Teaching to Think Through the Hands a Teaching Experience About the Use of the Scale Model for Architectural Design

Manuel Giménez Ribera, Jorge Llopis Verdú, Ana Torres Barchino and Juan Serra Lluch

Abstract In the contemporary architectural environment, characterized by the massive introduction of computer graphics in the design process, the attention is caught, even in offices regularly proposing extremely formal complexity designs, by continuity in the employment of one of the oldest ways to display architecture and design: the three-dimensional model. In the "Análisis de Formas Arquitectónicas" course at the UPV (Spain), an articulated teaching methodology has introduced the use of the model to complement the sketch learning, as a graphic mechanism of formal comprehension for the architectural object.

Keywords Model · Sketch · Learning

1 Introduction

In the contemporary architectural environment, in which the use of three-dimensional computer modelling software has become an omnipresent mechanism for formal manipulation and architectural representation, the attention is caught by what we could name as the rebirth of one of the oldest means of expression: three-dimensional models. Architectural offices characterized by the extreme formal complexity of their projects, such as Frank Gehry, Zaha Hadid, Daniel Libeskind or EMBT publish, as previously done with hand-drawn sketches,

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Fig. 1 Frank O. Gehry's office in Santa Mónica. Louis Vuitton Foundation scale models

series of photographs that show scale models of ongoing projects, which are introduced as the means of manipulation used by the office to supplement the computer graphics that characterize these days.

Architectural practices, that looked like computer labs since the 80s, now seem medieval workshops in which a number of architects, designers and students strive to give shape to the ideas, before or simultaneously to the computerized manipulation. Thus, a way of working in which the practice of manually developing scale models plays a key role in the formal ideation of cutting edge architecture, whose creation and construction has been possible only through the use of computers and modern software, often imported from other technical disciplines or designed for other sciences, often out of line with architecture itself (Fig. 1).

Faced with this paradoxical dualism between innovation—represented by the modern software used for creation and formal manipulation, and tradition—represented by the survival of sketches and scale models, the eldest tools of the architectural project—it bears asking about their roles in the development of contemporary architecture, as well as whether or not to preserve the learning of these traditional techniques in the training programs of architecture students in our faculties, and the need to set up teaching strategies that allow the students understand the reason for the survival of these manual techniques in our modern digital world.

2 About the Use of Scale Models in Contemporary Architecture

> Any movement of the hand in each of its works is directed in this way through the element of thought, its expression and gesture come by way of this element. All work done by the hand rests on thought.
>
> Martin Heidegger (2005, 79)

The persistence of the use of the scale model, as a physical and tactile experience within the architectural design process in the strongly digitized current environment, is not a paradoxical fact, but the evidence of the limitations of the computer to fulfill efficiently the requirements of every phase of design.

We could say that without the computers and modern software, the new architecture would not be possible, but the use does not completely displace the usage of traditional graphical techniques based on the direct application of hand gestures, for the characteristics of the digital world represent an estrangement between the hand, which is the basis for a great deal of our cognitive processes, and the resultant formal world. The thesis we hold is that the reason why architects like Gehry, Hadid and Tagliabue, characterized by manipulating a formal universe impossible to control without the computer, keep on using sketches and scale models is because they cover the need for a straightforward connection with the project, of tactile nature, that computerized graphical manipulation does not meet.

The existence of an intimate relationship between the eye, hand and mind is at the basis of modern psychology research. Authors such as Vigotsky (1978) provide evidence that the use of hand gestures plays a fundamental role in cognitive development in the early ages of humans. Touching, manipulating and interacting with the environment through eye-hand coordination, we perceive the world and develop categories that are at the basis of our own intelligence. This is what authors like neurologist Frank Wilson define as "*nexus hand-thought-language*", and to bring him to state "*any theory of human intelligence which ignores the interdependence of hand and brain function, its historical origins or the influence of this history on the dynamics of the development of the modern human being is, in general terms, erroneous and sterile*" (Wilson 2002, 21).

Contemporary authors such as Richard Sennett or Juhani Pallasmaa stress on this line as they analyze the role of traditional production techniques in the contemporary world and the tactile character of architecture as well as the effects of estrangement between hand and brain in the architectural field produced by massive digitizing.

Richard Sennett focuses on sociological considerations, emphasizing the estrangement that the virtual digitized world causes between productive activity and reality. In his book *The Craftsman*, Sennett notes that the use of computers is causing, in many cases, the disappearance of the circular experimental test process in architectural design; this process explained by many architects that, as Renzo Piano, described the design process as the way from the sketch to the drawing board, to the scale model and back to the sketch. A process in which the indeterminacy of manual drawing acted as a trigger for the creation of forms, and that the extreme accuracy and the need for precise determination which characterizes the CAD has shelved.

> The tactile, the relational, and the incomplete are physical experiences that occur in the act of drawing. Drawing stands for a larger range of experiences, such as the way of writing that embraces editing and rewriting, or of playing music to explore again and again the puzzling qualities of a particular chord. The difficult and the incomplete should be positive events in our understanding; they should stimulate us as simulation and facile manipulation of complete objects cannot. The issue—I want to stress—is more complicated than hand versus machine (Sennett 2009, 61).

Sennett's speech is not nostalgic, but proposes removing the mysticism of computers and virtuality as a paradigm for the future, as well as some negative effects that are already visible nowadays. Sennett denounces an epic discourse about the new globalized and digitized world which he considers similar to the messianic late nineteenth century machinism, suggesting a relativism about the machinist triumphalism of this era, but without casting doubts on the progress the computer means in many areas. To Sennett "*Abuses of CAD illustrate how, when the head and the hand are separate, it is the head that suffers*." (p. 61), that is, the uncritical use of computers may cause such a rift between the hand and the critical evaluation processes that it leaves us defenseless facing the requirements of the software itself, taking away from us the control of the process of production to make it depend on the characteristics of the tool itself (Fig. 2).

Meanwhile Juhani Pallasmaa develops a discourse based and focused on relevant issues of architecture. To Pallasmaa "*the tactile*" is a fundamental part of the architectural experience and the massive use of computers tends to displace this tactile character in exchange for an essentially visual experience, so that the computer breaks the connection between imagination and the object (Pallasmaa 2012, 74). We can say that computerized *making* differs significantly from manual *making*, and its widespread implementation determines the result through the

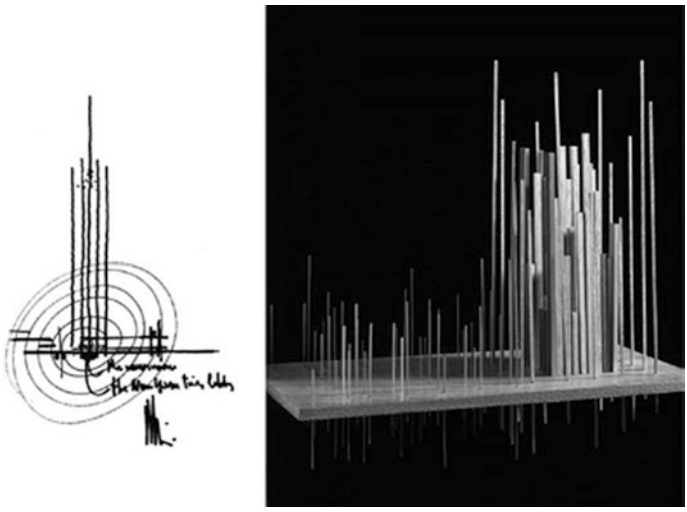

Fig. 2 Renzo Piano: Sketches and scale model for The New York Times Building

characteristics of the graphical tool used. To Pallasmaa "*To argue that for the purposes of drawing an architectural project the charcoal, pencil, ink pen and computer mouse are equal and exchangeable is to misunderstand com- pletely the essence of the union of the hand, tool and mind.*" (Pallasmaa 2012, 54).

The scale model would ensure the preservation of this link between eye, hand and mind, bypassing the visual rift that the computer imposes in our design processes. It would avoid, at least partially, that the computer routines prefigure the final forms, stemming their creation directly from manual handling and preventing them from being set at the beginning by the formal catalogue of the software used.

3 The Spanish Pavilion in Shanghai and the Conceptual Use of the Scale Model as a Design Tool

To illustrate the use of scale models in the design of highly complex architectures, we propose to analyze a unique case in which their use meets conceptual needs and complements the digital tools by way of using a technique that prioritizes materiality and tactility opposite the virtuality of computerized design: The Spanish Pavilion at Expo Shanghai 2010.

Its formal complexity and the extreme difficulty of its constructive realization require the use of complex programs that enable both the graphical definition of the final design and the material definition of many different construction elements. However, the design process of the building, as the office itself has been responsible for publishing, depends as much on these digital tools as on the use of scale models to determine the building from its early stages and enable successive approximations to the final result (Fig. 3).

The building is designed based on the formal analogy with wicker, understood as a common metaphor of both Spanish and Chinese handicrafts. From this formal ideation the building is materially conditioned. It is not only about coating the building with wicker as boundary surface, but materializing it from a structure that operates similarly to the traditional basket making. EMBT has developed many three-dimensional models, made of different materials depending on the design goal. Thus we find scale models made of corrugated cardboard, built by successive horizontal slices to determine the overall shape of the building, to which must be added scale models of "wired" character, which allow to adjust the form through the warping of the mesh, as well as to predetermine the steel structure designed using a tubular mesh that supports both the glass envelope and the subsequent coating of wicker sheets (Fig. 4).

The material used in each scale model is not unimportant, on the contrary, it prefigures the final design and ventures hypotheses about the formal and structural problems that will turn up in the project. This seems clear in the case of the structural mesh aforementioned, characterized by the linearity of the wire, input data for the subsequent computer calculation, allowing to continue the modeling

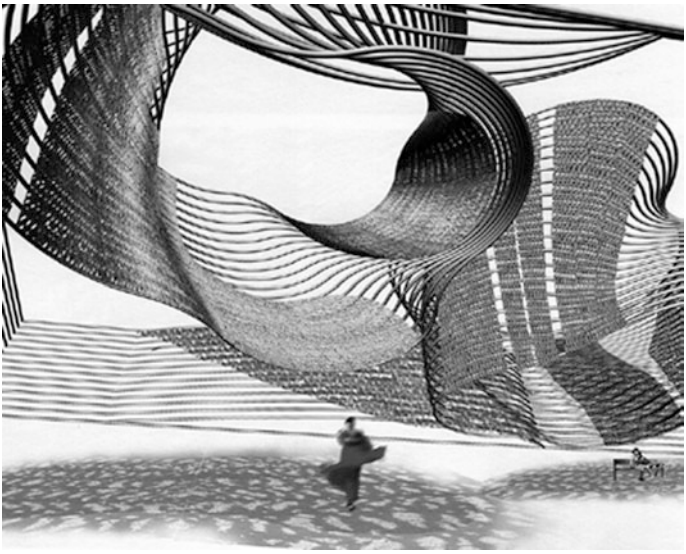

Fig. 3 EMBT: Spanish Pavilion in Shanghai: concept image

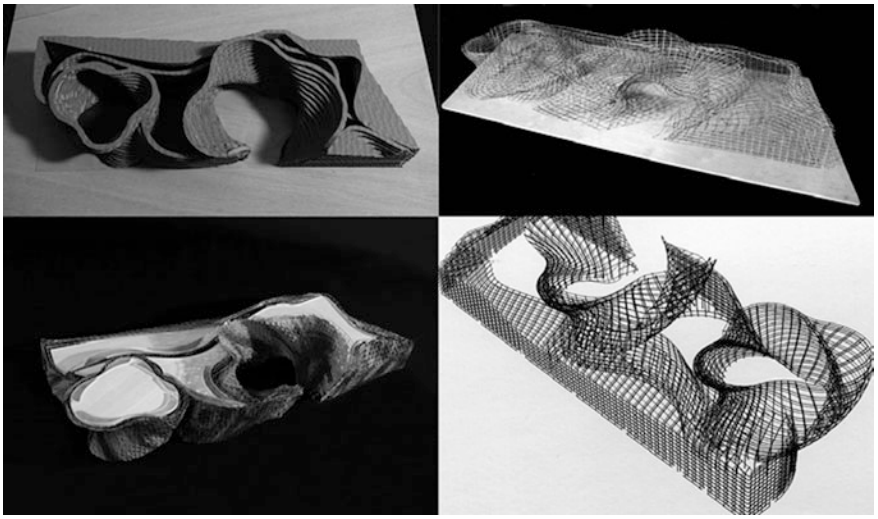

Fig. 4 EMBT: Spanish Pavilion in Shanghai: design scale models and digital rendering

and formalization process of the design project. A similar process, characterized by the simultaneous and complementary work in three-dimensional physical and computerized models, is used to determine the various elements of a smaller scale, as the individual wicker pieces that will form the final cover.

The use of the scale model of the Shanghai Pavilion in order to define the design ideas seems to be strongly related to the gestural idea of the building itself. It is clear that the scale model allows a clearer approach to the form and the final image than any computer program, so that there is an almost linear relationship between the previous results of the manual model and the final result. But there is another aspect that we understand as essential, direct experience with wicker and its performance, which provides an indispensable information to understand the way in which the building must be designed. Touching wicker, give shape to it, understand its texture and color under the light changes, develop the braided material and experience the features of its different degrees of transparency is a direct experience that no computer program can replace.

The scale model lets us "understand" directly the mate- rial and its behavior, braiding wire, anchoring them to the metal wire frame and twisting the final layers. It is a similar experience to that of the direct understanding of brick and stone which characterized architectural training in the preceding centuries, in which idea and construction were directly related to each other. The computer separates direct tactile experience and form, which means that in many cases the resulting forms lack material consistency. The scale model, however, allows direct connection with the built object, is an experience that relates directly to all our senses, and not just with the visual. Its use complements the computer giving back the feeling of the material in an environment increasingly characterized by virtuality (Fig. 5).

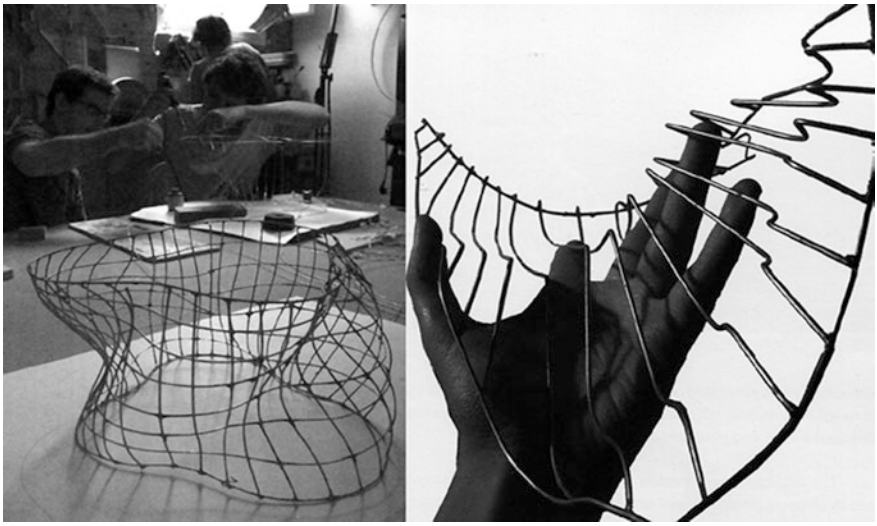

Fig. 5 EMBT: Spanish Pavilion in Shanghai: EMBT scale models workshop

4 Scale Model and Sketch in Análisis de Formas Arquitectónicas Course

Teaching in schools of architecture should deepen the students' understanding of this integrated approach, which coordinates the use of graphical tools, computerized techniques and three-dimensional models, to ensure the continuity of tactile strategies in an increasingly digitized graphical environment.

Our first year students, at least of the Análisis de Formas Arquitectónicas course, on the last section of the school year, undertake the mixed-use of drawing and scale models. This approach is undertaken once a series of graphic skills have been acquired during the first semester, having faced the first formal analysis of a renowned architecture. With minimal graphical prowess and after a first approach to the architectural idea implicit in the analyzed model, the last step prior to pass the course is the aforementioned circular experimental test process, formulated by Renzo Piano: concept sketch—scale model too, drawing board—naturally also computer—and back to restart the process, in a circular knowledge, understanding and corroboration process.

One's own hand will be responsible for transmitting the ideas acquired in the mind, while the eye reviews, confirms the validity of the generating ideas for the apprehended project.

This graphical process must be agile, quick, analytical, and so it serves as much a drawing as a scale model. Both mechanisms must contain an expressive synthesis able to recognize the analyzed architecture, be it in a few lines or with minimum dimensional elements; both should become an instrument for knowledge, able to summarize the genesis drawn, unequivocally, of the essential elements; both must structure the students' research within the design process, now somebody else's, subsequently his own, graphically confirming a cognitive abstraction. Ultimately, the students must analyze the generating ideas of a particular architecture, using lines, cursorily chosen, as well as simple models created with materials chosen by them, of an appropriate scale and arranged forming a synthetic volumetric discourse. These are, therefore, small size models, made with the appropriate elements, generating a specific object, a small sculpture that helps recognize the abstract signs that shaped the analyzed architectural object.

Pedagogically, this three-dimensional abstraction of the studied architecture allows the procedure to rethink the designed object and to transfer the primary concepts to the next step of the graphical process, where intentions are studied and confirmed time after time. This teaching system provides the student, through exploration and verification, with the answer to a professional need, acquiring a systematization of work, essential in the architectural practice, as it has been made clear in the aforementioned cases of renowned professionals.

In the case of the School of Architecture of Valencia, the teaching experience carried out in the Análisis de Formas Arquitectónicas course, designed to introduce students to the set of graphical tools to develop design processes, has focused on three types of three-dimensional models and their relationship with sketching and manual drafting.

First of all, we work on the use of concept scale models to complement the sketch as a tool for formal manipulation. This dualism is especially cultivated in the cases where the complexity of the analyzed architectural model requires a combined use of both tools, in order to provide students with a clear understanding.

These are not finished scale models, detailed or complex, but simple approaches aimed to understand the formal structure of the whole, with special attention to the complex joints or connection to the site in those cases in which topography is hard to model for a first-grader. Thus, the scale model is a direct extension of the sketch, as much for its abstraction level as for the direct relationship with manual gesture. In both cases the student "manipulates" forms to understand, going from one to another continuously. And in both cases the manual dexterity is secondary (Fig. 6).

Manipulating geometry to understand the architectural form of the analyzed building proves to be a process in which we emphasize during the first semester of the school year. Geometrize information, reaching an abstraction in the floor plan, elevation and cross section drawings, leads to graphically construct a volume—the axonometric system is the method most commonly used—with the essential parts of the analyzed building. The handling of the scale model elaborates on reducing to the minimum the elements with which we generate the form, and without which we would be describing a different building.

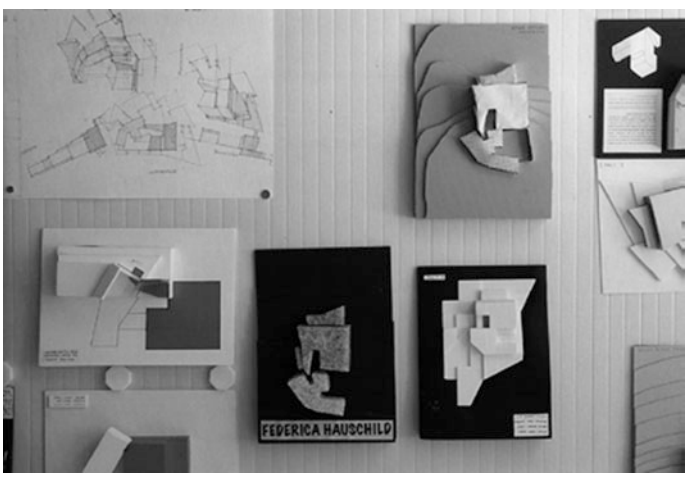

Fig. 6 Scale models as a complementary strategy to sketching in order to analyze the formal structure of the architectural object

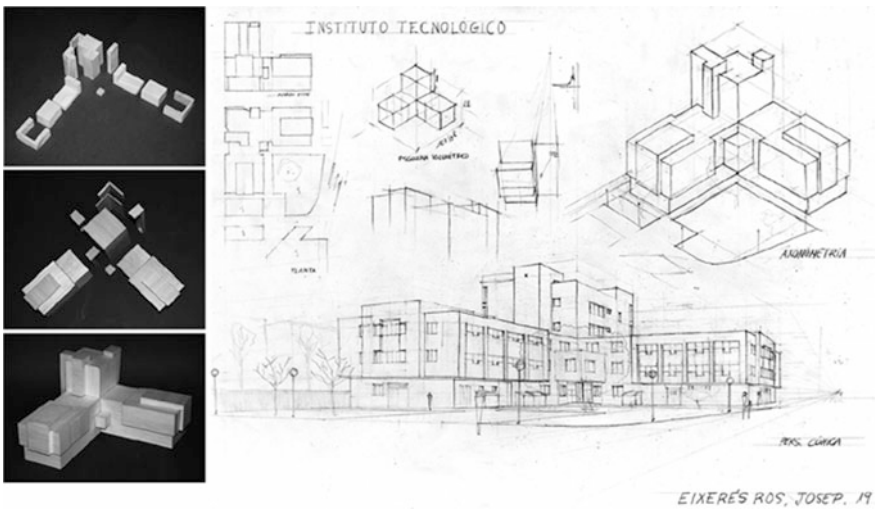

Fig. 7 Model of material research. Work of an *Análisis de Formas Arquitectónicas* student

This formal understanding ability, with the hands by drawing—two-dimensional, through the scale model—three-dimensional, enables the student to take the next step, which is none other than the fulfilment of a conical perspective, the representation of how the viewer perceives architecture. Abstraction, formal analysis through orthographic projections and the axonometric system, is reinforced by carrying the learned geometries into physical objects that are spatially combined in a scale model that allows the visual tour of the whole architecture (Fig. 7).

A second strategy developed in the course seeks to introduce the material factor in the analysis of the architectural object, transcending the mere graphical representation of textures. It is about introducing students to the constructive strategies through the experimentation in the materializing of the models. As in the previous case, the priority is not the material "mimesis" of the model but urge the student to reflect on the close relationship between the material and formal perception. The students are encouraged to experiment with different materials, rereading the original volume with other materials textures, analyzing the variations introduced by comparison with the scale models developed by other students, and all beginning with a conscious discourse of what the student intends with the changes.

It can be added a new interpretation caused by the conscious choice of the new material with which to build the scale model; by reducing the use of materials, depending on the concepts or ideas of the architectural object to relate, a material can lead to discover the footpaths as the main design idea, and the same material, used by a different student may describe the wired structure of the architectural forms embedded in the same place. Some cardboard contour lines made with metal representing the foot and car tracks, indicate a different design idea than a simple cardboard volume of the surroundings and some architectural geometries formalized in metal, discovering a bridge as design idea.

Being academic works developed on actual architectural models, analyzed with manual and graphical means, this sort of scale models represents a transition between the models of formal manipulation described above, and the design process models. They are an introduction for students to the visual characteristics of the form and the need to develop a design reflection on the constructive and material features of architecture.

The third and final type of scale model introduced in the course refers to the use of three-dimensional models as a mechanism for formal research, bringing the student closer to a conceptual use of a three-dimensional model as a trigger for the formal search that characterizes traditional sketching. These are abstract tests that combine the graphic character of sketching, with the material nature of the scale model. In these models, the formal search is entirely subjective. It does not necessarily refer to built models, as the aim is not to represent any architectural form. It is about helping the students to understand a double feature of the use of drawings and scale models. On the one hand it is intended that the student visualizes the way his sketch comes into being, interconnecting the two-dimensional image of the drawing with the resulting three-dimensional forms. Second, the students should understand the potentiality of both tools as conceptual mechanisms for formal generation, generating forms, both through drawings and scale models, in an arbitrary way, typical of the way in which some contemporary architects use both tools before introducing the computer in the process of material formalizing of the idea (Figs. 8 and 9).

Fig. 8 Model of material research. Work of an Análisis de Formas Arquitectónicas student

Fig. 9 Conceptual scale model. Work of an Análisis de Formas Arquitectónicas student

This set of teaching strategies intend to introduce students to the different objectives of the use of the scale model in contemporary architecture, understood as part of a complex design methodology, in which its relationship with manual sketching, both depending directly from hand gesture, while they come to complement the use of modern computerized tools, building a bridge between traditional graphical mechanisms and computer graphics, avoiding a rift that will preserve our inner need to use the hand to weigh and understand the world.

5 Conclusions

In the Análisis de Formas course, we consider—we might also use the verb to pull for—a teaching strategy capable of dealing with the duality between innovation and tradition; this is, maintaining learning through software and complementing it with traditional manual techniques. Both mechanisms of formal manipulation and architectural representation coexist in our classrooms covering all phases of ideation, understanding and design of the architectural form.

This integrative approach starts after acquiring a series of graphical skills, developing subsequently drawings and scale models of a built idea, recovering the conceptual circularity: analyzing the generating ideas of the selected architecture, abstracting its primeval concepts, to close the process corroborating intentions. The three-dimensional model, graphical manipulation and computer graphics complement each other and achieve, working in parallel, the learning of the formal ideation that was present in the chosen cutting edge architecture.

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