea to the client. Additionally, we had the opportunity to visit various exhibitions of the architect, where we could see some of the models as physical objects, specifically in the monographic exhibitions on his work at the Museo Patio Herreriano in Valladolid (2023) and the University of Alicante Museum (2018). We also consulted updated literature on architectural models. Through this detailed research, we established a taxonomy of the different models used in his studio, as well as the diverse purposes for which they are built, serving as an exploratory and anticipatory medium of architecture itself.

Types and uses of models in Alberto Campo Baeza's studio

Far from losing relevance in the professional field, physical models seem to have resurged in recent years due to, among other reasons, the prominence they have gained

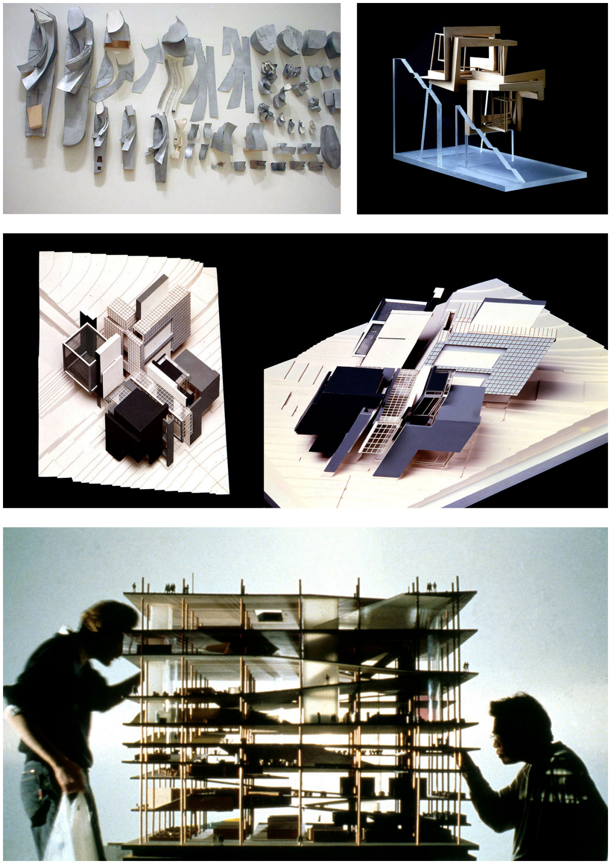


Fig. 2. a. Frank Gehry, 1996, Models from the Guggenheim Museum Bilbao; b. Peter Eisenman, 1988, Casa Guardiola model, c. and d. 1978, Axonometric model, House 2e. OMA, 1991, Jussieu Library.

Fig. 3. a. Alberto Campo Baeza, 2015, Raumplan House; b. Alberto Campo Baeza, 2002, Mercedes Benz Museum Project; c. Alberto Campo Baeza, 2014, Diagrammatic model of the House of Infinity (© https://www.campobaeza.com).

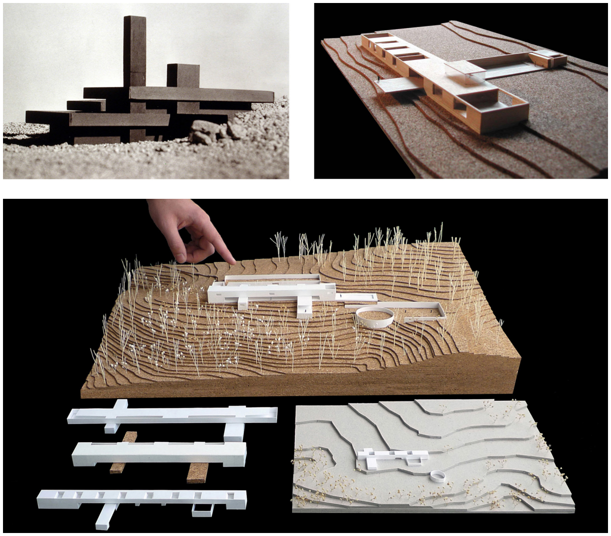
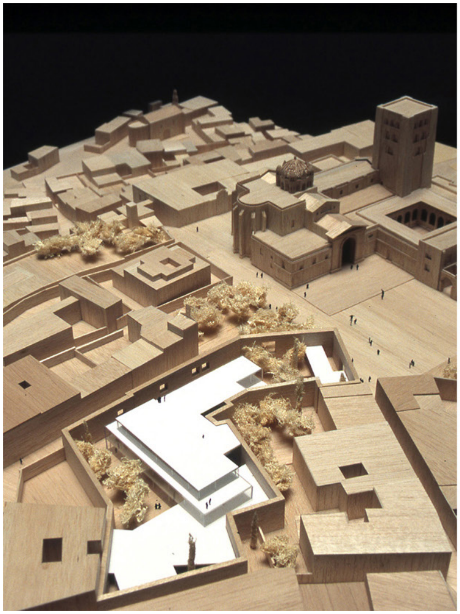


Fig. 4. a. Alberto Campo Baeza, 1974, García del Valle House; b. Alberto Campo Baeza, 2005, Chapoutot House; c. Alberto Campo Baeza, 2015, Hacienda el Baquillo (© https://www.campobaeza.com).

in the design process of some of the most well-known practices [Carazo Lefort 2018]. Perhaps the case of Frank Gehry is one of the best-known and most studied, but it is by no means the only one. His intense exploration of architectural form made the model a highly useful vehicle for ideation and communication in his professional practice. Peter Eisenman has also employed them. Several of the models of his early houses are well known, as in the case of his House II from 1969-1970, which the architect himself describes in these terms: "The house looks like a model and is built as such" [Eisenman Architects], and also in his Guardiola House from 1988 (fig. 2b). Eisenman assigns a crucial role to drawing and modelling in the design process, as he believes that true architecture resides in the project itself. His axonometric models especially challenge the boundaries between representation, object, and architecture (figs. 2c, 2d). He refers to them as "a three-dimensional object, an axonometric projection, and a plan" [Eisenman 1980, p. 18], and they undoubtedly constitute a milestone in the history of models [Bernal López-Sanvicente 2018]. However, OMA is perhaps one of the studios where the use of models has been given the greatest relevance since its foundation. Their models serve as reflection, testing, anticipated materialization, and are an unequivocal part of the ideation and configuration process of architectural form (fig. 2e).

A virtual tour through Campo Baeza's website highlights the fundamental role he assigns to models throughout his career. Few projects lack one or more models; in the more challenging, he uses them profusely. He has always promoted their use during his years of teaching at the School of Architecture in Madrid, insisting on the importance of creating both drawings and models because there are aspects that go beyond drawing. The projective limitations of drawings are overcome by models in all matters concerning three-dimensional, spatial, and sometimes even material aspects. Drawings and images can only represent visual qualities. Although the advent of virtual space, and with it the three-dimensional representation of architecture apart from physical models, has overcome some of the limitations of conventional graphic representation, achieving unmatched realistic effects, it has not contributed to the disappearance of models. Instead, it has renewed interest in these miniature



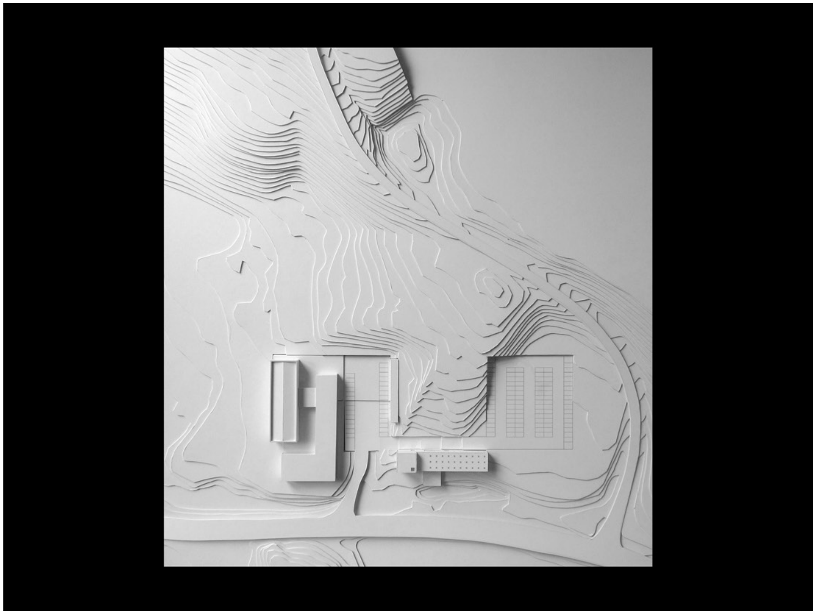


Fig. 5. a. Alberto Campo Baeza, 2012, Consejo Consultivo di Castilla-León a Zamora; b. Alberto Campo Baeza, 2023, Robert Olnick Pavilion (expansion of the Museo Magazzino) (© https://www.campobaeza.com).

architectures [Carazo Lefort 2011]. Observing the persistent use of models in architectural competitions from the past to the present day, their enduring relevance over time is undeniable. Their materiality is unsurpassed even by digital models, which, although they share three-dimensionality with physical models, are always perceived as views on a computer screen or rendered images –that is, projections– since they inhabit a virtual space. Models, on the other hand, can be seen, touched, and observed dynamically in real space, representing the project's geometry holistically, as a whole, and allowing the comprehension of the architectural object and space as a whole with the only limitation of their dimensional reduction. This aspect is sometimes an advantage, as it allows the project's idea to be synthesized very eloquently.
Models allow a complete control of architectural form, visualizing and apprehending its three-dimensionality. Additionally, although their materiality does not necessarily mimic the architecture they prefigure, their physicality does incorporate material values that enable other expressive registers. This research establishes a taxonomy of the different types of models that Campo Baeza uses in his professional practice, serving as a pretext to reflect on various relevant aspects and considerations in the field of architectural representation or ideation that should be incorporated into the academic debate. This article analyses the different ways in which Campo Baeza explores their use, considering up to nine distinct types: diagrammatic, ideation, contextualization, to ponder natural lighting, sectioned or fragments of construction details, conceptual and presentation, for photographic representation or for the creation of photomontages.

Diagrammatic models

A first approach to the use of models, aimed at understanding and exploring spatial relationships in three dimensions, reveals a significant aspect of their use in the early stages of the project. For example, we observe how

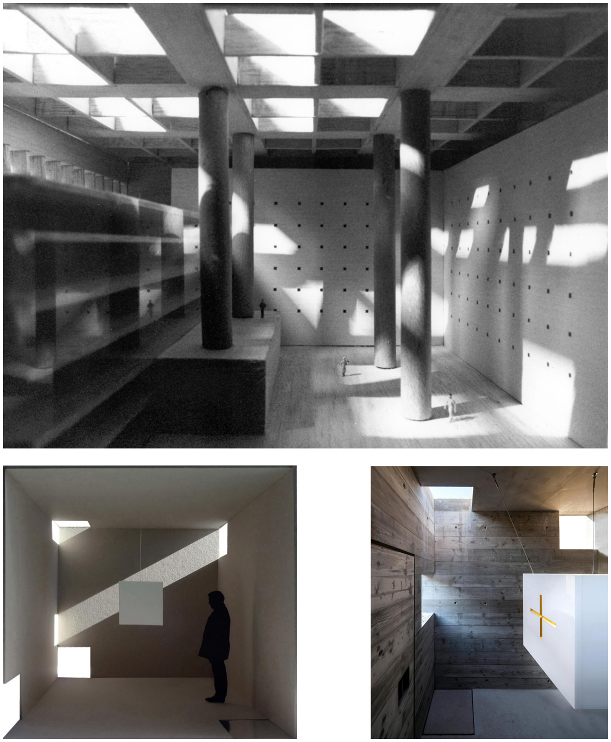


Fig. 6. a. Alberto Campo Baeza, 2001, Granada Savings Bank; b. Alberto Campo Baeza, 2019, Iheaven on earth, model; c. photograph of the work (© https://www.campobaeza.com).

a diagrammatic model for the Raumplan House is built using a simple cardboard and some basic folds (fig. 3a). The model allows for considering spatial interactions, the succession of diagonally articulated spaces after an ascendant spiral referencing Loos's architecture, and the stepped conception of spaces designed inside-out. The reduction to a diagrammatic definition of form in space represents the maximum synthesis of its spatial configuration. Its eloquence could never have been understood as effectively through diagrams. The dimensional reduction to the limit of the material –virtually negligible thicknesses– achieves a very precise condensation of the essential configuration. Another example can be found in the diagrammatic model for the Mercedes Benz Museum (fig. 3b), which explores the geometry of the spirals that intertwine and synthesize the project's original idea.

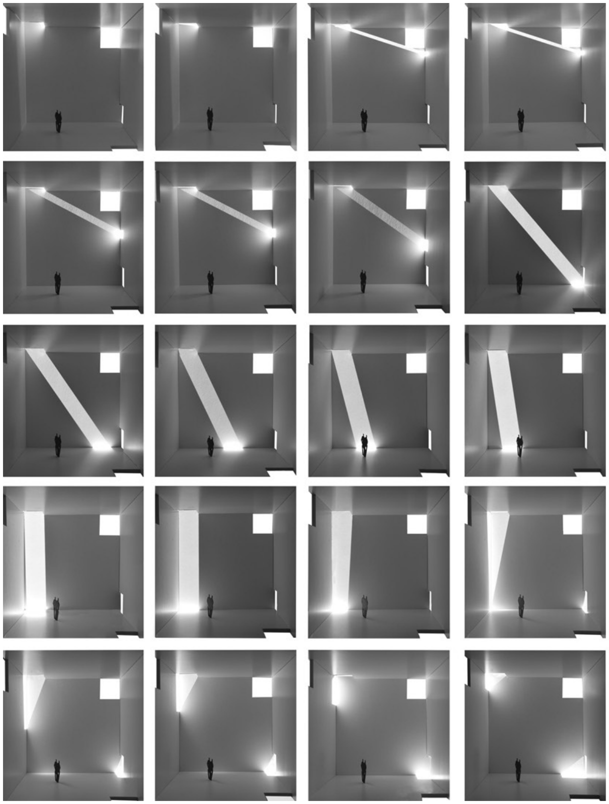
Similarly, the reduction of the model to a miniature that fits in a hand has also an added value. It represents the compression of the miniature, which is an inherent characteristic of every model in relation to the architecture it represents, bringing it closer to an axonometric view and to a considerable degree of abstraction in contrast to its small size. In this double process of reduction, the object exceptionally synthesizes the idea that gives birth to the project [Carazo, Galván 2014, p. 66].

It is important to note the role that the materiality of the model plays here. A simple cardboard, a piece of pressed board, or even a paper bag (fig. 3c) serves as a pretext to explore the project's geometry at a basic level. These models are made more for thinking about architecture in its preliminary stages than for describing it. Their physicality reveals their exploratory nature and evanescence, but their diagrammatic simplicity makes them extraordinarily effective in conceptualizing the idea, and they do not always correspond to the commencement of the design process. Their proverbial capacity for synthesis makes them an ideal vehicle for communicating the project's idea.

Ideation models

A similar phenomenon occurs with ideation models, which are commonly created as initial explorations of the project's geometry, testing the overall aspects of the project's volumetry, or as the first formalization of what the work will be like. They are usually made alongside the first sketches and contribute greatly to final decisions on how the parts will be articulated into the whole. This is a common practice that Campo Baeza has developed throughout his professional career, as illustrated by the García del Valle House (1974), the Chapoutot House (2005), or the Hacienda el Baquillo (2015) (figs. 4a, 4b, 4c).

In these ideation models, the project appears sketched out more or less definitively and serves both to advance the three-dimensional form for the architect and as an object that can be shown to the client during phases where there is still room to explore relationships between the different spaces that make up the program. We can see various initial explorations and project configurations that



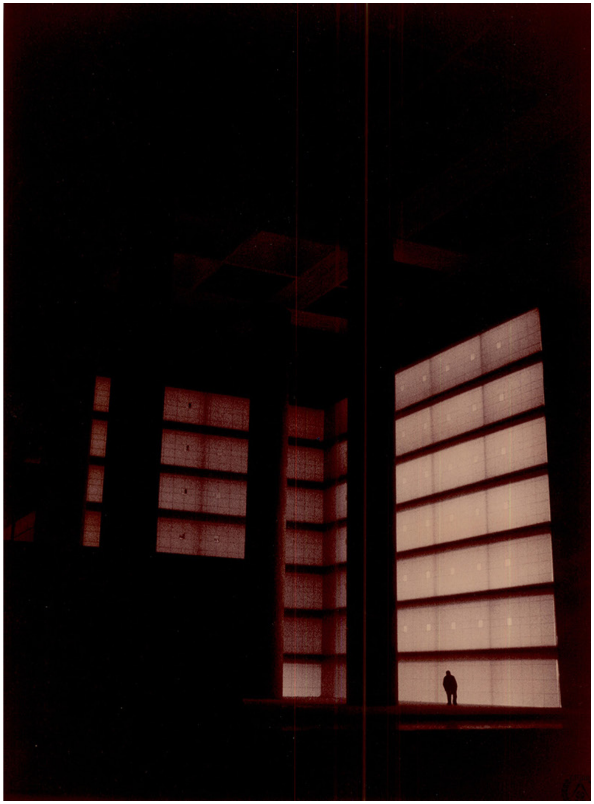


Fig. 7. a. Alberto Campo Baeza, 2023. Padiglione Robert Olnick. Serie fotografica di illuminazione all'interno basata sul percorso solare. b. Alberto Campo Baeza, 2001, Cassa di Risparmio di Granada (vista interna del modello della soluzione finale del progetto Saagio di luce 2) [U.d.s. 006; Archivio storico digitale della Biblioteca UPM].

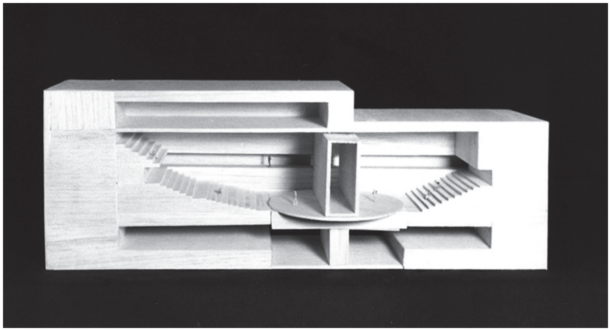


Fig. 8. Alberto Campo Baeza, 1993, Concert hall and chamber (detail of the project for the Copenhagen Philharmonic (© https://www.campobaeza.com).

constitute genuine variations on the same idea in these initial stages, moments that capture the project's creative process and lead to the final version, as observed in his project for Hacienda el Baquillo (fig. 4c).

Contextualization models

Models tend to have a certain quality of being isolated objects, artifacts, autonomous realities that serve to be viewed, touched, and perceived from different viewpoints in an exploration between hapticity and visuality. However, architecture is not a design object that can be placed anywhere. Unlike industrial design objects, architecture is designed for a specific place and is anchored to that context, making it meaningless to consider it in isolation [Holl 1989].
Models can also be very useful for exploring the way in which the architecture is inserted into a given context, anticipating the relationships of scale, tension, anchoring, and rooting of the project. Architecture belongs to the place, as once built, it becomes part of it and transforms it [Aires Mateus, 2006]. It is important to understand to what extent Campo Baeza considers the importance of these contextual models. Whenever he intervenes in a historic centre, he needs to gauge how his architecture affects the urban fabric, what the scalar relationships with it are, and the dialogue established with the adjacent architectural heritage. This can be seen in his project for the building for the Consejo Consultivo de Castilla-León (fig. 5a) or in his intervention for the elevated plaza in the Entrecatedrales project in Cádiz.
However, it is not necessary for the site to be a consolidated context with significant heritage value for the use of contextual models to be convenient and useful. For instance, scale, an eminently architectural condition, depends on a three-dimensional evaluation. This type of model allows for a scale control that cannot be matched by drawings or images, which are always deceptive when assessing scale issues. The scale control of the piece being designed within a context, its relationship with pre-existing structures or the landscape, recommends the use of this type of model, as observed in the case of the Robert Olnick Pavilion for the Magazzino Museum extension in Cold Spring, where the designed piece is introduced into a given context dialoguing with the larger existing building designed by Miguel Quismondo (fig. 5b). Also, in more landscape-focused interventions, these models are very eloquent regarding the accommodation established between architecture, context, and nature, as seen in the early version of the large platform project for a Landscape Interpretation Center in Lanzarote between 2009 and 2012 (fig. 11), which serves as a prelude to his domestic icon in Cádiz known as Casa del Infinito.

To evaluate and calibrate natural lighting

One of the essential elements in Campo Baeza's work is undoubtedly light. It is not just a functional concern about how to light the interior space or incorporate views from the outside into the work itself. Campo Baeza considers it the "basic, indispensable material of architecture", with the "magical capacity to create tension in space for humans". As deduced from his words: "Isn't light the only medium capable of making the unbearable gravity of matter weightless?" [Campo Baeza 1996a, p. 40], light holds a phenomenological significance. Most of his spaces engage in a dialogue with light, revealing how the sun traces its path across the sky.
This is not the place to address the various ways in which the architecture of this architect born in Valladolid operates with light as a project material, as he has extensively discussed [Campo Baeza 1996b], but it is appropriate to analyse how models can be used to study, observe, and even calibrate many of its effects. It is logical to think that an architect, so concerned with the effects produced by

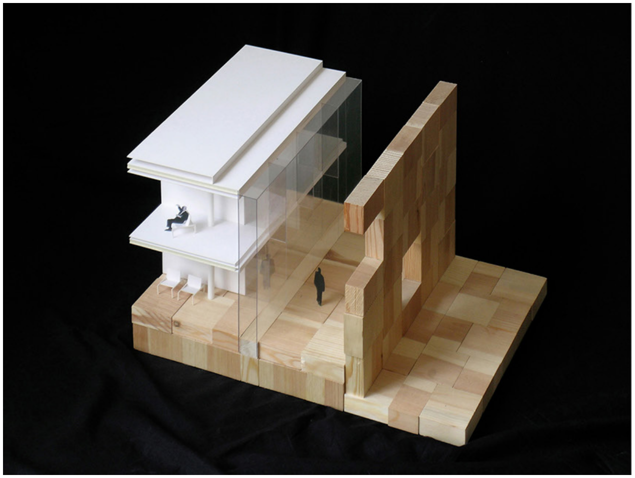
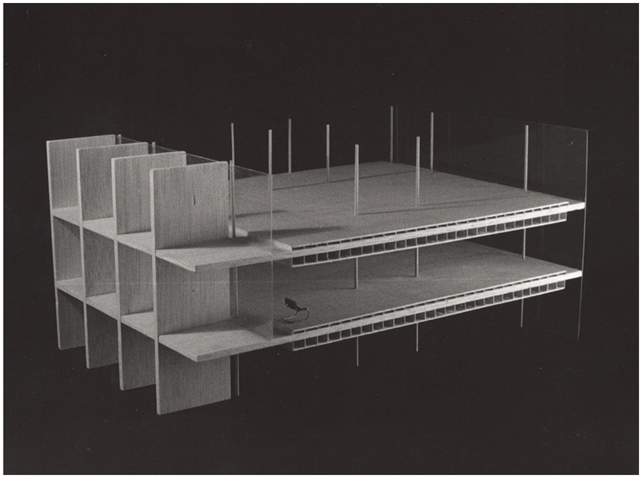



Fig. 9. a. Alberto Campo Baeza, 2012, Advisory Council of Castilla-León in Zamora; b. Particular model of the Granada Savings Bank (© https://www.campobaeza.com).

light and so convinced of the usefulness of models as a project tool, would explore the possibilities they offer. There are countless examples where the use of models aims to assess and calibrate the effects that light will produce inside once his architecture is built, achieving the desired effects of apparent weightlessness of matter.
For instance, the concern about the effect of light in the immense cubic atrium of the Granada Savings Bank Headquarters during the project process led to the creation of a large, sectioned model (fig. 6a) to observe the effects of overhead light within the space and the variation of brightness depending on light intensity and the sun's path. As Campo Baeza acknowledges, the central theme of the building is light –"a light *impluvium*"– and thus, besides the generous skylights that modulate Granada's brilliant light, there are also deep brise-soleils to the southeast and southwest, and alabaster pieces that temper the overhead light. This diffuse light effect was also tested using a translucent material model, as shown in a suggestive archive photo (fig. 7b). All this demonstrates the utility of models and their ability to anticipate various luminous effects capable of creating atmospheres analogous to those observed in built architecture.
The use of models also allows for the analysis and anticipation of light effects, their directionality, and their modulation based on the arrangement of openings in walls and roofs, the depth of walls and consequently their openings, their proximity to corners, or their isolated placement. We can see the extraordinarily eloquent effect that light produces in the sectioned model of the family pantheon, Il cielo in terra, compared to the real construction (figs. 6b, 6c). Or the detailed study of light entering and sweeping through the space in correspondence with the solar trajectory in the photographic series of the interior of the Robert Olnick Pavilion (fig. 7a).

Sectioned and fragment models

Beyond the need to section models to observe the effects of light within them, there is a whole genre of models that are sectioned to allow for viewing and discovering the interior space. These are especially useful for projects where the interior space is the main theme. This method enables us to see the interior in a manner analogous to being inside, allowing us to understand its configuration or aspects that would otherwise be hidden. An eloquent example of such sectioned models is the stereotomic podium housing the main program of the proposal for the Copenhagen Philharmonic

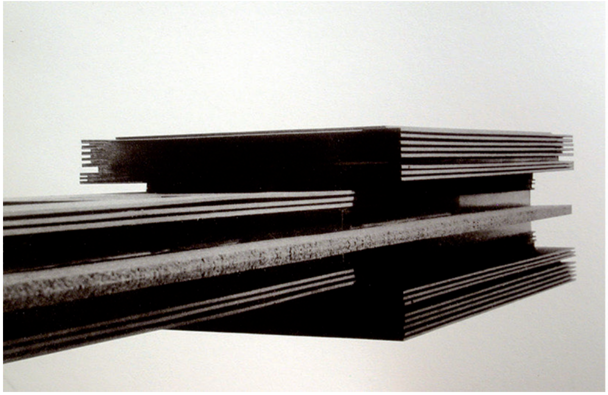
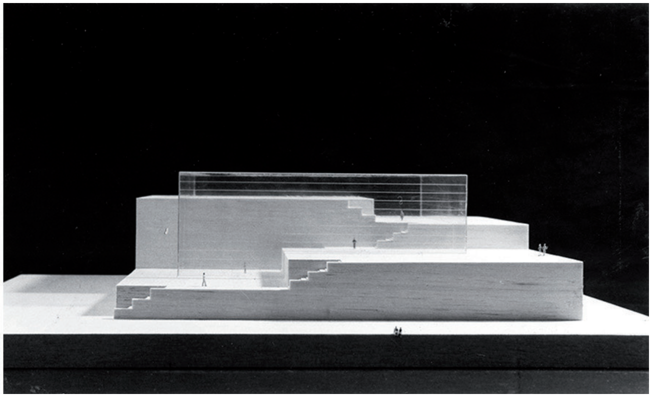



Fig. 10. a. Alberto Campo Baeza, 1971, Conceptual model of the Santander Festival Palace Competition; b. ACB, 1993, Conceptual Competition Model for the Copenhagen Philharmonic (© https://www.campobaeza.com).

competition, with the concert hall and the chamber music hall (fig. 8).
This possibility of dissecting part of the projected architecture also allows us to reference the construction and materiality of the architecture itself. It is not necessary for the materials used to be identical to those of the architecture they represent. The fact that the model has a physical component not found in graphic expression allows for the introduction of aspects related to the materiality of its components (fig. 9b). This can be useful for evoking contrasts between materials that the architecture possesses. This can be observed in the detail model of a fragment of the project for the Castilla y León Consultive Council in Zamora (fig. 9a); it shows the contrast between the robust stone wall surrounding the site and the white architectural piece with a light, almost immaterial glazing within that enclosure. A contrast of opposing thicknesses and materials is well understood in the detail or fragment model.

Conceptual and presentation models

However, the enduring prevalence of models, beyond their consideration as useful instruments during project development, even despite the advent of digital tools and their extraordinary capacity for realistic anticipation of the appearance of built architecture, lies in their materiality. For this reason, models are irreplaceable, despite their miniaturization compared to the real architecture. They place themselves in a hyper-plane regarding the representation of architecture. Observing them allows to change perspective and perception of the object in real time, enabling one to walk around them and contextually scale them with respect to their surroundings. For these reasons, they are also irreplaceable for communicating the merits of a project and, especially, for synthesizing an architectural idea.
Conceptual models perhaps best showcase their narrative function brilliantly. This is due to two determining factors: their miniaturization requires the elimination of all anecdotal and superfluous elements, and the materiality of the object itself allows for adding semantic layers related to architecture. The eloquence of these types of models, which synthesize the architectural idea, was discovered early in Campo Baeza's master thesis project model, with which he also won the competition for the Santander Festival Palace: a project that bridged the architecture of Mies and Jacobsen (fig. 10a). The same can be said for his conceptual model for the Copenhagen Philharmonic competition (fig. 10b).
These models are also very useful in cases where the relationship between architecture and context is crucial; they make it easy to understand these types of relationships due to their ability to synthesize and convey the project idea. The combination of both aspects makes

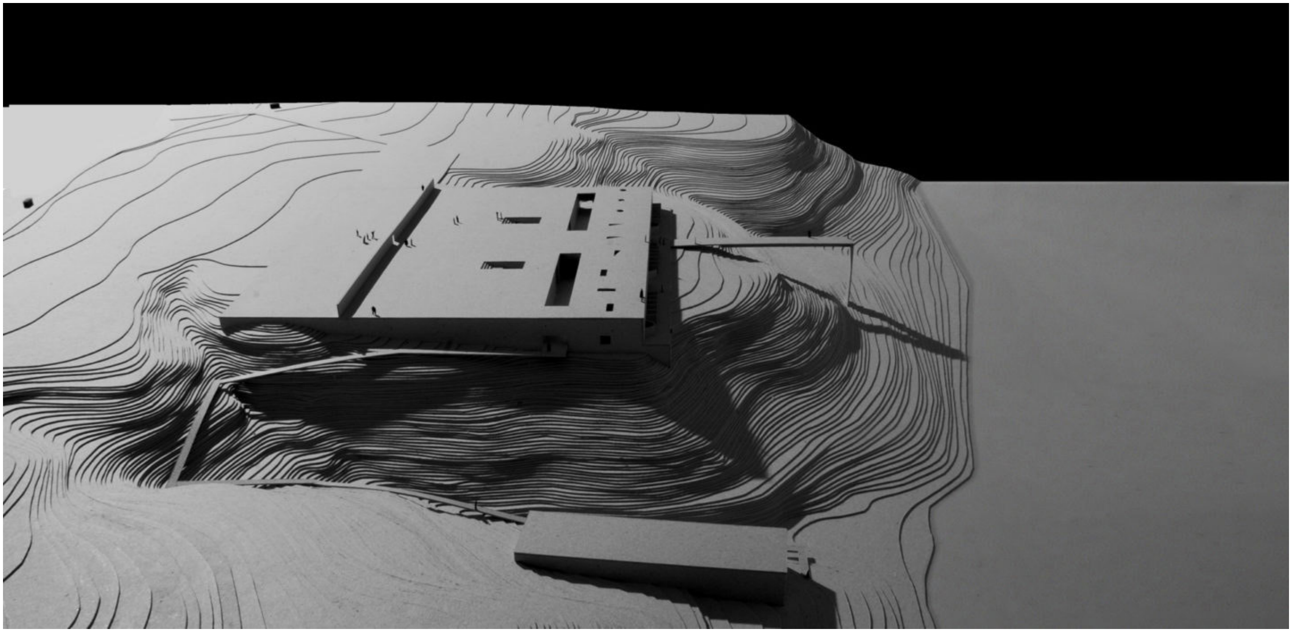


Fig. 11. Alberto Campo Baeza, 2012, Landscape Interpretation Center in Lanzarote, 2012 (© https://www.campobaeza.com).

them powerful communication tools, whose utility in competitions is undeniable (fig. 11). No prestigious office, when participating in a competition, fails to include a physical model or even more than one among their competition documents. In these latter cases, these are usually presentation models, generally of a larger scale and, therefore, with a higher level of detail and more careful elaboration.

For photographic representation and creating photomontages

Finally, models also play an important role in communicating the attributes of a given design, even taking advantage of their three-dimensional nature to be photographed and creating photomontages that anticipate how the architecture will look once built. This practice, popularized by Mies van der Rohe with the Friedrichstrasse skyscraper, although through photography and drawing, has expanded to the use of models. There are models that serve this purpose, and sometimes, from their conception, this goal is one of the fundamental objectives for their creation (fig. 12a).
These types of models intentionally photographed considering the horizon line height, the scale they are inserted into, and the distance from which they are photographed, can achieve very convincing contextualization effects (figs. 12b, 12c). It is true that with the development of rendering programs and the increasing sophistication of infographics, this use of models is gradually disappearing. Despite this, it remains a useful aspect of models, and if they are to be created for a specific project, with few resources and some skill, very expressive photomontages can be achieved with little effort.
To summarize the taxonomy presented in this research, the following synoptic chart synthesizes (tab. 1) the types, purposes, and examples of models analysed in the production of Alberto Campo Baeza's architecture. This analysis is not intended to be exhaustive over his entire production.

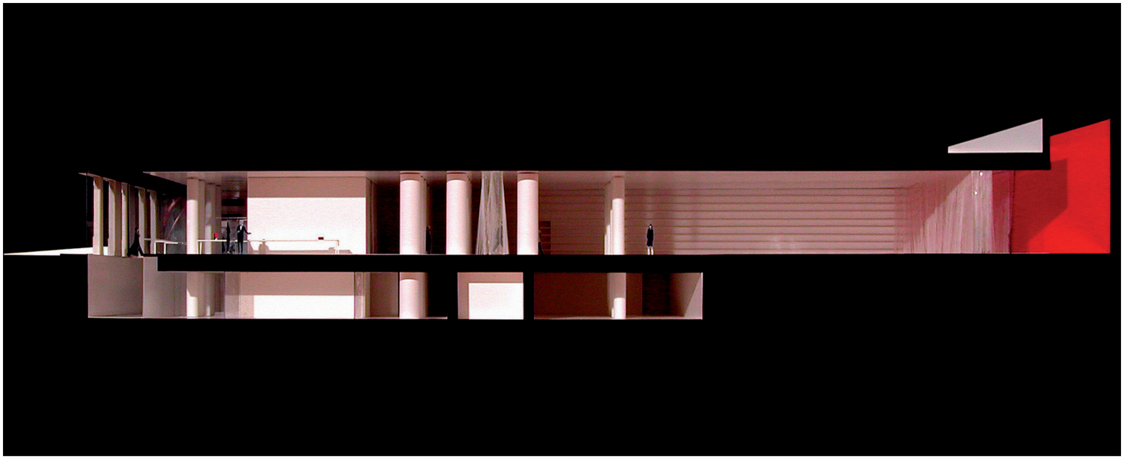
Type	Purpose	Characteristics	Examples
Diagrammatic	Understand spatial relationships	Maximum simplicity	Casa Raumplan, Mercedes Benz Museum Project, Casa del Infinito
Ideation	Initial exploration, project geometry and volumetry	Main project geometry without detail	Casa García del Valle, Casa Chapoutot, Hacienda el Baquillo
Contextualization	Scale and contextual analysis, materiality, volumetry	Volumetry in context	Consejo Consultivo de Castilla y León, Robert Olnick Pavilion, Entrecatedrales, Landscape Interpretation Center in Lanzarote
Lighting	Evaluate and calibrate natural lighting and shadows	Simple, with special attention to openings and materials	Caja de Ahorros de Granada, Il cielo in terra, Robert Olnick Pavilion
Sectioned	Understand interior space, analyse construction and perceptual aspects	Sectioned models	Concert Hall project for the Copenhagen Philharmonic
Fragmented	Analyse construction and material aspects	Fragment models of the whole to be studied in detail	Consejo Consultivo de Castilla y León, Caja de Ahorros de Granada
Conceptual	Synthesize project ideas, competitions	Simplicity, boldness, and expressive materiality	Santander Festival Palace competition, Copenhagen Philharmonic project, Landscape Interpretation Center in Lanzarote
Photomontages	Anticipate architecture in its location through context and model photography	Made to be photographed	Círculo de Lectores competition, Telefónica Tower, Alminar Tower

Tab 1. Tabella sinottica dei modelli analizzati nella produzione dell'architettura di Alberto Campo Baeza.

Conclusions

This article analyses and establishes a classification for the use of architectural models, using Alberto Campo Baeza's professional practice over more than half a century as a case study. Campo Baeza has produced some of the most iconic projects in Spanish architecture in recent decades. The simplicity of his architecture, its clarity, and the volumetric and spatial simplicity of his work may be more closely related to his prolific use of models during the project process than one might imagine. The miniaturization necessary in making models involves a search for the essence of geometry, thus freeing the project from the anecdotal or the superfluous. This progressive formal simplification is where the strength of many of his works relies on, and undoubtedly, the condensation of the project's idea in his conceptual models supports this strategy.

In any case, the selection of examples that illustrate and serve as a thread for this research shows not only a common practice in Campo Baeza's studio but also serves as a pretext to understand the varied possibilities that the use of models entails in architectural projects. His production is analysed as a case study, but it is evident that most architects who use models during the design process do so with similar purposes. The capacity to synthesize the project in conceptual models is a common practice and one of the greatest advantages of these miniature architectures. Even in those whose materialization is truly schematic, the underlying idea that organizes spatial relationships is evident. When used to insert the project into its context, they provide interpretive keys to the scalar relationships of architecture in the location, which are irreplaceable pre-



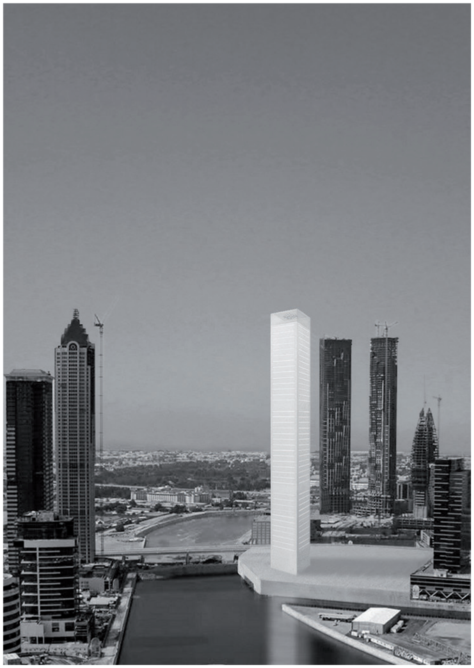


Fig. 12. a. Alberto Campo Baeza, Alberto Sixto Morell, 2005. Readers' Club competition template (Barcelona). Photomontages with models; b. Alberto Campo Baeza 2000, Telephone Tower (Madrid); c. Alberto Campo Baeza, 2013, Minaret Tower (Dubai) (© https://www.campobaeza.com).

cisely because of their true three-dimensionality. Likewise, the use of purely material aspects and the contrasts that can be introduced in this regard provide an expressive and effective means to establish contrasts between the projected architecture and pre-existing conditions. As three-dimensional objects, they can be used to study shadows and natural lighting effects that can thus be anticipated in the builtarchitecture. Even, when properly photographed, they can serve as a basis for the creation of photomontages, a practice that was decisive during the twentieth century and which new technologies have progressively replaced with digital photomontages through infographics.
The multiplicity of uses and types of models, as well as their various expressive, communicative, or synthetic purposes, are not necessarily exhausted here. At times, these models are considered as objects in themselves, almost like refined sculptures that also appeal to our aesthetic sense. Part of their success is also due to this reason, ensuring a long life for architectural models despite new technologies, without deliberately considering here the digital fabrication of models, which has proliferated in recent years.

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RUBRICS

Readings/Rereadings

Readings/Rereadings

Rassegna 32 on *(Maquette)*, or the Physical Model

Veronica Riavis

The journal *Rassegna. Problemi di architettura dell'ambiente* (Review. Problems of the Architecture of the Environment), directed by Vittorio Gregotti and graphically edited by Pierluigi Cerri, was published from 1979 to 1999. Comprising 77 monographic numbers issued quarterly, each coordinated by influential cultural figures of the time, the periodical was developed during a historical period where the scientific, social, and professional worlds were preparing for the inexorable advent of the new millennium and the consequent phase of change on both the theoretical and practical levels. As the title implies, this editorial is a collection of considerations designed to enhance the understanding of the various architectural characters within significant macro themes.

The issue number 32 of *Rassegna*, published in December 1987, was edited by Friulian architect and professor of composition Giovanni Vragnaz. This issue focuses on the theme of the 'maquette', which is the designer's fundamental physical support for conceiving, studying, and transmitting his or her thinking. The decision to dedicate an entire issue to this topic underscores the significance attributed to this tool in the compositional and communicative processes in architecture and beyond. The analyses conducted within the volume permit the reader to gain insight into the various dimensions and potential of the model. This provides a comprehensive and stimulating overview of the subject matter, which is presented in a clear and current manner.

In accordance with the graphic design of the journal, the cover is designed to visually focus on a few clear elements (fig. 1). On the one hand, the image of the great wooden model of the competition proposal for the facade of Santa Maria del Fiore submitted by Giovanni Antonio Dosio (16th century) is eloquent and evocative. On the other hand, the concise title of the theme addressed within the pages of the periodical, (Maquette), is also noteworthy. The two graphic signs, placed deliberately in round brackets, serve to highlight the breadth and generality of the topic, which is then explored in depth within nine essays according to a historical and interdisciplinary excursus.

The curator, from an etymological perspective, favors the term 'maquette' [1] over the word 'model', which is inherently ambiguous and refers to something to be imitated. Deriving from the Latin "*macula*", meaning "small sketch, drawing, rough draft", the term would be more accurately defined as a technique of the creative process, open

Fig. 1. Cover image of Rassegna No. 32, (Maquette).

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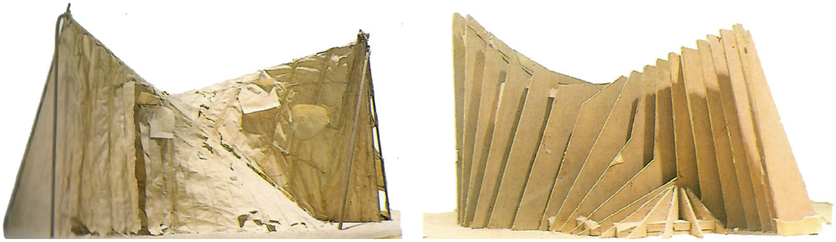

Fig. 2. Le Corbusier, two original preliminary model of the Pavillon Philips, 1958 (photo by E. Kossakowski, CCI, Paris).

and material, made up of successive modifications that can be evaluated by manual research. It serves to represent, to crystallize a thought and to anticipate a constructive reality [Vragnaz 1987, p. 5; Croset 1987, p. 45]. In the broadest sense, modeling can be considered a traditional technique of drawing. It encompasses a range of activities, from freehand sketching, which is a spontaneous and intuitive exercise in communication, to the clean tracing of an executive project. In both cases, there is an interaction between the means (drawing) and the end (project) [Maldonado 1987, p. 59]. Scale or life-size models (mock-ups) are usually constructed for the purpose of better assessing the aesthetic or functional characteristics of the reproduced objects (fig. 2). Supportive of drawing to improve the project according to Leon Battista Alberti, or its materialization for Giorgio Vasari, the maquette is regarded as the technical apparatus available to the architect to represent, plan, and construct, as well as to document, communicate, and propose potential new realities.
With this clarification, the model can be understood as a maquette in the various essays. It serves as both a drawing, prototype, or model of architecture and a resolving device for managing the construction site. Additionally, it can be used in cartography for military and defensive purposes or as an autonomous and independent work of art. In summary, *Maquette* aims to expand the field of investigation and examine the concept of the model, not only as a well-established theoretical instrument in the relationship between ideas and representation, but also as an object with multifaceted meanings and functions, as evidenced by its historical evolution within the context of various disciplinary discourses, between architecture, engineering, and visual arts in general.
In summary, the monographs are organized by subtopics of investigation [2]. Riccardo Pacciani and Lionello Puppi address the architectural model in the Renaissance, while Jacques Guillerme and Vincent Bradel outline the role of the maquette in evidential and civil engineering. Pierre-Alain Croset and Tomás Maldonado offer theoretical and practical reflections on the historical use of the tool. Finally, Massimo Quaini and, to a certain extent, Marc Miller explain the historical evolution of the spatial and urban model, while Germano Celant describes the maquette as a leading work in the 20th-century avant-garde.
This review interprets and reorganizes the theme of the model addressed in the various essays by splitting the conceptual and historical spheres. This is done to actualize its definition almost four decades after the publishing of *Maquette*.

On the concept of model
By definition, a model is an 'object of mimesis' that reproduces the form and characteristics of a work, whether existing or ideal, in full or at a different scale, as Pierre-Alain Croset reminds in the essay *Microcosms of the Architect* [Croset 1987, p. 47]. The term can be applied to areas other than architecture and it is most used to describe the principles of construction and reproduction: the former concept detects the action of assembling and joining the parts, while the latter one identifies the model as an artifact designed to describe in a personal and interpretive way the idea of a physical space by stimulating the critical imagination of the designer (architect, engineer, or product designer) or the observer. The act of representation entails the projection and crystallization of the architect's conceptual framework with plans, elevations, and maquettes. In this manner, the project is externalized, and its form is subjected to the judgment of the senses. For Croset, the architectural maquette it's a model that has been restored to its intrinsic dimension as an object. It can interact with the author's creative process as a materialization of his intellect. Its three-dimensionality affects the observer on a sensory level, transferring to him an idea of volume and space. A study tool that is intelligible, tactile, and visual, which allows the prefigured building to be represented, explored, controlled, and transformed [Croset 1987, p. 48].
The theme of perception is also addressed in Massimo Quaini's essay, *The Lay of the Land*. Model-making

procedures document the design and practical steps that determine the form, space, and composition of an architecture. In this context, the maquette can be considered a representation that is comparable and complementary to the drawing as a subjective tool for elaborating and presenting the design idea. But compared to the drawing, the materiality of the model evokes a spatial-sensory response in the viewer. The physical maquette, through haptic, kinesthetic, and synesthetic perception, conveys the 'concreteness' of space. This is in addition to the projective and Euclidean 'abstraction' required by sight, which is considered the intellectual sense par excellence.
As stated by Quaini, the designer uses the model to both visualize the formal, structural, or functional assumptions of an idea and to present the project to external parties, including clients, performers, manufacturers, and the public. Indeed, it can be employed in two distinct ways. On the one hand, it can be used to facilitate the learning of architectural and urban design principles for those new to the field. On the other hand, it can be utilized to enhance the clarity of conventional and symbolic language with a tangible object [Quaini 1987].
In his essay *Issues of Similarity*, the artist, designer, and philosopher Tomás Maldonado elucidates the creative-constructive strategy of modeling, which is based on the concept of similarity. Maldonado posits that the manifestation of similarity, both quantitatively and qualitatively, varies across models. In fact, the degree of similarity between the original and the reproduced objects can be attributed to three distinct categories: homology (form and function), analogy (structure and function), and isomorphism (form and structure, sometimes by function).

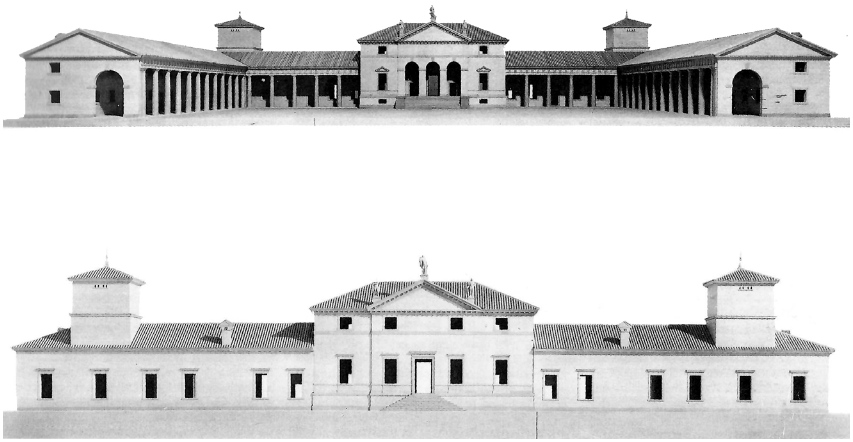

Fig. 3. Wooden model of Villa Saraceno in Finale, 1973. Centro Internazionale di Studi di Architettura A. Palladio.

The author additionally notes that both 'replicative' iconic models, which reiterate a 'referent' through proportional reduction (architectural maquette), and life-size models, such as the industrial prototype, are based on the principle of similarity. In the latter case, the product may be classified as either non-functional, semi-functional, or functional, depending on the operability of the parts and the introduction of appropriate mechanical aids. Finally, there are prototypes that are nearly indistinguishable from the final product and possess the same formal, functional, structural, and operational configuration as the modeled object [Maldonado 1987, pp. 57-59].
To the 'iconic' maquettes, drawings, and prototypes (kinesthetic and approximate analogies), the corpus of models also includes 'aniconic' diagrammatic and mathematical models (abstract algebraic reductions). These are similar models, where structure and function predominate over the form. These opinions of Tomás Maldonado [Maldonado 1987, p. 60] are shared and traceable in the essay *The Rôle of the Model in the Scientific Pursuit by Jacques Guillerme* [Guillerme 1987, p. 29].
In any case, the historical evolution of model theory and practice can be observed in terms of their role and use by the designer, performer, public, or client. The tracing of a linear and clarifying path of the different conceptions on the subject is a complex operation due to the realization purposes and the evolution of various knowledge.

Historical evolution of maquette between architecture, engineering, and art

According to Tomás Maldonado, physical maquettes –whether original or contemporary interpretations– are particularly useful for documenting and publicizing the technical and theoretical progress, as well as for bringing back to their origins –through the reconstruction and completion of architectural and archaeological remains– lost or unrealized works based on iconographic

and textual sources [Maldonado 1987]. The history of architectural models has accompanied humans throughout the centuries and bears witness to the evolution of technology and the profession, although, for a period, architectural historians did not consider them to be of interest.
It is evident that the ancient Sumerian, Egyptian, Roman, and Greek architects made use of them. However, it was during the Renaissance that maquettes assumed cultural significance, particularly in the context of gaining client approval of the proposed idea and as tools for research and design delineation to be passed on to the performers and workers involved. The issue of the Italian Renaissance building site is addressed in the essays by historians Riccardo Pacciani, *Wooden Models in Renaissance Design* and Lionello Puppi, *Models by Palladio, Palladian models*. Here the authors elucidate the stages of advancement of technical knowledge and provide theoretical references, also in comparison with the building practice in the Venetian and transalpine territories.
Croset and Pacciani remind us that in first- and second-hand sources the use of model was documented from the 14th century onward, referable to the Latin root *modus* (measure), its diminutive *modŭlus*, the terms *exemplar* and, later, *designum* [Croset 1987, p. 47; Pacciani 1987, p. 7]. As evidenced by Guillerme and Maldonado, in those years the maquette played a pivotal role in the differentiation and emancipation of the architect from the medieval master builder. This shift in patron behavior can be attributed to a change in their mindset, which began in the 15th century and continued throughout the subsequent centuries. During this period, patrons became increasingly interested in viewing the final version of a commissioned work before it was completed. At the same time, new drawing techniques were being developed, including linear perspective, and sophisticated scale models were constructed to visually translate the image of the new architecture to build. In this context, the execution of the model, and thus the consequent success of the project, could be evaluated according to the ingenuity of the craftsman or the genius of the theorist [Guillerme 1987]. A qualification of architects such as Brunelleschi, Ghiberti, or Michelozzo, who had received training in goldsmithing, woodworking, carving, and other crafts. They were adept at translating large-scale architectural works into smaller, more accessible forms, facilitating comprehension even for those not directly involved in the construction process [Maldonado 1987, p. 58].
In his analysis, Pacciani delineates how in some major Italian construction sites, such as the Duomo in Florence and San Petronio in Bologna, models were intended to simulate the formal and aesthetic qualities of architecture. Models of varying scale and detail, constructed from wood or different material, were useful for proposing an idea, resolving administrative and construction issues related to the site, and studying how to integrate the new building into the context or onto existing structures. The maquettes enabled the assessment of the placement of scaffolding and ribs, as well as the verification of the structures, techniques, materials, and decorations. Additionally, they facilitated the quantification of the labor required and the estimation of the costs [Pacciani 1987, pp. 10-13].
However, as documented by Pacciani and, more extensively, by Puppi, the Italian procedure was not widely implemented beyond the Alps or in the Venetian territories of the 15th and 16th centuries. In fact, to support dimensional documentation, 1:1 scale wooden outline was adopted in these places for ornamentation only [Pacciani 1987, p. 10; Puppi 1987, p. 22]. This 'rejection' of the model, as highlighted by Puppi, was a common practice among prominent architects such as Andrea Palladio and Vincenzo Scamozzi. In their cultural context, maquettes were regarded as ambiguous objects with a misleading reduction in scale. They could establish privileged, yet unreal, points of view [Puppi 1987, pp. 20, 25The Venetian Renaissance architect had an intellectual role that commenced with the conceptualization of the project and concluded with its realization, coordinating, and controlling the execution of the technical specializations involved, relying mostly on the use of drawing. There during the 15th century the notion of model was exhausted precisely in that of 'drawing in clean', or, rather, *model over disegno* and *modellum seu designum*, defined at the end of a preliminary graphic research approved by the client and accompanied by textual notes for the workers and the *protho de la fabrica* [Puppi 1987, p. 20].
Palladio's factories, which were based on classical models, became fundamental examples for the modern age. They were appreciable through the treatise *I Quattro Libri dell'Architettura* [Palladio 1570], drawings and site visits. Although physical maquettes did not form part of Palladio's design practice, there was a need to collect, compare, and visualize his works through their three-dimensional translation. This was achieved in the 1973 exhibition dedicated to the architect, which was curated by Renato Cevese and held in the Basilica Palladiana in Vicenza (fig. 3) [Cevese 1973; 1976].
Despite the divergence in methodological approach, the model witnessed

a transformation in the documentation of design hypotheses and their presentation to clients. This evolution can be observed in the case of Antonio da Sangallo the Younger and Michelangelo Buonarroti, though with markedly disparate approaches and circumstances as detailed in Pacciani's monograph [Pacciani 1987, pp. 16, 17].
The model was not only the result of a need for global and simultaneous perception of all aspects of a building; it was also the ceremonial tool and organization of space and power, with military and imperial finalization. This is in accordance with Quaini's essay. Indeed, for both strategic and collectors' reasons, numerous relief models of squares, fortresses, mountain, and coastal territories became prevalent in the 18th century as aids to understanding and controlling the territory and its pre-existences [Quaini 1987, pp. 65-68].
As Croset reminds, other types of architectural maquettes were also prevalent, particularly during the Baroque period. Scenic machines and ephemeral apparatus were designed and constructed in full scale for celebratory occasions, after which they were dismantled and destroyed. Such models were frequently integrated with perspectives and mechanical devices to simulate large-scale visual spectacles [Croset 1987, p. 50].
The models were not merely instrumental in the evolution of the research and construction of architecture. In fact, these 'objects of fiction' also entered scientific discourse to package and document major public works and infrastructure [Bradel 1987], for evidentiary purposes of engineering theories [Guillerme 1987], but also as tools for reading the territory [Quaini 1987] and documenting city development [3] [Miller 1987].
In *Three Invisible Collections for a Non-existent Museum*, Vincent Bradel examines the models constructed between the 18th and 19th centuries of public engineering works, including harbor accommodations, hydroelectric dams, road and rail systems, mines and reservoirs, lighthouses, and bridges. The varying scales of the maquettes demonstrated the soundness of the projects and facilitated the understanding of complex structures. At the same time, they fulfilled a deliberately disseminative role [Bradel 1987].
Guillerme, remaining within the field of engineering, elucidates how historically, models have been employed to exemplify the functioning of mechanisms, to study interventions of stiffening or structural lightening, and to evaluate the strength (internal and external, in terms of time and deformation) by comparative tests on homogeneous elements and materials. The initial analysis was purely qualitative, but subsequently evolved into more rigorous quantitative and numerical investigations. The "theory of the invariability of the effects" has consistently been predicated on the capacity to withstand rigorous testing of models at varying scales of reproduction. Conversely, the empirical observation of the effects on full-scale objects was conducted in construction sites. In this context, the models created by Antoni Gaudí (fig. 4), and Pier Luigi Nervi are of great interest [Guillerme 1987].
In addition, models of the territory, which did not describe its quantitative aspects –mainly offered by cartography by azimuth and planimetric projection– but also those inherent qualities of the landscape. As geographer Massimo Quaini elucidates in exhaustive detail, the landscape, comprising diverse morphological, physical-natural, and anthropic structures, also found its definition within the model. He delineates that the dichotomy between quantitative and qualitative paradigms is predicated upon Ptolemaic theory, which was subsequently revived during the Renaissance and in the 17th century. It reflects the comparison between the geographical representation (quantity and extent of places, measure, and proportion of distances) composed of letters and signs, and the chorographic representation (quality of places by their similarity and true form) that uses drawings, paintings and later models or plan-relief. The advent of pictorial cartography permitted the distinction between paper and model, two terms that, in the 17th century, were used to convey the same meaning. The model map is advantageous in that it allows the user to immediately place an object in space and identify a topographic

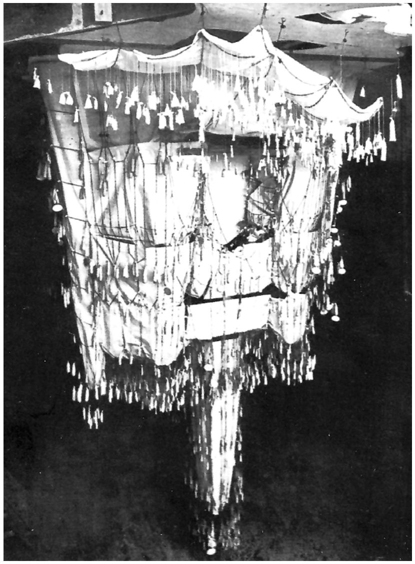

Fig. 4. Antoni Gaudí, funicolar model of the Güell colony, Barcelona, 1898 (Roberto Pane, Antoni Gaudí, Milano 1964).

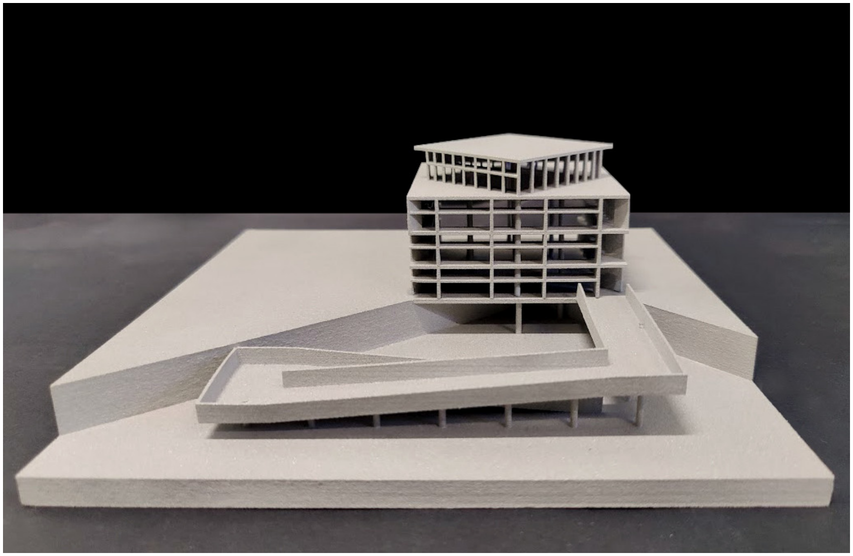

Fig. 5. Le Corbusier, the shadow tower in Chandigarh. Rapid prototyping model, laser solidified aluminum powder sintering.

feature in the landscape. For the author, that the combination of the two views is possible for the model, albeit with certain limitations. Conversely, the representation of an object on paper, both horizontally and vertically, necessitates techniques that compromise the perspective aspect or the localization function [Quaini 1987, pp. 63-65].
Furthermore, Quaini notes that by the end of the 18th century, the absence of elevation indications was perceived as a limitation of cartography, which could be overcome only through the technical paper of contours and descriptive geometry developed by Gaspard Monge. This integration subjected relief to a rigorous geometric language, effectively stripping it of any pictorial expressiveness. In any case, the use of topographic models was gradually superseded by the production of maps. This occurred concurrently with the decline in the significance of the globe as a system for representing the entire surface of the Earth [Quaini 1987, p. 70]. To the large scale offered by models, the modern viewpoint preferred the smaller scale of the map, where the multiple information presented in abstract language was easier to read and understand.
A critical examination of the role of the model itself, as addressed by Germano Celant in *The Project Is an Object*, reveals that from the beginning of the twentieth century, the practice of maquettes was invested by an epistemological rupture produced by the historical Avantgardes. The critic posits that the model, as an autonomous research device, can disregard the mimesis of its object reality and describing an ideational process by becoming a work of art. Consider the Cubist techniques of *papier collé* and *collage*, and later the Dadaist assemblages or ready-made, which could stimulate architects' creativity with new ideas derived from everyday objects. The Russian avant-gardes (Constructivism and Suprematism, with Kazimir Malevič and Vladimir Tatlin) and Neoplasticism (with, for example, Piet Mondrian, Theo van Doesburg, Georges Vantongerloo, Jean Gorin, and many others) sought, in different ways, to find new codes that were not imitative of objective reality. This rejection of history and the present was a defining feature of both movements. Starting from the same premise, the Dadaists, on the other hand, arrived at opposite operations and outcomes by resorting to the 'disorientation' induced by the re-composition of everyday objects and remnants. In opposition to tradition and academicism, the 'degraded' maquette simultaneously acquired an autonomous, self-referential, and artistic value. This resulted in a reversal of the conventional concept of architectural modeling: from the reproduction of an existing or planned building, they proceeded to conceptualize the work based on the model's suggestions [Celant 1987, p. 79]. These works were created to criticize society, but at the same time to stimulate unpredictable senses. In addition to parodying the project, Dadaist maquettes also dealt with the secondary effect induced by the recovery of the real. The purposeless image conveyed originality in rupture and disorder, as exemplified by Marcel Duchamp.
As Celant posits, the New Avantgardes and movements between 1960s and 1980s established new values, types, and materials for the model through the formal experimentation. These include, among others, the "artist architectures" of Jean Dubuffet and Nicolas Schöffer. The maquette became confused with

the object and thus with the work. The author argued that this confusion resulted in the maquette becoming sculpture itself, or alternatively, that it remained an architecture only drawn as the premise of the construction or its demonstration. Two additional circumstances posed important questions about the establishment and mode of contemporary three-dimensional thinking. The first was the use of the model in the representation of geometric form for demonstrative purposes. The second was its employment in the form research, understood as the dislocation of matter in space through the geometric synthesis of the structural pattern.
Finally, Croset's reflection on the maquette as an object evocative of the notions of measure, norm, rhythm, mode, and limit, and from the assumed Platonic sense of 'ideal form', also fits in. A recurring paradigm in architects such as Peter Eisenman and Massimo Scolari. For them, the model manifested itself as the result of a slow and patient maturation of artistic thought and the self-expression of architecture [Croset 1987, pp. 45-52].

The contemporary relevance of the physical model

A reexamination of *Maquette*, conducted nearly four decades after its publication, reveals that its conceptual and theoretical content remains as pertinent as ever, as well as its historical delineation of the use of models. Despite its sporadic use in the late 1900s and a stated apprehension about the proliferation of new digital modes of representation, the model has remained a fundamental element in the design, management, and documentation of a work. Indeed, physical models remain a valuable teaching and learning tool in architectural and engineering education. They are also an important research tool, facilitating the dissemination of historical and figurative outcomes. The capacity of physical models to convey psychological and perceptual information is a significant factor in their continued use.
To date, the term 'maquette' can be understood as both a tangible and an intangible artifact that responds to the conceptual dichotomy between the 'real' and the 'digital'. This distinction necessitates the actualization of the definition of the term 'model'. The construction, structure, and investigation of architectural designs can be facilitated by the use of digital modeling, surveying, and visualization tools that simulate architectural elements and spaces. These tools enhance the qualities of the designs through the incorporation of realism and proportion. The three-dimensional model is still the product of a creative, semantic, and geometrically defining act. It is the result of assembly and fitting operations offered by the increasingly popular solid, mesh, NURBS, BIM, and parametric modeling techniques, which grant continuous manipulation and sharing of content. On occasion, these maquettes can replicate real objects of various sizes that can be obtained through advanced acquisition practices, including 3D scanning, laser scanning, and photogrammetry. These techniques are useful in detecting and providing a highly accurate reading of the state of art for documentation purposes. Finally, digital models can be converted into virtual/immersive or augmented reality, or they can be used to produce physical artifacts through rapid prototyping.
In the current era of digitization, virtual models permit the designer to enter and navigate ideal architectural and spatial configurations, which are represented in life-size and replicate the visual sensations of the real world through real-time rendering. Nevertheless, the simulation of finishes does not permit direct tactile feedback with the materiality of surfaces. Similarly, the lighting conveys a mediated impression of reality, despite the geolocation of the maquette. The presence of a screen between the visitor and the model also affects the conditioning of digital, virtual, and augmented models.
Consequently, spatial and formal research aimed at creating environments with architectural qualities that involve the complete involvement of the senses continues to find the physical model to be the most effective tool, capable of bringing the reproduced work closer to the real thing, albeit on a smaller scale. A possibility offered once again by physical 'handmade' maquettes, creative results of the artist and real works of art, or by the production of models through 3D printing (fig. 5), which, depending on the technology and materials used, can translate digital models into physical ones, thus allowing even hypersensitive people access to the concrete, tactile and material content of the reproduced objects.
We therefore answer the question posed by Tomás Maldonado within the pages of the editorial about the possible future of iconic and aniconic modeling because of the contemporary computer science revolution [Maldonado 1987, p. 61]. This reflection addresses the implications of digital technologies and their simulation of reality and dematerialization of form. The author subsequently expands upon these themes in the book *Reale e virtuale* [Maldonado 1992].
Computer graphics and digital image processing facilitate the performance of numerous functions that were previously the exclusive domain of traditional modeling techniques. This enables the creation of a multitude

of potential applications. Consider the paradigm shift in the construction industry brought about by Building Information Modeling (BIM). This innovative approach not only facilitates collaborative and integrated design but also optimizes information gathering and management of the entire job order, including the construction and maintenance of the building. A hyper-structured model suitable for clearly defining quantitative aspects and identifying possible conflicts in implementation in advance, but somehow depriving the work of the qualitative aspect due to its excessive objectivity.
The advent of digital modeling and advanced simulation techniques has given rise to new professions, including the BIM specialist, coordinator, and manager, as well as the 3D artist. This last one combines technical expertise with personal creativity, as evidenced by the unique nature of architectural models.
As anticipated, digital maquettes, or computer-generated models, have become a prevalent feature in the realm of project and content dissemination. The advantage of these numerical and parametric models is that they contain and implement both geometric and nongeometric content that can be manipulated and managed in a single system organized at multiple reading levels. This provides the same performance as iconic and diagrammatic models. The visual arts, semiotics, psychology of perception, industrial production, robotics, as well as technical and scientific research are all engaged in a process of self-reflection and measurement against the operational field of virtuality, which encompasses both positive outcomes and possible risks [Maldonado 1992].
In 1987, there was a concern that the use of digital tools, which were not yet commonplace at the time, would render professionals unprepared. Additionally, there was a debate about the role of professional creativity in the new modeling dimension. The current situation is analogous to that described above. The question is whether our intellectual, creative, and sensory abilities can be replicated and replaced by the increasingly popular artificial intelligence programs that are advancing hypotheses increasingly ambitious in these fields. This could potentially deprive us of our uniqueness.

Notes

[1] From the Treccani dictionary: "Sketch, draft; in particular, model or reproduction in reduced size of a sculpture, monument, construction, mobile structure (ship, airplane, automobile, etc.); in the graphic arts, sketch of a poster, advertisement, book cover, and the like".

[2] The English translation of the monographs appear starting the on page 123 in the copies distributed abroad.

[3] Such as the *Robert Moses' Model*, the Panorama of New York City realized for the 1964-1965 New York World's Fair described by Marc Miller. The urban model, which covers an area of 836 square meters, was updated in later years with the addition of new buildings to ensure that the image of the entire metropolis always remained current.

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Reviews

Reviews

Laura Farroni, Manuela Incerti, Alessandra Pagliano (a cura di)

Misurare il tempo. Strumenti e tecniche tra storia e contemporaneità

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This valuable volume is part of the editorial series Architecture, Geometry, and Astronomy, edited by the same editors [1]. It documents the outcomes of the second international studies day: *Representing Time. Architecture, Geometry, Astronomy*, held at palazzo Gravina on the premises of the Department of Architecture, University of Naples Federico II on June 9, 2023.
Already from the title, one can sense the interdisciplinary reach inherent in the published contributions –and admitted following a double-blinded review process– which convenes three knowledge macro areas seemingly distant. Yet, their synergistic relationship since antiquity has embraced drawing as the preferential language suitable for describing its essence. As for the time factor, on the other hand, the need to measure it has always fueled advances in astronomical knowledge, in veritable assaults on the sky driven by the perfection of instruments essential to unravel its mysteries.
But even before the invention of optical devices, drawing and geometry founded rules and interpretive models of light, restoring architectural masterpieces, environments, and urban artifacts whose gnomonic dependence mirrored the cultures of a specific time, ascribable to the individual place and the "latitude in which the shading phenomenon occurred for measurement" [p. 13]. Differently, the modern imposition of the Western political clock has standardized the rhythms of life and work of subjectivities, prompting them to embrace the dictates of a colonizing mass operation.
As Alessandra Pagliano keenly observes in her introductory essay, the transition from the Sun's true time to the conventionally adopted civilian meantime "has made its measurement objective and increasingly minutely punctuated by the increasing reliability of its measuring instruments" [p. 14].
More broadly, in the becoming of a reciprocity founded on being, living, and inhabiting, the metaphor of the shadow has been charged with the valences of its illuminating dependence, in debates that stimulate a research worthy of positioning itself in the liminal lines, of separation or acceptance, between art practices and scientific postulates. After all, the concept of 'representation' combines the interpretive narratives of credible staging with the opinionable universalizing rules of drawing. Hence, the first focus of the volume brings together evidence of research focused precisely on the concept of measurement, linked to cosmology and its scientific foundations, to be traced in artistic experiments that actualize gnomonic by making the shadow a dynamic matter of creating works, in ephemeral architectures and installations that make us reflect on how we relate the tangible dimension of physical space to the immaterial dimension of the divine entity.
The second focus is devoted to the

tools and techniques of measuring time, to delineate the trajectories of a history that Edgar Morin defined as an expression of earthly identity [2] because in the transition from the planetary era to the mundialization era, we have immersed ourselves in such complexity that its intelligibility is stifled, atrophying the human capacity to contextualize and globalize. In this direction, Laura Farroni stresses the importance of rereading the multiplicities and long times of the past, reflecting on the voraciousness of the present to frame the labile future probabilities. According to this perspective, "studying the time measure, through the history of artifacts, implies the identification of the local in the global in a planetary dimension, through the continuous change of light" [p. 20]. Then let light be shed on our responsibilities to act, through actions that stimulate processes of ecological consciousness assisted by today's knowledge investigations.

The third focus is devoted to this specific aspect, calling in digital technologies for the surveying, analyzing, and communicating cultural heritages –tangible and intangible– all to be rediscovered. Case studies range from numerical data acquisition and digital reconstructions: of the Farnese Globe, housed in the National Archaeological Museum in Naples; of the solar clock with filtering hat in the former convent of La Baumette in Angers; of the sundial of San Michele in Bosco in Bologna; of the light simulation in digital models with astronomical value; and of statistical approaches useful in studying the alignment of Egyptian pyramids.

All the research collected and argued in the volume substantiates its very high quality, embracing Manuela Incerti's thought when she states: "it is precisely the scientific publication that, through the description of methods, processes, and languages used, can make the difference in a field such as the communication of cultural heritage that is increasingly devoted to spectacular and emotional aspects" [p. 22]. Therefore, I would like to thank all the authors who were a pleasure to listen to –in the sessions that articulated the study day– and, above all, to read.

Finally, we take this opportunity to announce the third edition of this unfailing event, which will take place in Ferrara on May 23, 2025, entitled: *Crossing the Time*.

The call for paper, soon to be published, aims to continue to reflect on that large portion of the cultural heritage through the three major themes of Architecture, Astronomy, and Geometry, to bring the debates back into the context of Drawing disciplines. Special attention will be paid to the impacts of digital technologies involved in process innovation and in a research result that always invites us to look to the sky.

Massimiliano Ciammaichella

Note

[1] The book can be downloaded in open access, at the publisher's web site: <https://edizioni.libreriauniversitaria.it/libro/misurare-il-tempo> (accessed May 23, 2024).

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Reviews

Enrico Cicalò, Valeria Menchetelli, Michele Valentino (a cura di)

Linguaggi grafici. Fotografia

Publica

Alghero 2023
940 pp.
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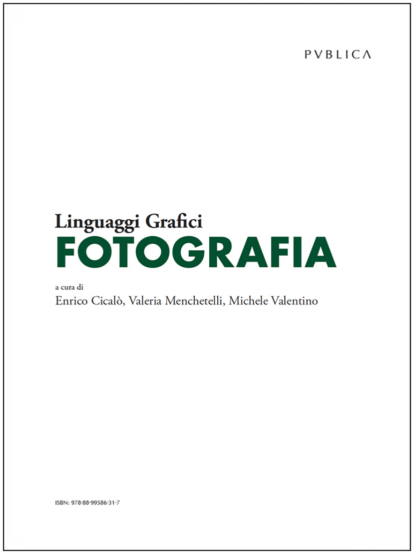

Linguaggi Grafici. Fotografia, edited by Enrico Cicalò, Valeria Menchetelli and Michele Valentino, is the fourth volume of the annals, published by Publica and made available in open access, inaugurated in 2020 with *Linguaggi Grafici. Illustrazione*, which was followed by *Linguaggi Grafici. Mappe* and *Linguaggi Grafici. Decorazione* [1].

As scholars know who (like the writer) eagerly await the proposal of the new theme every year and who have participated in past editions, the apparent generic nature of the suggested topic should not be misleading. The themes proposed for the *Linguaggi Grafici* series –dryly identified by a single word, a lemma that could identify a generic topic– upon further examination always reveal themselves to be subtly problematic and seductive. The curators who, despite some constant presence, alternate at the helm of these editorial occasions, manage to involve the scientific community on topics that enable the authors to find a resonance between their own interests and the proposed theme, allowing them to establish autonomy the boundaries of one's reflection, defining a space for action within the broader framework of reference. In this way, personal interests, embryonic research, unexplored curiosities can find a specific form and place within the broader theme. Furthermore, the *Linguaggi Grafici* calls, concise and stimulating, do not foresee the organization into different focuses. The distinction into sub-themes which ends up forming the framework on which to organize the contributions collected in each volume seems to be rather the effect of a reflection carried out 'downstream', sensitive to the emergence of the different lines of research that emerge from the authors' proposals. The *Linguaggi Grafici* volumes are therefore the result of an authentic dialogue between curators and authors, of an open dialectic that informs the final structure which– even beyond the value of the individual essays –represents the most interesting outcome of the entire operation, capable of showing how the discipline of Drawing fits within the chosen theme and –vice versa– how this animates the lines of research in our field.

Not many arguments are needed to agree with the curators on the urgency of addressing the theme of photography. Just remember that there is currently a dizzying number of photographic shooting tools active in the world, over seven billion, almost entirely made up of smartphones, therefore devices that physically accompany every observer for the entire course of their day. Photography, as mentioned in the call, concerns one of the "most transversal and widespread cultural tools of investigation, representation and reading of reality" which has "revolutionized all areas of thought and artistic expression and creative", supported by the "democratic ease of access and use", allowing "experimentation with innovative graphic

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languages and new lines of investigation" [pp. 10, 11]. Photography "has written a history which places us, today, faced with the impossibility of giving up its use, but which at the same time requires a reflection on the role that photographic images play in daily life". The volume, therefore, aims to present itself "as a space for reflection on photography as a form of graphic representation and visual communication, with the aim of exploring its cultural role, application potential, reasons, functions, uses, methods operational and expressive languages".
The substantial volume of 940 pages opens with two introductory essays from the editors. In the first [pp. 12-27], *I linguaggi grafici della fotografia: ragioni, funzioni, evoluzioni e definizioni* –using a structure already tested in the other volumes– a general exploration of the theme is proposed. In the part on *Reasons*, the current panorama of the distribution of the photographic tool is described, showing how it has practically spread pervasively in every field. The functions are examined below, giving an account of how the application areas are very different, "from the scientific one to the more purely personal one, from the documentary one to the artistic one" [p. 16]. In the paragraph on *Evolutions*, we take into consideration– in an essential but substantial way –the history of the instrument, the changes that have continuously crossed it even in its contacts with the world of figurative research. In the last part, *Definitions*, some 'verbal statements' on photography are examined and a specific definition is proposed that places it within the territory of graphic languages: "Photography is a form of visual communication in which the image is drawn with light through the combined effect of technical factors and an authorial intent, which therefore provides a reproduction of reality mediated by a subjective interpretation" [p. 25].
The second essay, *I linguaggi grafici della fotografia: temi, sguardi ed esperienze* [pp. 28-43], also signed by the three editors, gives an account of the categories with which the various contributions were organized and offers a precious critical synthesis. There are six sections into which the interventions have been divided. In the first, *Languages*, contributions are collected that concern relationships with other forms of expression and those that address constitutive themes. In the *Views* section there are reflections that show how photography is not an objective form but how it depends on specific ways of viewing and the choice of precise points of view. The *Techniques* section collects contributions that deal with various application technologies as well as different methodological methods. The *Experimentation* part is dedicated, also from a historical perspective, to exploratory aspects, such as photo editing, photomontages, and the use of AI. Within the *Narrations* section, alternative forms of storytelling are addressed, such as haptic communication, the relationship with time, and the themes of photojournalism. In the last part, photography is addressed as a form of *Documentation*, therefore as a vehicle for accessing specific knowledge, as also happens in the case of historical photos.
The essays collected in the volume are 36 and involved 53 authors to which are added the three editors with their two papers. Upon closer inspection, this is a significant percentage of the scholars active in our disciplinary field, which makes this work fully representative of the interests and methods of approach that run through it. Although in this short note it is obviously not possible to indicate, even briefly, the topics addressed in the individual contributions, it is important to point out how they cover a wide range of themes and how the multi-faceted investigation methodologies used within our area are able to outline an authentic inclusiveness, a consolidated breadth of views and a fertile disciplinary complexity.
A substantial part of the sixteenth volume of the *Einaudi Encyclopedia* [2], dedicated to indices, edited by Renato Betti in 1984, is occupied by information schemes in which the individual lemmas –systematically treated in the previous volumes– are placed in visual relation to each other through graphs, matrices, Venn diagrams, thus exploring the relationships between themes and topics. This type of approach, which by Betti's explicit admission is directly inspired by the idea of the labyrinth [Betti 1984, p. XII], in which the connections between the parts manifest themselves regardless of a hierarchical structure, shows analogies with the outcomes of the experiences of *Linguaggi Grafici*, in which investigations, definitions and connections between themes within a general topic intertwine, weaving connections between the areas of investigation explored in the different volumes. Now that the collection of essays for the next release is underway, the *Linguaggi Grafici* project shows that it has an overall horizon that goes beyond that of each individual volume and which will be able to support the construction of a conceptual map of the relationships between the topics that substantiate the graphic languages, towards which reflections, definitions and themes can converge, exploring other lemmas and other spaces, crucial for framing and specifying our range of action.

Edoardo Dotto

Notes

[1] Cicalò, E., Trizio, I. (a cura di). (2020). *Linguaggi Grafici. Illustrazione*. Alghero: Publica; Cicalò, E., Menchetelli, V., Valentino M. (a cura di). (2021). *Linguaggi Grafici. Mappe*. Alghero: Publica; Cicalò, E., Savini, F., Trizio, I. (a cura di). (2022). *Linguaggi Grafici. Decorazione*. Alghero: Publica.

[2] Betti, R. (a cura di). (1984). In *Enciclopedia*, Vol. XVI. Torino: Einaudi.

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Reviews

Adriana Rossi

Sant Cugat del Vallès. Verso l'accessibilità dei dati

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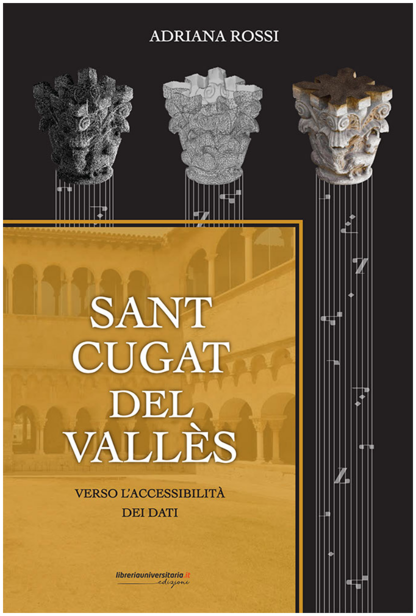

As often happens at the end of a deeply engaging effort, professor Adriana Rossi, has developed a keen sensitivity towards her subject of study which was also the aim of a previous research [Rossi 2014]. The acquired experience has thus become both a stimulus and a tool for further exploration. The book is the result of a new work, and it has been completely rewritten according to the author's own words. The text, published in December 2023 with the invaluable collaboration of Pedro Cabezos, publicly presents digital representations developed during a joint research project conducted in 2016 at the University of Campania [1].
The advancement of computer sciences has guided both theoretically and practically the optimization of ongoing objectives, gradually transforming the original goal. The focus of this latest volume is on the third chapter, *RI-trovare*, where the authors explore the possibility of combining graphic and visual sciences to dissolve traditional dichotomies in the realm of representation: material/immaterial, analogue/digital, real/virtual.
The first chapter provides a key to interpreting the architecture of the Benedictine monastery, located at the Abbey of Sant Cugat del Vallès (Barcelona, Spain), founded in the 11th and 12th centuries. The study centers on the square of the monastic cloister and the analysis of its construction elements. Building on the studies of the esteemed ethnologist and musicologist Marius Schneider [Schneider 1946; 1955], the author clearly and convincingly outlines and argues the connections among the iconic fragments sculpted on the cloister's capitals. There are 72 paired columns, with various reference classes marking the rhythm of monastic life and prayer. The text reveals an integration of different levels of spatial interpretation: technical, aesthetic, philosophical, and religious, making it challenging to read. Additionally, the lexical and stylistic choices are very meticulous and can be fully appreciated only upon a second reading, along with the scholarly citations and bibliographic references. Sometimes, these references may lead the reader to explore interesting but secondary paths to the main purpose of the work.
The original methods used to transcribe the highly concise and exclusively literary text by Schneider into images are noteworthy. Drawings, critical syntheses, video clips, and information systems recall the Eastern roots of a culture foundational to European identity, emerging along pilgrimage routes. The well-documented interpretation, supported by scholarly citations, avoids the risk of superficial judgments. This is not a narrative, or a fascinating array of visual, emotional, and intellectual associations conjured by the artifact's magic, but a culture –Sanskrit– considered the primary root and source of the West. The approach is not rigid but flexibly

oriented. The icons are not transcriptions of symbols, as common thought might suggest, but living signs within the sculpted actions, fragments of life that describe actions and reactions, capturing the ethical and aesthetic beauty of natural knowledge in a place of prayer, common in essence to all humanity. These layers of knowledge are managed by a single mind that reads and interprets based on personal experience. Consciousness is mutable, associating, intersecting, connecting, and dissociating relationships between concepts, prompting and facilitating thought. It is in this way that 'digital colors' emerge; the authors foresee the possibility of anticipating the logic that modern sensor systems promote an integration between analogue and digital.

The merit of the text goes beyond the pragmatism it proposes. The actions that were once at the forefront of experimental innovation now appear outdated. However, the commendable joint effort by Rossi and Cabezos to sensitize the reader to a more flexible and inclusive interaction remains noteworthy. Binary logic is no longer adequate for the nature of emerging applications. The value of computer science lies not so much in some computer graphics algorithm or the invention of some gadget, whether laser-based or photographic, but in a true cultural leap. This leap is based on the ability to intertwine, along the way, information that is not inherently intelligent but enlightening for the synesthetic experience, a logical consequence of processing many specific or elaborate details.

Starting from disparate and battered fragments, even the slightest and most incidental interrelations with the tackled theme allow one to perceive their undeniable relevance to its specific domain, a characteristic otherwise unsuspected. In this way, one can discern in well-worn iconic fragments the precise identity of fundamental concepts, transforming them from enigmatic to indicators of advanced visualization.

Jorge Llopis-Verdú

Note

[1] The book is available in open access at the link: <https://edizioni.libreriauniversitaria.it/wp-content/uploads/2024/01/9788833596730_-Rossi_San-Cugat_ebook.pdf> (accessed 30 May 2024).

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Reviews

Marinella Arena

Città sospese fra capi e fiumare. Strategie identitarie

FrancoAngeli
Milano 2023
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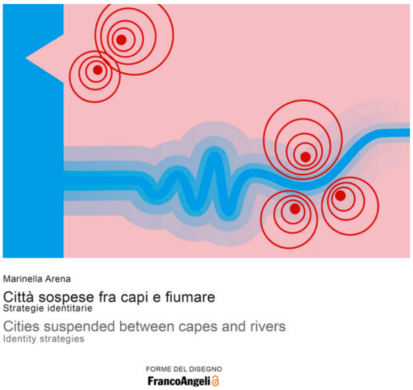
Open Access: <https://series.francoangeli.it/index.php/oa/catalog/view/980/836/5541>



The book by Marinella Arena deals with a crucial topic. Essential. Not only in the subject of her research (historic villages in a state of 'oblivion'), but also – and above all– in the gaze she reserves for small towns, specifically those on the Ionian coast of Sicily. A gaze able to interweave the urban and architectural survey with the immaterial dimensions of which these centers are permeated, through a vision that includes different perceptive levels. A deep interpretation, carried out with the sensitivity that derives from personal experiences, from the cultural context, from immersion in a 'scenery of everyday life' that, as the author emphasizes, has (successfully) conditioned her approach to research.
The topic of small towns, which encompass most of Italy's architectural heritage, is still an urgent one. Equally urgent is the need to focus on documentation strategies other than those traditionally used, sometimes well-structured and sometimes uncritical filing, which only rarely succeed in triggering actions to raise awareness, conservation, and enhancement of the identity of places. Precisely in the search for the deepest sense of identity that these centers can convey, the book enucleates a methodology that captures the essential, a knowledge process in which to intersect past, present, and future using the potential of drawing.
The title of the book, *Cities suspended between capes and rivers. Identity strategies*, has the power to immediately recall two focal points of the perspective vision in which Marinella Arena places herself and leads the reader. The sense of 'suspension' leads to reflect on the dynamics of abandonment that have stopped time in these urban centers, and on *another* time, a time away from the frenetic acceleration that often characterizes our daily actions, a time slowed down, suspended, to condense the perception of place. And then the 'identity strategies', which guide the survey and the cataloguing (and not vice versa), elaborating an overall representation that integrates the immaterial. Indeed, the power of the book is to transport the reader into the places analyzed, so vivid is the perceptive dimension searched, which transcends the purely material facts featuring the six historic centers analyzed.
The comprehensiveness of the research that resulted in this book is evident in the structuring of the data collected and in the graphic representations. After the introductory section, the first chapter frames the history of the villages in the economic and social events to understand the dynamics that led to the depopulation, and consequent crystallization, of the so-called minor centers in southern Italy and the Ionian coast of Sicily in particular. The chapter *For a methodological protocol* frames the survey methodologies applied and describes the logic of the reports produced for each of the towns investigated, namely Forza d'Agrò,

Casalvecchio, Mandanici, Fiumedinisi, Alì and Itala. The section *Drawings for an identity map* illustrates the methodological approach of breaking down the centers (between *Urban warps* and *Matrices*) and the graphical processes that succeed, with originality, in proposing a synthesis of great critical-interpretative value. The book closes with the chapter *A network of cities* which, starting from the territorial scale, harmonizes the data collected and develops coordinated forms of communication, 'unifying' the urban centers under analysis, and the bibliographical section, essential but revealing of the multiple suggestions that have contributed to the definition of the methodological approach.
The timeliness of the research lies (also) in the interpretation of the needs that the enhancement of that territory requires, appropriately grasping virtuous connections with some of the strategic actions of the National Recovery and Resilience Plan, in particular the digital transition as a necessary first step for the knowledge and protection of the architectural and landscape heritage in marginal areas and minor centers, often the object of inattention rather than care; the search for strategies for effective communication of the identity of places, and the need to broaden the socio-cultural impact of communication itself, as well as sharing with the scientific community.
The six case studies analyzed in this book –defined by the author as minimal cities, "cities suspended between the desire for rebirth and the threat of oblivion" [p. 23]– represent an ideal context for an in-depth study of the topic of small towns. "The network of small towns on the Sicilian Ionian coast is the perfect field of investigation for research that aims to experiment the potential of drawing. In fact, these small towns preserve the cultural and architectural identity of this portion of Sicily; they are rooted in same economic and cultural substratum, and have preserved, at least in part, an autochthonous language both in the architecture and in urban morphological structure" [Introduction, p. 12]. But, at the same time, the proposed methodology is shaped as replicable, extensible to other contexts and other places equally in need of being discovered, known, 'communicated'.
The action of the survey expands beyond the 'simple' measurement to aggregate the intangible aspects to the concreteness of the documented places, and in this sense the concept of "deferred survey" [p. 29] is particularly significant, complementing the direct survey and the instrumental survey, able to record all that is immaterial that animates places.
The methodological protocol structured to document and catalogue the case studies includes a report in which each city analyzed is described and represented by means of aerial photo, live drawing, site plan, restitution of the instrumental survey, axonometric view, texture maps, architectures, architectural details, and the synthetic representation of the Matrix (mother church) and any subsidiary churches. It is worth emphasizing the importance that onsite manual drawing assumes in the documentary process, a drawing that "directs the gaze to the founding elements" [p. 36], guiding observation, consistent with the need to rest to go beyond the visible.
Public space is analyzed as a widespread place able to create links of which an identity map can be drawn by including different levels of interpretation, including the perception and reconstruction of the collective memory of places. An interesting form of abstraction for describing urban features consists in the decomposition of cities into parcels; blocks are broken down and relocated in a dimensional reference system –the graphic representation of which is reminiscent of musical notes organized on a score– creating textures that highlight complexities, fragmentations, layouts.
At the basis of the urban shape of these centers, the Matrix, or mother church, creates an imprint on the urban morphology and "acts as an attractor of paths and sights, condenses the mass of the urban fabric and defines the skyline of the center" [p. 51]. The graphic symbolism used in the development of the sheets allows for a comparison between the Matrices, through icons that reveal the morphology of the façade, the presence and position of the bell tower, the presence of openings above the main portal, the presence of oculi, the typological structure with naves and halls, the orientation, the morphology of the churchyard and the presence of scroll-works. An analysis of the architectural language then focused on the design of the column as the unit of measurement to which all parts are related.
It is in the search for a symbolic and synthetic abstraction (a never easy task) that the author succeeds in describing the complexity of the territory and urban centers through very few elements (churches, fortifications, access routes to the center and the presence of watercourses). The urban aggregates are condensed "into fluid forms to enucleate their founding matrix" [p. 71], in search of traces to be synthesized in identity maps in which the emotional component is translated into an immaterial sense of belonging (*Topophilia*) that places the human being at the center, and where the human being is molded by the inhabited space in a two-way relationship. Graphically,

maps of feeling make explicit the "emotional density of a place" [p. 75], just as the blending of virtual and represented space through the superimposition of historical images in the urban scene captures city life, the memory, and give evidence of the intimate attachment to places.
A further degree of abstraction, aimed at proposing possible strategies of heritage enhancement, is reserved for "ludic permutations" that stimulate a path of knowledge through the recombination of architectural elements.
The book's concluding chapter delves into the description of the six centers analyzed (historical introduction, urban morphology, architecture, details, Matrix, and filial churches), placing the cities in a territorial, comparative perspective, tracing connections and giving homogeneity to the data collected, an operation at the basis of the proposed methodological protocol and coordinated communication.
Marinella Arena's study fills a gap by integrating previous knowledge, systematizing and comparing new data with an unconventional approach in its analytical and representative interpretations.
The book stimulates a reflection that overcomes the specificity of the context analyzed, dealing with 'irrelevant' cities, unattractive to contemporary society and the interests it pursues. But these places embody an inestimable heritage. They are our memory.

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Reviews

Alberto Sdegno, Veronica Riavis
(a cura di)

DAI - Disegno per l'Accessibilità e l'Inclusione

PVBLICA

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The physical and virtual practicability of spaces, combined with the possibility of taking advantage of information technologies related to the communication of goods and services, allows people with disabilities to access Cultural Heritage on an equal basis with other members of the social context. The research carried out in this field by Drawing has made it possible to teach the relationships between the various subjects to have a broader and more coordinated design vision of the aspects studied.
These questions aimed the volume edited by Alberto Sdegno and Veronica Riavis, a collection of proceedings that includes two invited lectures and 46 papers selected from the second edition of the international conference *DAI - Drawing for Accessibility and Inclusion* held in Torre Santa Maria in Udine on December 1-2, 2008, thirty years after the *European Day of People with Disabilities* proclaimed by the European Commission, as the organizers of the event recall in the introductory essay to the volume *Esperienze in ambito museale e interdisciplinarità: con il Disegno per l'Accessibilità e l'Inclusione* [pp. VI-XV].
The 106 authors are researchers, lecturers and PhD students from various universities and institutions, museum directors, professionals and scholars who have carried out analyses inherent to Drawing as a tool for improving spatial, socio-cultural, cognitive, psycho-sensory and museum accessibility and inclusion.
The volume opens with an introduction by the President of the UID - Unione Italiana per il Disegno Scientific Society, Francesca Fatta [pp. II-V], continues with contributions by the editors and invited essays by Aldo Grassini (President of the Museo Tattile Statale 'Omero' in Ancona), who in *I ciechi e la pittura* addresses the issue of the transferability of a painting to the blind and visually impaired [pp. XVI-XXIX], and by Paola Visentini (Director of the Friulian Natural History Museum and the Archaeological Museum of the Civic Museums of Udine) with *Progettare nuove realtà espositive o innovare realtà già esistenti: le soluzioni accessibili adottate dai Civici Musei di Udine* [pp. XXX-XXXVII].
After the introductory section, the various speeches are articulated into five focuses to address and formulate solutions to the problems that have emerged from the in-depth study of the conference themes.
The first focus, *Drawing for Accessibility and Spatial Inclusion*, includes a series of articles that, through the examination of a series of case studies, consider the representation as a tool aimed at the physical or virtual enjoyment of spaces that, for various reasons, are considered inaccessible. In fact, the arguments collected in this section propose overcoming architectural and mental barriers through co-design operations that involve the included and the excluded in a design activity whose results are tested in a virtual mode,

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as in the contribution by Giuseppina Scavuzzo and Patrizia Cannas *Il progetto emancipante: il disegno come strumento di "self-empowerment"* [pp. 4-17], or they test prototypes of tactile abacuses designed to easily visit areas without light, as described by Francesco Stilo in *Per un itinerario tattile del sotterraneo come luogo di culto in Calabria* [pp. 80-93].

Other dissertations –including Claudia Pirina, Giovanni Comi, and Vincenzo D'Abramo's, *Ridisegnare l'archeologia. Il progetto dell'accessibilità in aree archeologiche* [pp. 110-125]– instead identify compositional principles capable of responding concretely to the need to make archaeological contexts accessible.

Two reflections conclude this part: the first, on innovative cases and related critical issues emerging in Heritage conservation –an issue addressed by Alessandra Biasi in *Notazioni sull'accessibilità per i beni culturali: l'intreccio tra progetto di restauro e nuove tecnologie digitali* [pp. 126-137]– and the second, to understand how, through visual perception and technical usability, architecture or the city can be involved in Design for All.

The second focus, dedicated to *Drawing for Accessibility and Socio-cultural Inclusion*, examines some proposals of a formative nature aimed at enhancing Cultural Heritage through thematic paths reproduced with tactile panels intended for different users, as in the essay *Valorizzare la città della memoria: il valore del Disegno per la comunicazione tattile* by Ivana Passamani, Cesira Sissi Roselli and Virginia Sgobba [pp. 152-171], or by physical copies of artifacts modeled to allow haptic exploration –a topic presented, for example, by Giuseppe Nicastro, Alessandro Luigini and Francesca Condorelli in *Stampa 3D e fruizione aptica per la valorizzazione del patrimonio culturale abruzzese: il caso studio dei tabernacoli lignei dei frati marangoni tra XVII e XVIII sec.* [pp. 172-187] –, or by investigating issues related to the legibility of typographic characters.

Additionally, the authors Maurizio Marco Bocconcino, Mariapaola Vozzola, and Martino Pavignano describe virtual reproductions of museums, which are designed to facilitate consultation of heterogeneous collections in the article *Il Disegno nelle strategie per la valorizzazione e l'accessibilità del patrimonio museale universitario: la collezione Curioni del Politecnico di Torino* [pp. 200-215]. There are also the virtual galleries, prepared through gigapixel photographs with the intention of increasing the dissemination of artworks, according to the research of Pedro Cabezos-Bernal, Pablo Rodríguez-Navarro, Teresa Gil-Piqueras, Daniel Martin-Fuentes and Adriana Rossi [*Creating Virtual Art Galleries to improve dissemination and accessibility*, pp. 228-243]. The contributions are further enhanced by a historical narrative of two monuments expressed effectively through hand drawings, and a reflection on the skills that the discipline of Drawing can offer in designing multimedia art therapy experiences.

The third section of the proceedings, which is devoted to accessibility and cognitive inclusion, opens with an analysis of the role of Drawing in offering new cultural, lexical, technological, and sensory tools that are useful in enhancing the performance of therapeutic devices in VR for different mental states. This research is presented by Piergiuseppe Rechichi, Valeria Croce, and Marco Giorgio Bevilacqua in their article, *La realtà virtuale nella diagnosi e terapia dei disturbi d'ansia: literature review per individuare contributi e potenzialità del Disegno* [pp. 326-343].

The focus then shifts to a system of guiding strategies and solutions based on a plurality of languages and the use of digital technologies, with the aim of enhancing the enjoyment of cultural heritage. This is expounded by Valeria Menchetelli and Elisabetta Melloni in their paper, *Dall'accessibilità alle accessibilità: il disegno per l'inclusione molteplice del patrimonio culturale* [pp. 344-365], and subsequently, with the programming of an inclusive robotic drawing system presented by Lorenzo Scalera, Stefano Seriani, Alessandro Gasparetto, and Paolo Gallina in the essay *An eye tracking approach for inclusive robotic drawing* [pp. 364-375]. We find, furthermore, Massimo Ciammaichella and Luciano Perondi's reflection on the current state of the art about *Editoria e didattica del disegno nelle scuole secondarie di secondo grado* [pp. 376-393]. In their contribution, special attention is paid to complementary graphic tools useful for the development of knowledge referring to the teaching of Drawing in secondary schools.

The section concludes with a teaching experience presented by Cristina Candito and Alessandro Meloni in *Un disegno prospettico accessibile. Aspetti percettivi e tecniche didattiche nell'ambito dei disturbi dello spettro autistico* [pp. 394-408]. The text was designed with the aim of conveying the basic rules for practicing perspective drawing to students with autism spectrum disorders.

The *Drawing for Accessibility and Psycho-sensory Inclusion* is examined in the fourth focus and begins by documenting, through specially made images, the visual perception, and related limitations of people with dyschromatopsia with the aim of promoting an inclusive and empathetic visual culture, as expounded by Alice Palmieri in *Questioni di percezione. Racconti inclusivi e visioni*

insolite nel settore moda [pp. 412-425]. For the cognitive domain, we also find *The 3D virtual restoration as sensory inclusion: the Samnitic tombs of Santa Maria Capuavetere* [pp. 426-441], where Sara Gonizzi Barsanti presents possible immersive simulations of the frescoes of some ancient Campanian tombs.
Other essays, on the other hand, highlight new accessible and inclusive communicative processes through innovative approaches to learning and multisensory engagement, as in the chapter *Flowing accessibility* by Giulio Giordano and Marzia Micelisopo [pp. 442-453], or have highlighted the role of artificial intelligence both in relation to perceptual-cultural accessibility and as a tool for enhancing visualization capabilities, as demonstrated by Enrico Cicalò, Michele Valentino and Simone Sanna in *Dalle parole alle immagini e dalle immagini alle parole. Traduzioni linguistiche per l'accessibilità visiva attraverso la visione artificiale* [pp. 454-473]. In *Segni e disegni per l'accessibilità ambientale*, Christina Conti and Ambra Pecile instead present a systems approach to accessible design that introduces the performance of the enabling and sensory components of an environment in a multidisciplinary and multiprofessional process that places people in individual variety at the center of the design [pp. 476-489]. Additionally, the volume includes reflections on the potential role of Drawing in the multidisciplinary and multisensory experiences offered by nature: in *FOREST THERAPY - RITORNO ALLA NATURA. Esperienze multisensoriali per il benessere psico-fisico*, by Ornella Zerlenga, Massimiliano Masullo, Margherita Cicala and Rosina Iaderosa, the outcomes regarding design and communication products accomplished in the field of representational techniques are indicated [pp. 490-505].
The topic on museum accessibility and inclusion, absent from the previous edition, is addressed in the fifth focus. Some solutions for sensory and cognitive disabilities are indicated, such as the visual-tactile information panels for villa D'Este presented by Director Andrea Bruciati with Lucilla D'Alessandro, Tommaso Empler, and Alexandra Fusinetti *VILLÆ (Tivoli, MiC). Percorsi di inclusione museale e accessibilità* [pp. 508-521]. The use of Braille texts, maps, and relief drawings transformed into multimedia, three-dimensional, and augmented reality content it's an approach exemplified by Federico Gabriele D'Intino in *Multi-sensory Guide: designing a new inclusive tool for Cultural Heritage* [pp. 522-537].
The methodology addressed to the tactile and cognitive fruition of paintings for blind and visually impaired recipients is also outlined –as Sonia Mollica describes in the essay *Dal modello digitale alla fruizione tattile. Creazione di un percorso museale interattivo e percettivo* [pp. 538-551]– and reflects on Drawing as a 'cultural mediator' capable of transforming the experience of an image into an aesthetic-perceptual exercise, as reported by Elena Ippoliti together with Flavia Camagni and Noemi Tomasella in *Modelli visuali cognitivi per l'esperienza museale. Il caso della Galleria Nazionale delle Marche* [pp. 552-561]. There are also the suggestions by Tommaso Empler, Adriana Caldarone and Alexandra Fusinetti regarding the most appropriate modes of communication to enable effective accessibility to cultural venues for those with hearing, visual or cognitive disabilities [*Procedure per l'accessibilità dei musei. Integrazioni ai PEBA per le disabilità sensoriali e cognitive*, pp. 568-581]. It also specifies the procedures useful for offering an expanded audience of content that emerged from the study of an architecture painted on cardboard and the illustrated activities of a project aimed at eliminating physical and cognitive barriers in museums and public cultural places, as presented in *Digitisation, 3D modelling and digital fabrication: an accessibility project for MAO in Turin* by Roberta Spallone, Marco Vitali, Davide Quadrio, Laura Vigo, Mia Landi, Francesca Ronco, Giulia Bertola, Fabrizio Natta and Enrico Pupi [pp. 596-616].
Other experiences in the museum field are reported: the study proposed by Giuseppe Amoruso and Polina Mironenko on digital layouts developed for some Jordanian museums [*Digital Museology. Rappresentazione avanzata di spazi museali per l'accessibilità e l'esperienza interattiva*, pp. 634-647] and Luca Zecchin's project on Sardinian exhibition complexes [*Disegnare lo spazio e il movimento. Piccoli musei per tutti*, pp. 648-661].
In *Strumenti digitali per l'accessibilità spaziale di siti culturali complessi* [pp. 662-681], Mariangela Liuzzo, Dario Caraccio, Egidio Di Maggio, and Laura Floriano examine the potential of integrated three-dimensional surveying, digital modeling, and virtualization techniques for ensuring access to spatially complex or inaccessible cultural sites for all user categories.
Within this framework is also the temporary exhibition designed and presented by Manuela Incerti with Stefano Costantini considering the declinations of Drawing and its possible connections with the five senses [*Attraversa i tuoi sensi: accessibilità e inclusione nel Museo di Casa Romei a Ferrara*, pp. 682-697]. Concluding the last section is the essay *Modelli fisici per la percezione aptica di architetture dipinte: la Trinità di Masaccio* by Alberto Sdegno and Camilla Ceretelli, in which they present the study carried out to

increase the communicative potential of a painting in terms of spatial perception, through the elaboration of a three-dimensional digital maquette of the depicted environment and its reproduction in a physical model capable of making the work usable even to a blind or visually impaired audience [pp. 710-723].
Overall, the volume, available in open access [1], provides an interesting overview of research conducted in accessibility and inclusion by those working in the field of Drawing, while stimulating multidisciplinary reflections and new initiatives.

Silvia Masserano

Note

[1] The book is available at the site: <https://www.publicapress.it/index.php/book/dai2023/> (accessed on 15 May 2024).

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Events

Events

Days of Contemporary Cultural Heritage Representation and Conservation

Enrico Cicalò

Each territory manifests peculiar demands driving research in different directions, based on the resources communities intend to invest in for their development. Thus, it is not surprising that in Urbino, at the center of an area rich in history and culture, just a few steps from the Ducal palace –home to the *Galleria Nazionale delle Marche* that houses works by Raphael and Piero della Francesca, among the most important of the Renaissance– an important school of conservation and restoration has been founded that takes care of the precious cultural heritage of this territory. This is the framework in which the first edition of the *Days of Representation and Conservation of Contemporary Cultural Heritage* took place, which was configured as the ideal context in which to stimulate debate on the issues of heritage protection in relation to the contribution that different disciplines can make. In the case of graphic sciences and the disciplinary scientific group of Drawing, the contribution offered is rich and varied and includes research on the definition of graphic-representational standards, experimentation with enabling technologies for different audiences, the definition of digital workflows, the application of AR and VR in museum contexts and cultural institutions, and communication for the transmission of knowledge, just to name the most investigated strands of research. In particular, these are precisely the topics –declined in the context of innovation in the preservation of objects made between the early 20th century and the present day (works, installations, architecture, inhabited environments, museums and exhibition settings etc.)– protagonists of the first edition of the *Days of Contemporary Cultural Heritage Representation and Conservation* hosted on the 30th of November 2023 in Urbino at the Department of Pure and Applied Sciences of the School of Conservation and Restoration of the University of Urbino; organized by Laura Baratin, Francesca Gasparetto, Veronica Tronconi and Alessandra Cattaneo for the School of Conservation and Restoration, Department of Pure and Applied Sciences, University of Urbino; and by Marcello Balzani, Federica Maietti, Luca Rossato, Fabiana Raco and Fabio Planu for the Department of Architecture, University of Ferrara, DIAPReM/TekneHub.
This first edition –focused on the highly topical issue of conservation and restoration interventions involving architectures and works created since the early 20th century, in relation to both the more theoretical and applied aspects– has been entitled *A Possible Dialogue: representing and preserving the contemporary*; a title that suggests the need to look beyond traditional technical-scientific questions to share innovative approaches and research results in the technical-representational field. The emerging questions placed at the center of the reflection proposed by the Days concern the technologies that can help restorers and architects in the design of conservation interventions, the approaches that can support professionals to carry out innovative and informative work regarding the socio-cultural role of conservation, and the ways in which traditional representation theory can support a new model of cultural communication.
The conference aimed at a recognition activity through the collection of contributions and experiences to build the state of the art on representation techniques to support contemporary conservation. The call collected 24 proposals of contributions, 14 of which will be published in the days' proceedings edited by Marcello Balzani, Laura Baratin, Federica Maietti, Luca Rossato, Fabiano Raco and Francesca Gasparetto, and 6 were presented in the Turtle Room of palazzo Passionei, partly in presence and partly via webinar. Among the topics discussed, the theme of digitization in all its different possible facets, from representation tools to documentation methods, from communication strategies to

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Fig. 1. Flyer and program of the event.

the problems inherent to the management of digital data, from the challenges for preservation to the potential of virtual restoration, took center stage. A rich and stimulating program, then, representative of the challenges that characterize contemporary conservation and restoration of cultural heritage.
To complete the program of the days could not miss a guided tour of the restoration laboratories of the School of Conservation and Restoration –coordinated by Laura Baratin– with the invaluable guidance of Francesca Gasparetto and Veronica Tronconi, who illustrated the activities of the laboratory of restoration of painted artifacts on textile support, of the laboratory for the restoration of processed and/or assembled synthetic artifacts, in which contemporary art artifacts made of the most diverse constituent materials are treated, and finally of the laboratory for the restoration of scientific and technological instrumentation of historical interest. It is within these laboratories that one can experience the richness, value and differential quality of the work of the teachers and researchers of Drawing, who in Urbino develop

valuable and original lines of research that explore increasingly relevant areas for the development of territories that intend to invest in culture and art; strands of research these, which can and must expand following the virtuous Urbino model, including through the repetition of the event that it is hoped can become a constant point of reference for research on representation for the protection and enhancement of cultural heritage.

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Events

Disseminating and Implementing the Culture of Drawing through Editorial Production. The Initiative *1 Book: 1 Drawing*

Laura Farroni

The culture of Drawing leaves a trace of itself in the large production of monographic volumes, where the textual narration is combined with that graphic intended as an expression of the author's sensitivity and the articulated research process carried out on the topic analyzed.
Therefore, the laborious work of authors is made available to the scientific community and can stimulate new reflections leading to insights. The *Unione Italiana per il Disegno* in 2020-2021 launched the telematic initiative entitled *1 Book: 1 Drawing*, dedicated to the presentation and discussion of monographs that today include curators published by teachers, researchers, and scholars related to ICAR/17 - Drawing.
1 Book: 1 Drawing is based on a simple and streamlined proposal, open to monthly meetings, to be held on Fridays from 5 pm to 7 pm. Each event hosts the presentation of three or four volumes, listed in the list of scientific publications of UID members, which can be consulted and updated every year on the website [1].
The protagonists are the authors and three discussants, chosen by the organization, who have the task of highlighting the most significant aspects of the volume, the research methodologies, and their effects. The constructive comparison is also articulated in the presence of critical issues or different interpretations.
The discussant has the task of choosing an image extracted from the text that is the most representative and valid to initiate the subsequent debate with authors and/or curators. The intention is to offer a discussion open to the public that goes well beyond the traditional presentation of an unpublished text, capable of enhancing even contributions not necessarily declared, but underlying the multitude of manifest representations.
The debate is moderated by a member of the organizing committee that summarizes the structure of the work, ensuring the correct duration of the interventions, followed by the involvement of the public at the end of the event.
The format includes two further engagements by a member of the organizing committee in opening and closing in which to deepen the issues dealt with, maintaining a common thread with previous events. At the end of the meeting, the discussions were concluded and the volumes to be presented in the following month were announced.
Alongside the organizational structure, there is the management of the cultural aspect of the presentation of content because one of the objectives of the cycle of meetings is to offer members of the UID the opportunity to monitor editorial production, starting in 2021. Thus, it was decided to divide the various volumes to be presented into three categories:

- geometry, treatises, history of representation, drawing, and theories;
- case studies, H-BIM;
- virtual reality, contemporaneity, visual and multimedia communication.

These understand the heterogeneity of the topics to be brought back to the discipline of Design and relate to the work carried out by the UID commissions, whose results were explained in the II Seminar on the evaluation of research in the SSD ICAR/17 - DRAWING - VQR 2015-2019 | 4 March 2020 [2].
In January of each year, the calendar of events is planned, trying to collect the most representative volumes of the multitude of areas in which the drawing is placed. The platforms used range from Microsoft Teams to the current Google Meet [3], becoming the channel of communication chosen by all the initiatives of the UID. This year the format has undergone a variation, with the possibility of involving, at the suggestion of the authors and/ or curators, a discussion outside the field ICAR/17 - Drawing, to attest to the consequences of

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Year event	Reference year of publication	Curatorship	Monographs	Topic A: Geometry, Treatises, History of Representation, Drawing and Theories	Tema B: Survey, Case Studies, H-BIM	Tema C: Virtual Reality, Contemporaneity, Visual and Multimedia Communication
2021	2020	/	22	7M	7	8
2022	2021	11	21	3C+8M	3C+6M	5C+7M
2023	2022	10	14	4C+5M	4C+7M	2C+2M
2024	2023	15	16	6C+3M	3C+9M	6C+4M
total		**36**	**73**	36	39	34

Tab. 1. Summary table of curatorial data, monographs over the years and divided by topics.

the results of the research or study in other areas capable of dialogue with the Design. Social issues, and relations with institutions and businesses, recall the important role of the Third Mission to which the academic community is called to respond.

The data that can be collected during the four years are useful to understand the progress of research in which the members of the scientific community are engaged.
The reference years are from 2020 to 2023. Only the monographs were considered for the year 2020, while the curators were also introduced for the following years because the UID lists showed a considerable increase in their importance, which must be attested. The following table summarizes the data by category (tab. 1).

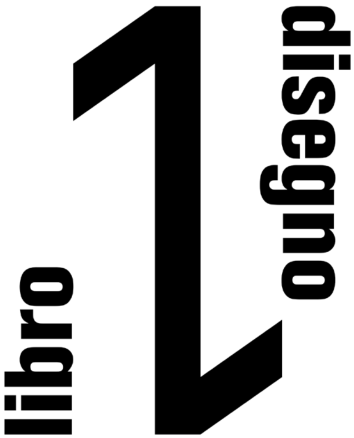

Fig. 1. The logo of 1 Libro: 1 Disegno (graphic processing by Massimiliano Ciammaichella).

Fig. 2. 2. Composition of flyers of the iniziative 1 Libro: 1 Disegno (graphic processing by Massimiliano Ciammaichella, graphic composition by Marta Faienza).

The number of meetings was: 7 for 2021; 10 for 2022; 8 for 2023 and 2024 is 9. The organization also produced a logo (fig. 2), and each meeting is represented by a poster with the program (fig. 3).
Through *1 Book: 1 Drawing* it was found that the culture of representation accommodates a plurality of approaches to research worth measuring in open debates in which volumes are evidence of studies and research.
The authors have space to express all the actions implemented in the basic and application research, motivating the choices made in the articulation of the contents, a process that is not easy and that thanks to this initiative has a way of emerging. Being able to disseminate the results in an agile form becomes an opportunity to weave collaborative relationships between scholars and researchers. In addition, the participation of the public sector makes the event an important opportunity for cultural comparison that, now, in the voracity of convention communications tend to escape.
Finally, each meeting is recorded and uploaded on the YouTube channel of the UID, remaining available to the community, because the main objective is to ensure the maximum dissemination of knowledge on the Drawing.

Notes

[1] <www.unioneitalianadisegno.it> (accessed 28 May 2024).

[2] <https://www.architettura.uniroma1.it/archivionotizie/ii-seminario-sulla-valutazione-della-ricerca-nel-ssd-icar/17> (accessed 30 May 2024).

[3] Meetings are accessible with the meeting code "kzy-nawx-rcr".

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Events

UIDSS2023 Applied Games for Heritage Education

Alessandro Luigini, Daniele Rossi

Between 19 and 24 June 2023 in Brixen-Bressanone, the *UIDSS2023*, UID PhD Summer School was held, which, as every year, the Scientific Technical Committee funds by supporting the higher education of ICAR17 PhD students nationwide (fig.1). Participation in *UIDSS2023* was possible following applications in response to a call for applications, and followed criteria based on plurality, rotation and the promotion of the participation of small and medium-sized sites. The number of applications exceeded 40 compared to the available places, which were 15 financed by the UID and 10 self-financed by the campuses, and PhD students of the XXXVI, XXXVII and XXXVIII cycles from 14 different universities (University of Bergamo, Cagliari, Catania, Chieti-Pescara, Florence, Genoa, Perugia, Pisa, Roma Tre, Roma Sapienza, Napoli 'Federico II', Sassari and the Politecnico di Milano e di Torino) participated.
The theme of *UIDSS2023* was *Applied Games for Heritage Education* and was chosen as the context for bringing together expertise within the domain of our discipline and a wide range of interdisciplinary skills needed to finalize the work of digitizing and interpreting heritage. Heritage digitization, as is well known, is a broad spectrum of activities that shares only the first phase of detection while it differs considerably in the finalization of acquisitions in often very different contexts: whether it is documentation for conservation, museum exhibition, VR, AR and MR use or the realization of educational pathways, it is clear how the methodological approach on the one hand and the necessary know-how on the other can change radically. In this multifaceted context, where the possible fields of application can often change and in which we must be ready to seize new opportunities for scientific research, the increasing use of applied games and video games in general for heritage enhancement is evident.
The video game itself is becoming recognizable as a cultural product, like other media that in recent decades have progressively transcended the limit of the technological product to become cultural products –such as photography, radio, cinema, television etc.– and the time is ripe to consider it as a privileged field of research.
While the scientific literature on the importance of games in the construction of social competences and socialization processes is extensive, from Piaget's and Vygotsky's theories to Pellis' social game theories, game studies is a growing discipline that recognizes the importance of video games not only as forms of entertainment, but as cultural, educational and social tools and that analyses not only the games themselves, but also the players' experiences, gaming communities, the gaming industry and the impact of video games on society.
Within this framework, James Paul Gee's volume entitled *What Video Games Have to Teach Us About Learning and Literacy* [Gee 2003] sets out a series of learning principles capable of developing multimodal skills, such as, for instance, visual reading to interpret maps and other representations, systemic thinking to understand the complex organizational systems of a video game, or online/offline collaboration to work with other players to achieve common goals.
Over the years, video games have emerged as important cultural products, influencing and reflecting the social, artistic and technological dynamics of our era. Initially perceived as forms of entertainment, video games are now recognized as complex media that combine storytelling, visual art, music and interactivity to create immersive experiences not only because they make use of technologies related to virtual or augmented reality systems, but because the gameplay on which the narrative hinges is immersive.

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Fig. 1. Flyer of the event.

Fig. 2. Study sketches of the scenarios.

Video games have begun to explore complex themes such as morality, psychology, history and culture, contributing to a broader dialogue on contemporary social issues such as discrimination, climate change and social inequalities, making them ideal tools for educating and raising awareness among a young audience increasingly removed from traditional media.
Now recognized as a form of cultural and artistic expression not only by the public and critics, but also by cultural and academic institutions, applied games offer new ways of exploring, learning and interacting with history, art and traditions. On the one hand, video games can recreate historical environments in detail, allowing players to explore cities, buildings and landscapes as they appeared in past eras. On the other hand, they can combine fun with learning, making the discovery of cultural heritage an educational experience through quizzes, puzzles or treasure hunts that help consolidate knowledge.
Often reference is also made to commercial titles that provide opportunities to educate on heritage –such as the *Assassin's Creed© Discovery Tours* released by UbiSoft for ancient Egypt, ancient Greece and the Viking Age– but it is clear that the large productions of the video game industry cannot meet the needs of a widespread, often minority and peripheral heritage that would benefit from valorization methods capable of alternative engagement.
For these –and other– reasons, it seemed opportune to train our future PhDs in the design and realization of games for heritage education and to give them prospects for the development of promising areas of research in the near future (figs. 2-5).
The organization of *UIDSS2023* was shared between the host institution –the Faculty of Education in Bressanone, Free University of Bozen/Bolzano– and the School of Architecture and Design of the University of Camerino, and was integrated with the interdisciplinary and international conference EARTH2023 Digital Environment for Heritage Education, organized by the EARTH Lab of the Free University of Bozen/Bolzano, as an initial training phase for the PhD students participating in *UIDSS2023*. On 19 and 20 June, in fact, there were presentations by the philosopher of science and pedagogue Stefano Moriggi with a keynote speech entitled *For a media archaeology of educational environments* (full proceedings in progress with the publisher Springer) and several dozen research paper presentations in which digital environments were developed to host heritage education processes or, vice versa, heritage education processes were developed in digital environments. This apparent play on words, however, tells of the symmetry between the work of those who digitize and interpret heritage versus those who deal with educational and cognitive processes in digital environments, and explains very pragmatically the need for our field to develop research in this context.
The following days saw many training lectures by tutors and experts and many fieldwork and design activities for four applied games, which we will briefly describe below. The lectures were given by Waltraud Kofler, art historian who introduced the participants to the historical and artistic heritage of Brixen, Demis Basso, full professor of General Psychology who provided a framework on the cognitive aspects of videogames, and Andrea Dresseno, president of *IVIPRO - Italian Videogame PROgram* who proposed critical readings, taxonomies and case studies on the relationship between videogames and heritage.

Participants were also able to experiment with expeditious digitization methodologies using neural radiance fields (NeRf) to produce assets to be inserted directly into three-dimensional scenes or, as in some cases, use the same methodology to create the entire game environment.
Four application areas were identified on which the participants focused, as if they were four chapters of a single story. For each of a group application, a 'Game Design Document' (GDD) was developed, an essential design document for the planning and development of a video game that provides a comprehensive and detailed overview of the project and serves as a guide and reference for the entire development team.
The GDD usually illustrates the general outline of the game, including genre, target audience and main objectives; a brief description of the gameplay including game mechanics, control system, rules, animations and interactions; a description of the visual style of the game, by means of moodboard images and sketches illustrating the appearance of characters, environments and props; and the design of the user interface and navigation systems.
The four designed games tell four stories that can be considered as episodes of a unified story of the heritage of Brixen that takes place in the streets and buildings of the city. The game dynamics and the stories are different from each other, but they all have the same educational objective: to tell the story of the material and immaterial cultural heritage belonging to them through a language, that of the video game, which, like others in the past, is increasingly becoming a medium capable of cultural expression. In particular: *The Mysteries of St. Michael* tells of an art historian who, as is the custom of the

Fig. 3. Scenarios taken from the game The Mysteries of St. Michael, designed by Arianna Lo Pilato, Enrico Pupi, Piergiuseppe Rechichi, Michela Schiaroli and Elisabetta Tortora.

Fig. 4. Scenarios taken from the game Brixner Dom. A letter from the past, designed by Stefano Botta, Michela Ceracchi, Francesco Cotana, Salvatore Di Pace, Federica Itri and Giancarlo Sanna.

Fig. 5. Scenarios taken from the game Aurora, designed by Simone Cera, Alessio Buonacucina, Dina Jovanovic, Roberta Ferretti, Pietro Azzola and Marco Proietti.

Fig. 6. Scenarios taken from the game Brixen Quest. In Search of the Lost Cavallefante, designed by Jacopo Bono, Martina Castaldi, Gloria Russo, Andrea Sias and Fabio Zollo.

municipal administration of Brixen/Bressanone, is invited to visit the town's landmark tower: the Weisser Turm, and from that moment on, a narrative plan begins in which he finds himself on an intricate journey that, through enigmas and trials, will lead him to discover that the apparently evil 'master builder' is a character who has been waiting to be freed for centuries, and with it the secret of the cultural heritage he conceals.

Brixner Dom. A letter from the past revolves around the cathedral and the square in front of it in Brixner Dom, where a young artist in search of new inspiration uses riddles and the eerie guidance of six signs left by the Krampus. Collecting cards that tell the story of the city's cultural heritage, the protagonist will eventually discover that the fatuous fire that guided him is none other than Paul Troger, who frescoed the cathedral and the fake dome that was incredibly concealed by a 19th-century remodeling.

Aurora takes place in the 18th-century library of the Major Seminary and tells the story of Elga, a young architecture enthusiast who decides to track down the places portrayed in some old family photos Through a journey through memories, made up of challenges and enigmas to be solved, Elga will realize that she wants to stay in this place, taking the place of the previous librarian: her grandmother Aurora.

Brixen Quest. In Search of the Lost Cavallefante revolves around the well-known fresco of the Cavallefante, allegedly stolen by the Krampus on the night of 5 December before the arrival of St. Nicholas, which will instead turn out to have been stolen from the community by other ill-intentioned persons who will be unmasked by the protagonist following a series of vicissitudes that will lead him and the players to the discovery of Brixen's heritage.

Credits

CTS Working Group: Francesca, Fatta Elena Ippoliti, Alberto Sdegno, Ornella Zerlenga.

Scientific Coordinators: Alessandro Luigini (Free University of Bozen), Daniele Rossi (University of Camerino)

Lecturers: Waltraud Kofler (Free University of Bozen), Demis Basso (Free University of Bozen), Andrea Dresseno (IVIPRO).

Tutor: Alessandro Basso (University of Camerino), Francesca Condorelli (Free University of Bozen), Elisabetta Caterina Giovannini (Politecnico di Torino), Maurizio Perticarini (University of Camerino), Giuseppe Nicastro (Free University of Bozen).

Partecipants: Pietro Azzola (University of Bergamo), Jacopo Bono (Politecnico di Torino), Stefano Botta (Roma Tre University), Alessio Buonacucina (Sapienza Università di Roma), Martina Castaldi (University of Genoa), Simone Cera (University of Cagliari), Michela Ceracchi (Sapienza Università di Roma), Francesco Cotana (Università degli Studi di Perugia), Salvatore Di Pace (Sapienza Università di Roma), Roberta Ferretti (University of Florence), Federica Itri (Università degli Studi di Napoli 'Federico II'), Dina Jovanovic (Politecnico di Milano), Arianna Lo Pilato (Università degli Studi di Napoli 'Federico II'), Marco Proietti (Sapienza Università di Roma), Enrico Pupi (Politecnico di Torino), Piergiuseppe Rechichi (Università di Pisa), Gloria Russo (Università di Catania), Giancarlo Sanna (Università degli Studi di Cagliari), Michela Schiaroli (Roma Tre University), Andrea Sias (University of Sassari), Elisabetta Tortora (Roma Tre University), Fabio Zollo (Università degli Studi G. d'Annunzio Chieti-Pescara).

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Events

eXploЯA *virtual journeys to discover* in*accessible heritages*

Sofia Menconero

"Space melts like sand running through one's fingers. Time bears it away and leaves me only shapeless shreds" [Perec 1999, p. 91 translation by the author].
Architectures that have remained marks on paper stored in archives or surviving in the form of projects after their material life; monumental heritages that have disappeared due to anthropic or natural causes; spaces that are impractical or completely closed to public use; intangible heritage; altered constructions for which the original meaning has been lost. Many occasions make cultural heritage inaccessible in the broadest sense of the term, which includes physical, sensory, cognitive, geographical, and cultural aspects.
The *eXploЯA* Study Day was conceived with the aim of enabling the (re)discovery of these heritages. The means proposed for this exploratory journey under the sign of accessibility, as the event's title suggests, are the digital tools of extended reality (XR) with various variations such as virtual (VR), augmented (AR), and mixed (MR) reality.
The international Study Day *eXploЯA. Virtual journeys to discover inaccessible heritages* (fig. 1) took place on March 15, 2024, at the Aula Magna of the Department of History, Representation, and Restoration of Architecture of the Sapienza University of Rome, with the participation of 95 attendees in person and about 50 connections on the streaming platform.
The promoting and organizing committee of the event includes many PhD students and research fellows from various Italian universities: Alma Mater Studiorum University of Bologna, Mediterranean University of Reggio Calabria, Sapienza University of Rome, Polytechnic University of Turin, University of Sassari. The group, coordinated by Francesco Stilo, consists of Vittoria Castiglione, Irene Cazzaro, Michela Ceracchi, Fabrizio Natta, Marta Pileri, Lorella Pizzonia, Andrea Tomalini, Noemi Tomasella, and Maria Belén Trivi. They were awarded the *Premio UID Giovani Vito Cardone*, which annually funds an innovative cultural activity proposed by the young members of the *Unione Italiana per il Disegno* (UID) which awarded the *eXploЯA* project in the 2023 edition.
Welcoming the audience and speakers of the study day was the set-up in the vestibule of the Aula Magna: an exhibition space dedicated to ten posters and five physical models made in 3D printing (fig. 2), collected following the 'call for drawings and models', which were other ways to participate in the initiative in addition to the more usual call for papers. The exploratory 3D models will be available in the event website repository [1] once the review process has been completed.
The scheduled speeches were preceded by institutional greetings from Daniela Esposito, Director of the hosting Department, Graziano Mario Valenti (Coordinator of the Drawing curriculum of the PhD in History, Representation, and Restoration of Architecture), Orazio Carpenzano (Dean of the Faculty of Architecture of Sapienza), and Francesca Fatta, (President of the UID), who unanimously expressed their appreciation for the activity proposed and managed in all its aspects by the young group. The interventions –twenty-six in total– were moderated by members of the organizing committee and divided according to the three thematic sessions already indicated in the call for papers: *Drawing, Modelling, Exploring.* A dense but dynamic program consisting of ten-minute presentations and additional time for questions and comments from the audience and moderators.
The publication of the proceedings in open access mode, involving all 47 accepted contributions following the review process, is scheduled for June 2024 on the editorial platform

PUBLICA Sharing Knowledge, which has endorsed the initiative together with the UID. Meanwhile, four contributions were awarded as best papers at the event based on evaluations received during the anonymous refereeing process.
Both the morning and afternoon sessions were opened by two invited speakers. Edoardo Dotto (University of Catania) and Enrico Cicalò (University of Sassari) were the earliest two guests to present their critical interventions. The first speaker proposed a reflection derived from the dual nature of architectural form –the material, physical, and spatial nature of built works, and that of thought elaborations– namely how the representation of architecture *in absentia* still plays a significant role today in the relationship between the graphic representation and architecture, also emphasizing the sedimentary value of knowledge, techniques, and methodologies in the field of drawing which stratify over time without replacing each other. The second guest spoke about graphic-digital intelligence in the era of digital positivism and digital transition, and its implications for the representation and communication of cultural heritage. The statistical evidence on the (poor) digital literacy –informative and functional– of the population necessitate a reflection on cultural proposals in the ICT field capable of stimulating and including different types of audiences. The afternoon saw two international guests, the Spanish Pedro Manuel Cabezos Bernal (Universitat Politècnica de València) and the Argentine Lucas Fabian Olivero (Universidade Aberta, Lisbon), with two talks linked by the guiding thread of immersive visualization. The first addressed the theme of panoramic photography, emphasizing its importance for documentation, particularly with the gigapixel technique, and the dissemination of cultural assets. The latter guest illustrated the topic of immersive 360° drawing, from the geometric-projective foundations on which to base the construction to its application through interesting examples in architecture.
A comment by UID Secretary Elena Ippoliti closed the study day, expressing the high level of interest reached by the cultural activity winner of the *Premio UID Giovani Vito Cardone*. The name of Vito Cardone was mentioned several times during the event, starting from the two international guests from those foreign academic realities that professor Cardone contributed to connect with the research activities of UID members.
The *eXploЯA* study day has thus repeatedly touched on the theme of memory, from that dedicated to the previous UID President to that linked to cultural heritage and its protection. The memory of inaccessible heritage

Fig. 1. Event banner.

Fig. 2. Exhibition space with posters and 3D printed physical models.

is particularly important to ensure its more problematic transmission to future generations. This is achieved by reinforcing or relocating certain pieces of what is the very tall tower of our history and cultural identity. The organizers of *eXploЯA* and the authors of the interventions of the international Study Day have shown how drawing and its digital and virtual applications always prove to be excellent means for the delicate task of reshaping the shreds of space that time merges, thus preserving the memory of cultural heritage.

Note

[1] Link to the event website: http://www.explorauid.com (accessed 27 May 2024).

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Events

Innovative National and International Experiences Compared between Memory and Amnesia

Fabiana Raco

The UID Symposium on Internationalization and Innovation of Research is part of the *Days of Restoration and Cultural Heritage 2024* and aims to promote the internationalization of research and its constant innovation. Held in Ferrara on March 19, 2024, the conference aimed to give continuity to the events of previous years to promote research at the international level and to present the roadmap of the work of the Innovation Commission, starting from the strategic areas of development that include the themes of Digitization, Visualization and Social Innovation for the enhancement of Cultural Heritage, the conservation of the built, historical, and artistic heritage, and the contexts of city, territory, landscape and environment.
The theme chosen for this edition of the Symposium lies between 'memory' and 'oblivion', an extremely topical antithesis that sees the project of amnesia as a way for society to digest errors/horrors (primarily recent wars) In an attempt at a socio-cultural reset.
On the one hand, 'memory' is a whole: of history, places, buildings, and people, as the ability to remember to evolve and innovate. On the other hand, 'amnesia' is a tragic emptiness: of traditions and processes that are thus forgotten in a kind of great island of the Lotophagi of Homeric memory that connotes the society in which we live.
The UID Symposium 2024 involved eighteen contributions, eight chosen for oral presentation in the two sessions *Innovation of Research* and *Internationalization of Research*. The symposium was organized by the DIAPReM research centre and the TekneHub laboratory of the University of Ferrara in collaboration with UID - Unione Italiana per il Disegno and the International Academy *After the Damages*.
Following the Association's statutory goals, UID President Francesca Fatta opened the event by highlighting the significance of encouraging ongoing discussion and debate regarding the results of research and teaching efforts. The discussion was then led by Marcello Balzani of the University of Ferrara, President of the Innovation Commission, and Stefano Bertocci of the University of Florence's Department of Architecture, President of the UID International Relations Commission.
The topic of Gaia Leandri's contribution (Department of Architecture and Design, University of Genoa) opened the discussion with the theme of the storytelling of the memory of digitally reconfigured pictorial apparatuses. She introduced the reflection on the role of the discipline in Third Stream activities, public involvement, and society at large. The dialectical relation that arose from the speech given by Cecilia Bolognesi (Politecnico di Milano, Department ABC) because of extensive research on the historical residential legacy of ALER Milan, was memory and identity, of places and the connections between them. The theme presented by Riccardo Florio, Raffaele Catuogno, Teresa Della Corte, Anna Sanseverino, Caterina Borrelli, and Alessandra Tortoriello (Department of Architecture, University of Naples 'Federico II') concerning the case study of the archaeological heritage of the Baths of Baia, is representation and memory as an ongoing method of investigation and understanding of fragments, traces, spaces, techniques, and materials. In the context of a more extensive research project on fascist rural towns, Cettina Santagati, Raissa Garozzo, and Rosaria Privitera (University of Catania) examine the relation between tangible and intangible cultural heritage for the reconstruction, deconstruction, and collective memory of Borgo Caracciolo. Paola Raffa (Università degli Studi 'Mediterranea' di Reggio Calabria) expands on the themes of social innovation and inclusion with a contribution to the role of the discipline for shared

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spaces. She also introduces the topic of building territorial and trans-territorial networks as an intriguing domain for applying disciplinary contents and products. Ensuring the cultural heritage's traces in cross-border contexts to build shared memory is the focus of Sandro Parrinello, Matteo Bigongiari, Alberto Pettineo, Ilaria Malvone, Francesca Picchio, Anna Dell'Amico, Ludovica Galeazzo, and Gianlorenzo della Bartola's intervention. New research goals can be identified, and a wide, global dialogue can be developed by addressing territorial changes that may reveal the identity of the locations through exchanges, documentation, and representation. 'Openness and fragile patrimony', 'dispersed cities', and 'abandoned places' are terms used to describe the results of a research process that were presented by Emanuela Borsci, Antonio Conte, Marianna Calia, Roberto Pedone, Rossella Laera, and Ali Yaser Jafar. The studies conducted in the Southern Italian region, in Basilicata, Iran, and Afghanistan defined a transferable model of analysis and documentation for the over five hundred urban settlements scattered over the affected areas and the over one thousand abandoned communities in the national territory. The theme of memory loss, oblivion, and war is finally addressed by Andrea Pirinu (University of Cagliari), Emanuela Chiavoni (Sapienza Università di Roma), and Andrés Martínez-Medina (University of Alicante). The Mediterranean Wars between the 16th and 18th centuries defined an investigative process that, from the scale of the territory to the scale of the type of architect, implemented a regional database accessible to successive elaborations. In considering the many objectives that the knowledge project requires, and the many topics and fields of application that were presented, the 2024 edition of the UID Symposium on the Internationalization and Innovation of Research as part of the sixth edition of the *Days of Restoration and Cultural Heritage* has therefore contributed to the larger discussion on the role of the field of the discipline in defining protocols for the survey, documentation,

Fig. 1. Banner of the event.

representation, and communication of cultural heritage at different scales. Using integrated digital representation and information for implementing strategies for the transfer of the tangible and immaterial value associated to the Cultural Heritage under study into practice and for disseminating that value to a broad audience was one of the reflections' primary issues. The symposium proceedings will be included in an edited collection published by Maggioli Editore titled *Survey and Representation Research, From Architectural to Industrial Design*.

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Events

Dialoghi con gli Archivi di Architettura "Eredità contemporanee"

Giovanni Rasetti

In the context of the D'Annunzio pine forest, the spaces of the former Aurum liquor factory now the city museum 'Factory of Ideas', hosted the study day *Dialoghi con gli Archivi di Architettura "Eredità contemporanee"* (*Dialogues with the Archives of Architecture "Contemporary Legacy"*) organized by Caterina Palestini of the Department of Architecture of the Università degli Studi G. d'Annunzio Chieti-Pescara for the *Unione Italiana per il Disegno* in collaboration with the State Archives of Pescara. The event on May 10, 2024, reiterates the annual appointment of meetings dedicated to the debate on the documentary graphic heritage kept in the Archives of Architecture, programmed by the UID Archives Commission with a view to dialogue with city archival and museum institutions, in relation to the readings and dissemination that drawing can offer in its dual role as a tool for configuration and analysis of the project.
The meeting emphasized the importance of the often lesser known but no less important provincial designers who contributed to the postwar reconstruction in Abruzzo, shaping the modern Adriatic city. Among them were Antonio Cataldi Madonna –whose selection of drawings, unpublished and kept by the family, was present for the occasion– Luigi Alici and Paride Pozzi, designers who played a crucial role, as evidenced by the plans preserved in the State Archives and in institutional offices. In addition to these purely local figures, there are the works of nationally renowned authors such as Giovanni Michelucci, designer of the transformation in 1938-1940 of the old Kursaal marine pavilion into the Aurum liquor factory –for the occasion the setting of the event– and Luigi Piccinato, author of the reconstruction plan and master plan for the city and the Stadio Adriatico.
The day, which began with a guided tour of the spaces of the former Aurum liquor factory, was introduced by institutional greetings and a preliminary discussion on the topic, with speeches by Francesca Fatta, UID President, Maria Amicarelli, Director of the State Archives of Pescara, and Caterina Palestini President of the UID Archives Commission. The seminar was attended by leading figures in the field of archival and architectural Cultural Heritage, who shared their experiences and knowledge.
Andrea Aleardi, for the Giovanni Michelucci Foundation, opened the series of talks with a speech entitled *Drawing the New City*, in which he explored Michelucci's graphic approach, highlighting how drawing represents not only a design medium but also a graphic diary documenting the evolution of architectural ideas. Aleardi emphasized the value of drawing as an expressive tool, capable of narrating through a sequence of preliminary sketches the spaces conceived and represented by the architect. The speaker reported how the concept of the 'variable city' provided a vision of the city as a democratic and constantly evolving work of art, shaped by the daily needs of citizens and the interaction between technicians and artists, developed by Michelucci. Concepts that are reflected in the genesis of projects such as the church of St. John the Baptist on the A1 Florence North Highway (1960-1964) and the Ravenna Auditorium (1963-1965), which not only respond to functional needs but also embody a poetic vision of space, in which architecture becomes a means of exploring the cultural and spiritual identity of a community.
Sergio Zevi, scientific head of the Piccinato Archive of the DPTA Department, Sapienza Università di Roma, presented *Luigi Piccinato's Plans, Projects and Drawings for Pescara*. Zevi illustrated the importance of Piccinato's work in the urban planning of the nascent Adriatic city devastated by the 1943 bombings, analyzing the post-war reconstruction plans and design drawings that helped define the modern face of

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Fig. 1. Flyer and program of the event.

the city. In particular, the design of the city's stadium, built between 1952 and 1954, inspired by the Olympic Stadium in Rome and initially an example project for CONI for the construction of stadiums in provincial cities, provided a significant sports facility, but also represented a symbol of rebirth and modernity for the local community; while The Pescara Master Plan, developed between 1954 and 1957, further consolidated Piccinato's contribution to the definition of the city's contemporary urban layout. Zevi also emphasized the detailed documentation preserved in the archives, which includes not only the final designs but also sketches, preparatory drawings and detailed plans. This wealth of materials allows for a thorough understanding of Piccinato's creative process and his methodological approach to urban planning and architecture.

The point of view of realized projects was provided by Maria Vittoria Marini Clarelli, representative of the General Directorate for Contemporary Creativity of the Ministry of Culture, who offered an institutional perspective with her talk *Archives and Biographies*. She discussed the importance of mapping and enhancing contemporary Italian architecture through the selection and cataloging of significant buildings. The census project, initiated in 2002 by the Directorate General for Contemporary Art and Architecture (DARC), had as its primary objective the selection and indexing of significant buildings and urban areas. This initiative, born out of the need to document the country's urban and architectural transformation in the post-war period, has evolved over the years, broadening its scope and integrating new technologies for the dissemination and exploitation of the results obtained; the

project has surveyed about 5000 architectures throughout the country, based on a unified filing methodology and homogeneous selection criteria. The criteria include quantitative aspects, such as bibliographic recurrence, and qualitative aspects, such as technological innovation capacity and technical or social problem solving.
Elisabetta Reale and Laura Farroni concluded the presentations with the contribution *From Archives to Drawing: the graphic paths of Abruzzo projects*. Reale, formerly of MIC's General Directorate for Archives, and Farroni, from Roma Tre University, explored the national project on architectural archives, focusing on the census of architects' archives in Abruzzo.
In particular, Elisabetta Reale emphasized how the documentation preserved in archives represents not only a fundamental historical testimony, but also constitutes an essential reference for restoration work, confirming the indissoluble link between archival and architectural assets, both for the reconstruction of design activities and for the preservation and enhancement of architectural works, hence the need to integrate digital data collected in different archival systems to create thematic paths dedicated to in-depth knowledge of this heritage. A key element of the presentation was the illustration of the results obtained through the publication of specific guides, including *L'architettura sulla carta. Archivi di architettura in Abruzzo*, which offers an exhaustive overview of the main regional archives, and the digitization and on the creation of dedicated IT platforms such as the *Sistema Informativo Unificato delle Soprintendenze Archivistiche* (SIUSA) and the *Architects' Archives* Portal.
Finally, Laura Farroni's talk offered an in-depth and innovative perspective on the graphic paths of Abruzzo projects. Her presentation explored the concept of 'constellations of Abruzzo', understood as a set of mental representations connected by associative links. These constellations make it possible to establish relationships between various figurative codes, offering a new way of cataloging and describing preserved works. She emphasized the importance of the evocative contribution of drawing, the control of geometric structure in the restitution of architectural images, but above all the analysis of these features, presenting examples of integration between sketches, of realized and unfinished projects, and analytical reconstructions with digital models.
The study day *Dialoghi con gli Archivi di Architettura "Eredità contemporanee"* provided an important opportunity for discussion and insight. It promoted the protection and enhancement of project drawings and works created in the Abruzzo region, helping to strengthen the dialogue between institutions and the scientific community. The event highlighted the value of archival heritage as a fundamental resource for research, preservation and dissemination of contemporary architecture.

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Events

Information and Training Seminar on Evaluation

Graziano Mario Valenti

Within the rich and heterogeneous panorama of activities that the *Unione Italiana per il Disegno*, in line with the principles of its statute, organizes in favour of its members and more generally for the scientific drawing community, the Training [1] and Scientific Production and Evaluation [2] commissions worked together to plan and implement a seminar dedicated to the topic of scientific evaluation. The event held in Rome on 14 March 2024 with the title *Seminario informativo, formativo, sulla valutazione* continues a tradition –previously established in the years 2019, 2020 and 2022 [3]– of inviting the scientific community of the area of Drawing to a critical reflection on the best practices of evaluation and self-evaluation of research and the consequent implications in the training field, considering them within current and future scenarios.

The seminar was structured into two parts over the course of a day. The first part, 'informative', dealt with the topic of evaluation from a general and transdisciplinary point of view. The second part, 'training/formative', dedicated attention to specific aspects of the evaluation in reference to the scientific disciplinary sector ICAR17 (now CEAR-10A).

For each part of the seminar, four main topics were identified, presented, and discussed by a guest, two moderators and, in several cases, by participants from the public present.

The seminar was introduced by the president of the UID Francesca Fatta and by the presidents of the Training and Scientific Production and Evaluation commissions, Maria Linda Falcidieno and Rossella Salerno.

The 'informative' part of the seminar began with a presentation by Matteo Bigongiari [4], who discussed key points of the innovation process of the National Scientific Qualification that are of particular interest in the works of the CUN.

The seminar then continued with presentations by the first four guests. Marco Margarini [5], introduced by Sandro Parrinello and Roberta Spallone, illustrated data and provided considerations on the articulation of scientific production, the objectives and principles of Research Quality Assessment (VQR), the evolutionary perspectives of VQR and the methodology and critical issues in evaluation of scientific journals. Data showed that most of the evaluated scientific production consists of conference proceedings, journal articles, and monographs. In the previous VQR, journal articles were numerically predominant, while monographs received better evaluations in non-bibliometric areas. The innovations of the 2020-2024 VQR include a broader definition of scientific products and a promotion of scientific transparency and reproducibility linked to Open Access and Open Science. Margarini also emphasized the importance of training evaluators to ensure a fair evaluation based on the quality of the scientific product regardless of the type of publication.

Fabrizio Cobis [6], introduced by Carlo Bianchini and Marcello Balzani, discussed the use of resources from the National Recovery and Resilience Plan (PNRR) in the university and research sector, particularly focusing on the commitment deadlines set for December 2025. His contribution highlighted the importance of using resources efficiently and swiftly, a challenge for Italian institutions whose main critical factors are the implementation and concrete management of resources, as well as their planning. In this scenario, it is essential that administrative staff can promptly respond to researchers' needs to avoid delays that could jeopardize projects. Cobis emphasized that the real success of the PNRR will be

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measured by the ability to create a new sustainable research management model even after the program ends in 2025.
Francesca Bottaro [7], introduced by Lia Maria Papa and Graziano Mario Valenti, illustrated the activities of the CoARA coalition aimed at reforming research evaluation, a necessity arising as a response to radical changes in research methods due to digitalization and increasing international collaboration. Research evaluation today is primarily focused on the number of publications and the prestige of the journals where they are published, measured by the Journal Impact Factor. This approach has led to negative consequences on the quality and integrity of research, prompting the academic community to consider the need for reform. Previous initiatives such as the San Francisco Declaration on Research Assessment (DORA) have already suggested abandoning the exclusive use of metrics based on scientific journals. The proposed reform aims to create a broader and more coherent movement at the European level, involving key factors such as universities, research centers, funding agencies, and academies. The reform agreement, published in July 2022, is the result of a co-creation process facilitated by the European Commission and signed by over 700 organizations. The reform aims to improve the effectiveness and efficiency of scientific research by promoting open science practices and recognizing a broader range of contributions to scientific knowledge.
Donato Malerba [8], introduced by Laura Farroni and Michele Russo, discussed potential scenarios for artificial intelligence (AI), highlighting how AI is becoming a transformative force in various sectors, including scientific discovery and evaluation. His contribution focused on the use of AI to improve the efficiency of the peer review process, noting some operational tools useful for statistical control and compliance. Malerba also pointed out that AI is a valuable aid for reducing evaluative biases and improving the quality of review decisions. However, there are ethical concerns related on the opacity of algorithms and the potential for existing biases to be replicated. There is thus a need to balance accuracy with transparency and fairness in evaluation to prevent AI systems from negatively influencing decision-making and reducing author trust.
Donato Malerba's intervention concluded the 'informative' section of the seminar, which resumed in the early afternoon with the 'formative' part introduced by Alberto Sdegno, representing the UID's doctoral working group.
Sdegno's contribution highlighted the importance of the doctorate as a first step for young researchers, supporting the need to balance quantity and quality of publications, since it seems clear that today there is a greater production of articles by doctoral students, but these risks being at the expense of quality. Methodological rigor and the impact of research are considered fundamental for the training of the PhD, equally important is the inclusion of new technologies such as artificial intelligence. Finally, Sdegno recalled the need for a transdisciplinary approach, to integrate knowledge and skills in a broader way, promoting a holistic vision of reality and research. This approach is seen to improve understanding and collaboration between various fields of knowledge, enriching the overall scientific and cultural landscape.
The seminar then continued with presentations by four more guests.
Fabrizio Apollonio [9], presented by Antonella Di Luggo and Alessandro Luigini, first addressed the complexity of the topics under discussion, recalling that the nature of scientific research has been debated among epistemologists and scientists such as Karl Popper and Thomas Kuhn. He focused on the difference between the 'scientific fact' and the scientific article, then delving into the challenges of identifying the product of scientific research. Apollonio's contribution also touched on the distinction between research evaluation and review. Evaluation aims to monitor and verify the impact of research in terms of costs and results, while review focuses on validating the scientific product. Criteria such as transparency, reproducibility, and the need for appropriate evaluation tools to ensure scientific quality were discussed. Finally, Apollonio addressed the demarcation issue between scientific products like articles, monographs, and 3D models, highlighting the specific challenges for interdisciplinary scientific areas. Research product evaluation must consider the peculiarities of each discipline and adopt appropriate evaluation criteria to recognize the scientific value of contributions.
Roberto Delle Donne [10] and Itala Del Noce [11], introduced by Elena Ippoliti and Ornella Zerlenga, illustrated the value and potential of Open Science, considered a fundamental practice to make accessible not only the final products of

research such as articles and books but the entire research cycle, including data and methodologies. The free dissemination of research output online can produce significant scientific synergies and social impacts. The availability of open access publishing platforms is crucial to support these principles. The Department of Architecture and Industrial DRAWING at the Università della Campania 'Luigi Vanvitelli', through its publishing brand DADI Press, is committed to promoting open access.
Alessandro Barbano [12], introduced by Maria Grazia Cianci, explored the role of ethics in our society, particularly in journalism. He underlined the close link between ethics and democracy, pointing out recent issues in social media communication and the public sphere that raise ethical concerns. Barbano emphasized the complexity of balancing freedom of expression with the need for ethical behavior. He discussed the legal responsibilities of newspaper editors, who are criminally liable for everything published in their newspapers, and the criteria for publishing defamatory news: truth, social utility, restraint, and respect for privacy. Barbano concluded by reflecting on the importance of maintaining a balance between investigative journalism and protecting individual rights, warning that excessively limiting press freedom could harm democracy itself.
Riccardo Larini [13], presented by Fabrizio Gay and Edoardo Dotto, highlighted the challenge of evaluating scientific work, emphasizing how interdisciplinarity and collaboration between humans and technologies can improve this process. Larini, with a background in teaching and creating digital courses, highlights that assessment serves not only to measure learning but also to certify skills, improve metacognition and ensure the quality of scientific research. He illustrated the distinction between different types of evaluation, such as diagnostic, formative, and summative, and described the use of technologies in evaluation, emphasizing that these should enhance rather than replace human evaluation. Larini stressed the importance of asking the right questions in the context of evaluation and using scientific criteria to reduce subjective biases.
At the end of the seminar, there was a lively debate with interesting insights. The UID president Francesca Fatta, the presidents of the 'Training' and 'Scientific Production and Evaluation' Commissions Maria Linda Falcidieno and Rossella Salerno, and the seminar coordinator Graziano Mario Valenti briefly commented and concluded the event.

Notes

[1] CTS members: Maria Linda Falcidieno (president), Elena Ippoliti, Alessandro Luigini, Alberto Sdegno, Graziano Mario Valenti. External members of the CTS: Maria Grazia Cianci Lia Maria Papa.

[2] CTS members: Carlo Bianchini, Edoardo Dotto, Alessandro Luigini, Roberta Spallone, Rossella Salerno (president), Graziano Mario Valenti, Ornella Zerlenga. Members external to the CTS: Fabrizio Gay, Antonella Di Luggo, Laura Farroni. The following ordinary members also participated in the organization of the seminar: Sandro Parrinello, Matteo Bigongiari, Michele Russo.

[3] I Seminar evaluation of research in the SSD ICAR/17 – DRAWING, Rome, 9 May 2019; II Seminar evaluation of research in the SSD ICAR/17 – DRAWING - VQR 2015-2019, Rome, 4 March 2020; III Research evaluation seminar Disciplinary strategies and policies of the SSD ICAR/17 – DRAWING, Rome, 12 May 2022; IV Research evaluation seminar in the SSD ICAR/17 – DRAWING - Outcomes and implications of the VQR 2015-2019, 11 November 2022.

[4] Councilor representing Area 08 - Engineering and Architecture, at the National University Council.

[5] Director of ANVUR Research Evaluation Area.

[6] Director of the MUR Office - Incentives and support for the competitiveness of the private production system and public/private cooperation at a national level of the General Directorate of Research of the Ministry of University and Research.

[7] Legal and Policy Officer at the Directorate General for Research and Innovation of the European Commission. He works in the Open Science and Research Infrastructures unit, where he contributes to the development and implementation of the European Open Science Agenda. In particular, he is part of the team dealing with the initiative for the reform of research evaluation.

[8] Full Professor of Computer Science, University of Bari.

[9] Full Professor of Drawing, 'Alma Mater Studiorum' University of Bologna.

[10] Full Professor of Humanistic Studies, President of the University Center for Libraries 'Roberto Pettorino' of the Università degli Studi di Napoli 'Federico II' SHARE Group Coordinator (Scholarly Heritage and Access to Research).

[11] DADI_PRESS editorial committee - SHARE Book, Università degli Studi della Campania 'Luigi Vanvitelli'.

[12] Italian journalist and essayist.

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