Digital practices in architecture:
Six international experiences[1]

Práticas digitais na arquitetura: Seis experiências internacionais

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ABSTRACT – The main question stated in this paper is that in architecture projects developed with digital support, the changes that occur nowadays, with this extensive range of tools and experiments are reflected not only in the representation, but also on the design and production of architecture. Nowadays we observe the novelty of the forms generated, and the re-organization of the work processes in the architecture offices. We also see how these new technologies have maintained the dialogue with the most traditional methods of design as one of their central axes. Throughout this paper, it is done an analysis of the different ways in which the utilization of these new digital technologies are intervening on the architecture of our days.

Key words: digital media, digital fabrication, contemporary architecture.

RESUMO – A questão principal apresentada neste artigo esta relacionada com projetos de arquitetura desenvolvidos com suporte digital. As mudanças que ocorrem atualmente, com a extensa gama de ferramentas e experimentos, se refletem não apenas na representação, mas também no projeto e produção de arquitetura. Observamos novidades nas formas geradas e a reorganização dos processos de trabalho nos escritórios de arquitetura e também vemos como essas novas tecnologias tem mantido o diálogo com os métodos de projeto mais tradicionais como um dos seus eixos centrais. Ao longo deste trabalho, é feita uma análise dos diferentes modos na qual a utilização destas novas tecnologias digitais estão intervindo na arquitetura dos nossos dias.

Palavras-chave: meios digitais, fabricação digital, arquitetura contemporânea

On digital in architecture

The main question stated by this paper is that in architectural projects developed with digital support, the changes that occur nowadays, with this extensive range of tools and experiments are reflected not only on the representation but also on the design and production of architecture. Nowadays, we observe the novelty of the forms generated and the re-organization of the work processes in the firms and also see how these new technologies have maintained the dialogue with the most traditional methods of design as one of their central axes. Along this paper, an analysis of the different steps in which the utilization of these new digital technologies are intervening in a significant way on the architecture of our days through a selection of architects and their projects done.

Moreover, this transformation is taking place both in the processes of design and representation and in the activity of the architect as well as the function of architecture in a world in constant change. This way, it is possible to affirm that the introduction of the digital media in architecture goes beyond a mere logical use of tools for the drawings of projects, as several authors have been arguing (Ibelings, 1998; Steele, 2001; Dollens, 2002). The different ways to relate with this new field of experimentation reflect a variety of possibilities to communicate the experience of architecture in the information age.

Firstly, one can distinguish between architectural attitudes that interpret the contributions of the digital technologies in a formal and more expressive experimentation, and those attitudes whose emphasis is put on what these media produce on the behavior and the processes of work.

As for that first group, a more instrumental position is situated: it is an investigation of forms and ways to express them. According to the cases, this type of experimentation grants special attention to the image processing, with the photomontages through rendering, to pixels applied as texture to the facades, or to the surfaces of buildings interpreted like treated skins by technology. This can be appreciated in the projects carried out by the studies of Herzog and De Meuron, Dominique Perrault, and Jean Nouvel, which have been analyzed in the first part of this article.

In these cases, the digital media is utilized from a representational approach and themes are perceived to be similar among them in relation to a new complexity of forms and spatial combinations. In the interval of this evolution, the contribution of Frank Ghery is fundamental for projected buildings erected more clearly like symbols of innovation and the experimentation with new possibilities of digital software, incorporating processes imported from other subjects such as the aeronautics industry.

Continuing this evolutionary line, another group is distinguished. It is represented by the work of FOA (Foreign Office Architects), NOX and Greg Lynn, who were concerned about the changes that new technologies might produce on the renewal of architecture by exploring new processes of design, tools, spatial concepts, and building forms and generating experimental work, many times unfinished or partial, but opening innovative possibilities for the profession.

Some of these recently developed projects are in Barcelona with the transformations of the 2004 FORUM of cultures and Sagrera Urban Renewal, which has enabled the study of work processes directly. Thus, the analysis of the architectural positions represented by the selected architects and/or teams will be to draw cartography of the different influences of the digital in architecture.

Practices and works

Herzog and De Meuron: Pixel volumes

Herzog and De Meuron's production can be called "Pixel Volumes", based on their insistence on the search for creative forms and treatment in each project. The Swiss firm maintains ties with the contemporary conceptual art movements, seeking new materials and new solutions to choose a surface texture and to seek the best technique for applying it. The making, the efficacy, and the minimalism has always been important in its creative process, as a consequence of integration between simplicity and complexity, the encounter between the artificiality of modern technology and the order perceived in the natural phenomena. The Main Building and Entrance Plaza for the Forum 2004 in Barcelona is one of the examples used to express these concepts and its representation.

The building is based on a triangle that is suspended and perforated by vertical holes that permit the circulation of air and light. Also, the representation of the longitudinal section, on which a texture is printed on the covering, and exterior and interior renderings. The blue rogues texture is observed in the photographs of the model and also in the natural size mock-up.

In the last projects, such as that of the Holy Cross Museum in Tenerife Island (Spain), they have advanced a step in their language program incorporating ornamental shapes from landscape analogies obtained by means of the digital manipulation of figurative elements. The concrete is perforated based on the computer processing of a photography showing the picture elements (pixels) and a coat of lava is proposed as a transition from a figurative landscape to an artificial one by means of a process of digital fragmentation, selection, and extrusion.

Digital manipulation, consciously done, produces a new geometric order extracted from nature. In its intense and fertile evolution and investigation in the construction of artificial landscapes by means of abstract processes, Herzog and De Meuron have moved from the ornamentation of the box incorporating messages and multimedia images to the construction of artificial landscapes by means of abstract processes, inspired in the secret geometry of nature, reinventing processes and mechanisms previously stated in its initial formation (Ibelings, 1998; Montaner, 2002; Baltzer and Forster, 2004).
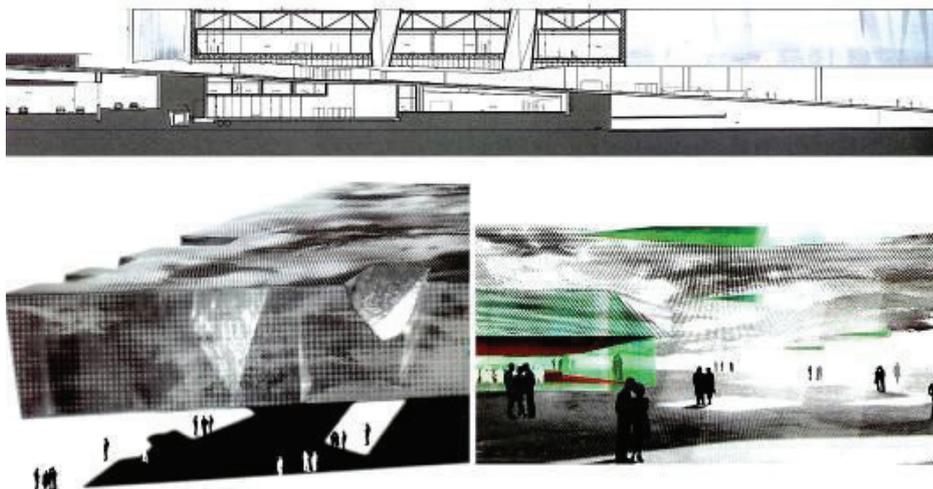

Figure 1. Design for the FORUM 2004 building and square, Barcelona (Herzog and De Meuron, 2000/2004).
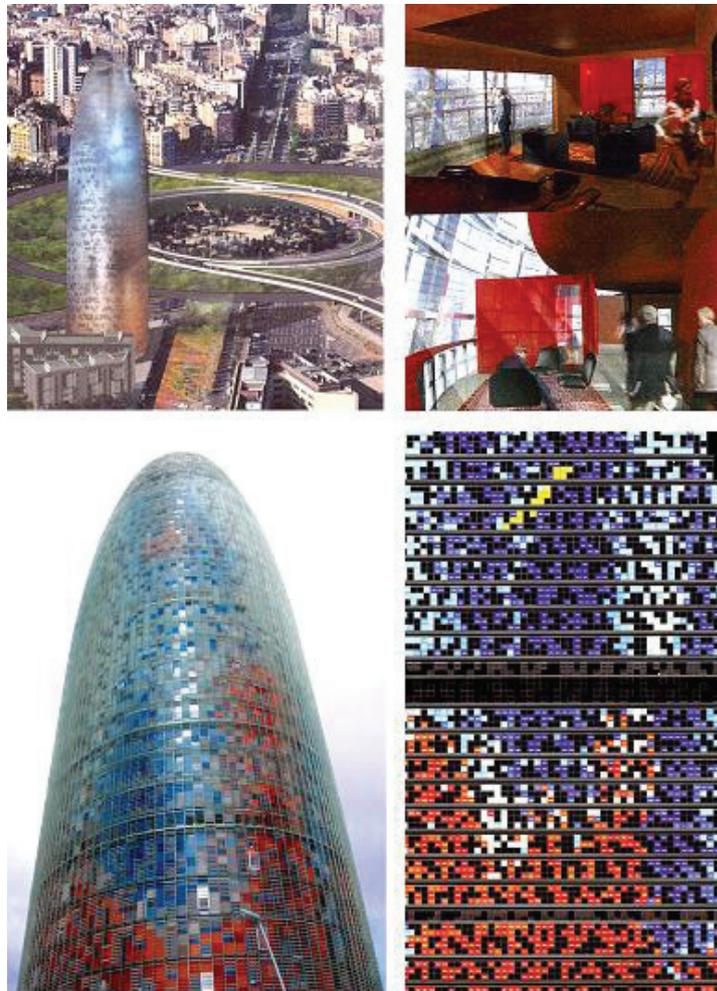
Figure 2. Design of Agbar Tower in Barcelona (Nouvel, 2003).

Jean Nouvel: Collage of new geometries

Subsequently, the French architect Jean Nouvel passes from a superficial processing, explored through mechanisms and simple volumes, to a constructive elaboration of the hangings and the forms in the urban landscape, conforming this way with the textures several types of collages that enable the opening of singular geometries (Ibelings, 1998; Montaner, 2002). That is crystallized without certainty in the design of The Agbar Tower in Barcelona, as a crucial experiment of the functional space of offices as an icon for the city, where the surface occurs in texture, color, and in a new shape in the skyline.

In the play with the real, the imaginary, and the symbolic, Nouvel utilizes these mechanisms to intensify the emotion produced by the design of the objects exposed and represents this manipulated perception of the volumes and spaces that it creates. Activated by lighting, it is a form that melts and marks the urban horizon. It shows a new language of design operations, based on the digital orchestration, as well as on cultural conceptualization and architectural innovation. Involved in the constructive execution of the building, with an unfolding of technical representations that are transformed in expressive resources, in tectonic and chromatic explorations, in creation of new surfaces and structures, there is a multitude of drawings that consolidate and scatter at the same time their architectural concepts. It is no wonder that it is accompanied by spatial renders, lighted interiors that are surrealist, which more than explaining the form of the precincts seems to try to evoke a spirit of the age.

Thus, in the design of the Copenhagen Philharmonic, the exterior skin of the box becomes a screen of image projections and planned lights. The application of these mechanisms will make the parallelepiped volume change according to the lights from night to day and it will be the expression of an intense interior life, a symbolic reflection of the autonomy of the building set against its environment and of the new will to contribute to the place where the building is located.

Dominique Perrault: Form and abstraction

On the other hand, his colleague Dominique Perrault maintains a fidelity to the combination of forceful volumes while deepening the situation of the surfaces as architectural interfaces. He explores the communication of different situations of lighting and dissolution of the form, which refer undoubtedly to conceptual art works and to a mute resistance set against the shrill culture of the media. This way, digital tools assume a more silent, but also subversive, role, with perspectives done with renders to express in a better way the effects of the light to illuminate or to reflect.

Perrault's work is characterized mainly by the use of industrial materials such as metal grids that serve as a "skin" to the building, giving a singular visual effect to the forms. It is achieved through processes that collect diverse contemporary subjects and techniques, and also by a determined architectural language oriented to the abstractions and arisen from these own processes of design.

Two ways to understand Barcelona's nature have given rise to the conception of the project of the Hotel New Diagonal. On one hand, the base of the building is inserted in the horizontal city, defined by the regularity of the Cerdá urban plan and, on the other, the body of the same one is inserted into the vertical city of the Sacred Family, and the towers of the Olympic Village. This morphology creates a play of volumes, such as a building 'bucket', a rectangular parallelepiped divided in two, lengthwise, with one of the halves displaced towards the sky. Also, in the two projects by Perrault for Tenerife, the Front of the Sea and studies for The Thalassou Hotel, a private evolution of the architectural proposals is noticed, with a notable incidence of the digital media (Baltzer and Forster, 2004).

Frank Gehry: Undulated bulks

The work of Canadian-American Frank Gehry reveals an important work of interaction with the media. In this sense it constitutes mediation between digital and analog processes, like the sketch and study models, as complementary mechanisms with an intense digital development that reaches the construction (Montaner, 2002; Ackerman, 2003; Puebla Pons, 2002).

From a technological perspective, Gehry's office integrates a mix of resources. He shows a special persistence on an intense process of physical modeling through models of various degrees of detail and application scales. In his process of design for the Guggenheim Museum in Bilbao we can observe that there are different types of sketches. There are those with simple lines and those that have striped colors, diverse and digital models, work, and representation models with support of a lot of kinds of materials to project the building. The proposal of the museum required evidently a symbolism that interacted with its program.

In the project documents, two-dimensional views appear. They are carried out with tools that are considered as "at the outset" in the dynamic and evolutionary world of the CAD. In fact, aside from the three-dimensional representations of CATIA or Rhino software, and the hardware of the office of Gehry belongs to a digital technology of standard demands.

Finally, in the concert room of the Disney Theatre designed by Gehry's office, the digitally built model is converted gradually in the organizing base for the construction of the future building, contributing the assembly of geometric data of high precision and reliability required by the work builders, combining sketches with some digital study models.

FOA: Fluid processes

In the Foreign Office of Architecture (FOA) the priority and interest of this team, whose head is Spanish Alejandro Zaera-Polo, is to explore the materials and the techniques as source of knowledge, from ways of generating ideas and effects. The generated architecture has carried an evolution of the open process to project from structures that reflect the fluency of the information in the contemporary age.

As well as the Guggenheim in Gehry, the contest for the Maritime International Terminal of Yokohama, carried out in 1994, supposed an important point of inflection in the path of FOA. The experience acquired with the project for the port of Yokohama led them towards a clarification of the graphic message from the symbolism of the great wave of the Japanese artist Hokusai, where an intelligible project is created shown through a model and by the use of photomontages, also with exterior and interior views, and by the efficacy of the plans and elevations, and especially multiple sections, which refer to the shipping construction, but also to the possibilities of digital multiplication and isometric views.

Their representation process has achieved important changes in recent years. The diagrams, as for example in the virtual house, have become another key theme of the architectural speech, after a few years of oversight. A diagrammatic model represents more than in a graphic way, the functional aspects. The intention is to associate methodological components and expressions of ideas. As they say:

> A diagram can be connected with certain action areas – for example, to determine so great or to the extension of the organizations in study – and refers to processes that occur sometimes in the real space and sometimes in other dimensions of the reality (Zaera-Polo, 2001).

In one of their last projects as for the Square of Cultures in the Barcelona Forum 2004, they use graphic resources that are more precise, but are still powerful and

new. The drawing operations based on algorithms as possibilities of design, and, by extension, of the conception of the architectural object became a reality, especially in FOA's work. The strategies that intervene in the creation of complex organizing landscapes arise from the elaboration of topography generated artificially by means of an integration controlled by rigorously shaped guidelines. The organizing prototype proposed for the park is inspired on the dunes, a frequent model in the coastal zones.

In recent years, the group has prompted their own attitude and a series of technical resources for its application. Its architectural thought and its form of representation are linked in the process of design. The result is transformed and treated so that the objectives proposed are more easily understandable. Likewise, from the layout and manual sketches that are utilized in the architecture to the diagrams, algorithms of distribution, and graphics of digital form, there are each time more alternatives in the ways of representation at the moment the architectural information is treated.

FOA Developed a series called phylogenetic tree for their projects with different formal and spatial organizations. The intention is not to repeat them or to replicate them but to identify characteristics in individual projects that can be cultivated or developed. For example, there is a will to group the categories by colors, and the icons utilized to represent graphic the categories are very present, with econometrics, individuals showing movement, etc (Steele, 2001; Baltzer and Forster, 2004).

NOX: Informational architecture

For NOX, the Dutch architectural firm headed by Lars Spuybroek, the main characteristic is the incorporation and integration of the digital tools in the design process. Moreover, the material execution of its projects permits us to verify in the physical reality the result of its experimentations. The first evidence is the project for an experimental building about fresh water built in Holland. More than adapting information technologies to architecture, NOX synthesizes them and integrates them in the daily use of its buildings.

In the H2Oexpo, the fusion of the walls, the floor, and the ceiling produces an effect of architectural body that is expanded like a wave to absorb the territory, becoming an interface from which the visitor reacts and interacts with the building, expanding and renewing what we understand as architecture built toward a multidimensional space that includes movement, sound, light, and interactivity.

The use of animations is another one of the digital resources that renew the architecture of NOX. This it is declared and is carried out in an animated sequence developed from the vortexes on the eight structural lines, for the design of the exposition wetGRID. It is also shown from a model with the groups, with clips of the model and evolutionary 3D plan, a model of work and photography of the exposition wetGRID.

The office of NOX is in the age of the information and it can be observed with the project for the Son-O-

Figure 3. Square of Cultures in the Barcelona Forum 2004 (FOA, 2003).

House where they experience in small-scale the design mechanisms that can serve to confront with larger projects. Destined to show in reality everything that can be done with the new technologies, it wants to reflect the routine movements of the inhabitants of a house and to make them evident through the changes that they cause in a determined musical sequence.

The process begins with the analysis of movements of different people inside their homes. With cameras in different locations and their connection to the computer, some sequences of movements are obtained and they are complex structures of the three elements in cooperation in the body: the extremities, the hands, and the feet. The movements are synthesized in a certain choreography that is later transferred to a model formed by bands and they are transferred to the computer. The result is a composed, three-dimensional structure of ribs and arches, where the visitor is, at the same time, interpreter and spectator.

The architecture of NOX is an inform(ation)al architecture, according to their texts (Spuybroek, 2004). In other words, it is informal and at the same time it uses information to be produced. It experiences the interaction with different materials to process forces with the transformation. That technological vanguard of experiments with materials like soap, glue, varnish, threads of wool, sand, globes, paper, etc, are related to the structure of various natural or organic phenomena, like, for example, sand, in constant transformation when the wind models the dunes in a desert or a beach; or soap bubbles, that vary its form according to the air and its own movement.

Greg Lynn: Animated form

Finally, Greg Lynn, a young American architect, utilizes the animated art and the special effects to transform forms and spaces. His morphogenetic sequences originate in the use of the software that is able to mutate the evolutionary forms as evolutively determined criteria.

In the project for contest of The International Harbor Terminal of Yokohama (won by FOA) he intends to assume a continuous movement, product of a complex exchange of visitors, inhabitants, and media of marine and urban transportation. The natural elements refer to the architecture for the body and that recalls its organic elements are the arguments that Greg Lynn employs to explain the topology of his objects. It is served of formal concepts as blobs, teeth and flowers to establish the principles of his projects (Steele, 2001; Lynn, 1999, 2002).

The surface in movement is also perceived in the proposal for the Opera of Cardiff, which is presented like an interface between the land and the water. Lynn takes advantage of this connection and carries out a new public space under which people can interact. Like its condition of limit, it seems to intend to blur its own conception, through its constant interactions with the urban and marine environment that surrounds it.

As an example of this evolution to finalize this analysis, Lynn has installed an animated approach to the architecture through his investigation work on the complex of embryological dwellings, combining architecture with industrial and product design, new attitudes and possibilities before the drawing as well as a various
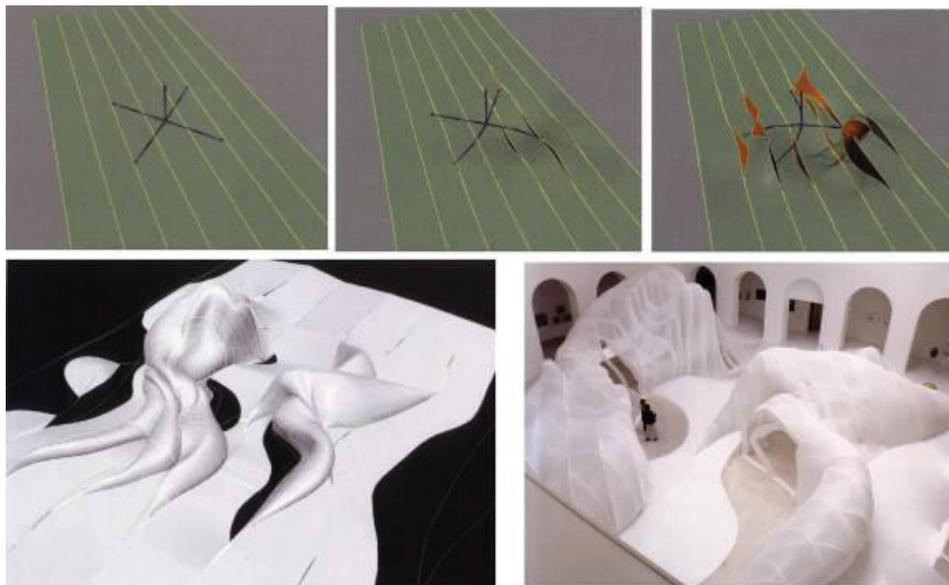

Figure 4. Exposition wetGRID (Nox, 2005).

instrumental technical one for the application in the process of architectural creation. Through a commercial milling machine installed as fundamental work team tool, in their office, they develop the potential of the stereolitography to show the digital forms in physical models. The formal solution of the project is conceived from the animation in a space-time of the forms, with surfaces generated previously.

Conclusions: Tools, practices and buildings

In the projects analyzed, it is noticeable in the first place the formal variation found among designs, like the Herzog and de Meuron, and Dominique Perrault, adhering to simple volumes, with the sinuous compositions inaugurated by Gehry and exploited by FOA, Nox and Lynn. All of them, with different bases and mechanisms, but showing an extensive geometric repertoire, which is linked with the utilization of the digital tool in the representation or in the exploration of the forms, which also has to do with the dimension of the assignments, the situation of the offices and even the generation of the architects.

The instrumental positions are also differentiated among the different studies analyzed, for example in the project of the Centre Pompidou of Metz, in which many of them participate. They cover from the processing of images, photomontages and perspectives of Herzog and De Meuron, Perrault and Nouvel, to the conceptual and formal experimentations of Nox, Lynn and FOA, revealing in general a polarity of generations and technologies, but also an integration of tradition and vanguard, which expresses the diversity of the digital media in architecture.

Dealing with projects in different countries with associated professionals from diverse locations, these firms also show the communicative interaction extended geographically and culturally. The information and communication technologies get a strong involvement in the design process.

Besides a substantial advance among the expressive aspects is noticed, even among theoreticians of the project, all the offices investigate the execution of these innovative works, presenting the production automated in Nox and Lynn, the elaboration of sophisticated facades by Nouvel and Perrault or the integration of constructive process in Gehry and FOA. The digital media, instead of being relegated to an operating role of the design formulation, act as the motivation for exploration in all the sequence of architectural concreteness.

Therefore, in conclusion, it can be verified a significant point in common for the majority of the architects mentioned. The incorporation of digital tools in their firms, instead of favoring a tendency toward buildings with cold or mechanical forms, has given rise to projects with a greater approach to natural forms, to crystalline structures with biomorphic variations, to a greater interest by the relations of the buildings with the human body and their behaviors.

Also, as for the work processes in the firms, instead of spreading towards more distant and impersonal relations, what has been generated is an increment in the communication among their members as well as between the study and its outside: the client, the developers, the technicians, etc. It has permitted that the ideas that had historically remained in the mind of the architect during the process of development of the project could be approached more to the eyes and the hands of each of the participants that intervene in it.

It is noticeable that in the different ways to interpret what the digital technologies can contribute to architecture there is a certain generational factor. The architects formed according to analog and traditional media have been able to see that the rise of the digital is an important tool to carry out in a precise and faster way their projects, which a greater capacity permitted them to generate complex forms and express their ideas graphically. This is a look emphasizing the tools, whereas a generation of younger architects tried to show that the main by-product transformation of the incorporation of the digital media is conceptual. For these, technology is not only a tool but something that permits to experience ways of life, and consistently they have seen the need, in many cases, to combine their work as architects with theoretical reflections that analyze these aspects.

Also, the horizontal extension of the digital media should be recognized. That consists of advancing from the very initial phases of the project towards the execution of the work, by incorporating formal resources of graphic creation on one hand, and automated production on the other. Moreover, the integration of the process and the communication of the actors of the project establishes a continuity from the assignment to the physical reality of the work.

To conclude, another important aspect that this analysis tries to suggest is that the contribution of the transformations that the digital tools are giving to the schools of architecture are not merely instrumental ones. For many architects, the graphic representation of a project is not only a previewing of the building by sophisticated renders. It is also a way to express a work process, to intervene in ways of life that have been affected by a culture dominated by technology, and to communicate a creative experience that puts in new play challenges that affect them as architects but, also, as people that live and experience with speed of the changes of our age: the age of the digital.

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