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**The Teaching of Constructions:
Virtual or Material**

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Learning by doing?

In teaching construction there is frequent opposition between the procedures of "learning by doing" and "theoretical" learning. Generally speaking the first procedure seems to be supported by a somewhat archaic view of "doing" architecture (including its process of feasibility), which is limited, owing to practical needs, to simple structures produced by simple technology.

This kind of teaching method enables the students' involvement, who are willing to passionately participate whenever they clearly see the object growing through their manual work and it is rewarding for their teachers too. Yet the risk of giving a slightly distorted view of the real professional procedures does exist because out of necessity, most of the problems related to the building process and its responsibilities are omitted and, however, the complexity of the real operative context is mitigated: through experience students get some familiarity with the problems related to the *subject* (at least one subject) constituting architecture and its tendency to get under way (junctions, measurements, behaviour under stress, finishings, surface treatment, workability, production limits, etc.).

In my opinion this is the most important aspect: however partial, experience produces a mental attitude capable of creating the coming up project and makes us aware of what is happening in the passage from an abstract and conventional representation to its reification (*embodiment*), thus using all necessary corrective feedback coming out during the building process. The acquisition of such awareness and sensitivity is even more precious, because the tendency to replace any direct experience by sheer virtuality is bothering (without they can realize it) new generations since children's games, which are more and more neglecting any form of manual skill (who can still build a bow or a sling?) and any chance of using space tangibly.

However simplified it might be, experience is not replaceable and at the planning stage, that is in thought before action, it involves also the need of foreseeing and rationally solving the sequence of the activities which are to be organised in a building yard.

Moreover, the prevailing employment of computerized representation systems tends to deceptively replace the three dimensional control of filled and empty spaces in the architectural work, by favouring the object representation (its image) rather than the object itself. Illusoriness is due, among other things, to scale reduction (the object is perceived "from outside") which cannot replace the perception of real space (without turning to highly adulterating means) and of sensory stimulation (except visual stimulation, partially), only given through the experimentation of the real object.

Virtual representation enables and favours the creation of forms which are totally independent from their real possibility of achievement and this, mostly at a learning stage might be very dangerous.

In other words, the nature and inner essence of the planning stage themselves can be distorted and adulterated

On the basis of that, I think that the learning by doing method might (or even must) become an important formative stage as long as it is not regarded as the only achievement of the present architects' building culture. Yet, there is a serious obstacle to

this approach: the number of potential students for arranging direct experiences is necessarily limited, and experimentation costs quite high (material supply and direction of operations).

Anyway we need to deal with everything which is left apart from the learning by doing; the knowledge of the whole building process and the variable dynamics arising among its actors: purchasers, industrial production, regulations, available resources, operative methods of complex bodies, relations with building contractors, relations between building contractors and producers, awareness of environmental impact of design choices, etc.

This short preamble helps present some remarks about the changes and problems that, without the learning by doing method, come out with the exponential growth of computer instruments. The irruption of computer science in our culture undeniably plays a major and irreversible part even in the changes in construction theory teaching and teachers, who should cope with them, but are often totally unprepared (this lack of preparation is also evident among architects by profession).

Computer and design/construction

In theory, one of the major advantages brought about by computers in architecture's operative process is, among others, the continuity between the idea and the achievement: the transmission of numerical data from the planning idea to the means of fabrication, that can be travelled over within design, is in fact interrupted by the interposition of building contractors and by ever changing necessities of the building yard. However this potentiality is more and more present and implicit in the world of architecture too.

In one of his writings M.C. Lorier (an interesting issue appeared in "Techniques e Architecture", September 2005) reports the description of the main stages in recent history about the role played by computer in structural engineering made by engineer Jean-Marc Weil. In the early 20s an engineer who wanted to display a building behaviour had only statics' equations at his disposal; calculus was based on finite elements, starting from the data of materials' strength from a mathematical point of view. What happened in nodes and articulations was at the core of the analysis: basically, the object was to be comprehended before being calculated.

Towards the mid-50s the rise of computer science in building engineering enables to start working by displaying the object and its behaviour. But since the early 80s three dimensional modelling gradually develops and computer is working "without us", on the basis of our hypotheses and insights, but making calculations itself, and only by ethical choice does the engineer keep the computer's mathematical reasoning under control.

Significant engineer Weil says: "on the screen the structure looks like a field of constraints, with colours, shapes, movements, 3d images, here loses its shape, there it moves. It's so beautiful that we often forget we aim to build an object". And also "you can create a complex shape, look at what the computer says, and then "carve" the model.

This means that the objects we create are not the same we would have conceived

without computer, neither structurally nor morphologically. It does not matter if the creator himself does not check scientifically the use of these tools. Just think that neither Eisenman nor Gehry are able to use them directly: the computer's potentialities are now part of their mental form and the identification of the possible solutions.

Ms Lorier rightly notices that all this needs a redefinition of relations between engineers and architects, who can rely on a much more fluent system of communication, allowing them to communicate on new principles of shared and enriching freedom.

It obviously exists the other side of the medal: if you completely separate the creation of forms from their constructive development, that is if the architect supplies the engineer with complex forms, totally free, as if it was like "a statuesque attitude" following a software or a formula, so that the engineer should make it constructable and feasible, your procedure would be intellectually doubtful, even though not impossible. At least economically speaking. And this is happening more and more in the world of well-known professionals (who are given much more freedom than it is granted to unknown designers), and obviously, in the academic world, where there is no real threat of feasibility assessment, but where the threat of an incorrect approach, which is very difficult to be treated from, does exist.

It is crystal clear that digital technology can presently offer an unprecedented formal freedom, freeing architectonic forms from orthogonality. The past gives us examples of architects who have avoided simple geometry even if they committed themselves completely: just think of Gaudí's architecture, who, however was said to maintain with iron hand the constructive sense of forms he was about to plan. In his speech for his admission to San Fernando Royal Academy of Fine Arts (Madrid, January 16th 2005) Rafael Moneo says that "...we must outline that Gaudí is an architect who did not care for arbitrariness... he endeavoured to show his architecture was not arbitrary and each form is the careful result of construction... Form is born from construction procedures which use geometry as their support, and by following them, it looks like something unexpected and innovative". And more "...the invention of form coincides with the invention of the construction process".

In the past the evolution of forms took mostly place under the pressure of the new materials evolution and the new knowledge of structural behaviour. Just think of Frei Otto's tensile structures and his innovative insight, completely devoid of digital calculation; he schematized deformation and movement of tightened membranes by carrying out study models: a paradigmatical example of inseparable link between form and matrix, so to speak (through an unpopular and ambiguous word nowadays), functional.

In his speech Rafael Moneo asserts the sovereignty of arbitrariness in architecture, by arguing his case with ancient times works (the genesis of the Corinthian capital told by Vitruvius) and by quoting Claude Perrault (one of the founders of the Academy of Science in Paris, 1666), he says that architectonic elements are the result of a transformation from arbitrariness to familiarity: routine leads us to regard what in the past was arbitrary as a natural thing. Paradoxically, in our times, the logical consequence of this assertion might lead us to say that nothing can appear arbitrary to us in architecture, since we have got used to not finding nothing extraordinary

and astonishing in the most bizarre and useless forms (however pricey they might be).

But with time passing great changes have affected architecture and construction. If it goes without saying that the equation form=function belongs to a deterministic and absolutely undemonstrable view, as there is an infinite range of possible forms in the same program (use) - but the program itself may have many aspects - and owing to constructibility needs, I think it is exaggerated asserting the total indifference of one towards the other, or even the possibility that form might, consciously or not, make use and constructibility too difficult.

Computer and innovation in teaching: a future in research

Let's get back to the first remarks about the connection between computer science/planning and computer science/construction, so to what this connection involves in the teaching process: in the end, this thesis tends to outline what is already clear, even though not completely systematized, or not so settled as to turn into teaching subject: it goes without saying that the coming of the digital age and the heritage accumulated, even distressing in its progression, has also revolutionary effects on architecture and construction for those who deliberately or for age limits keep away from the secrets of computing. But in this area, applications and tools have been developing accidentally, in accordance with the type and importance of several needs: so they range from the systems generating complex forms to systems simulating visual perception, from calculation programs of any kind, to various databases, and so on.

These resources differ for the function and importance they may have in planning, but should find their own collocation, as if we were to deal with many kinds of consultancy.

On the other hand, bear in mind there is another great demand of innovative approach: side by side with the development of computer science a sense of diffuse awareness of environmental dangers for the territory has been growing, regarding them as a problem strictly connected to the settlement process, and which cannot be neglected by those who, broadly speaking, deal with architecture (...).

This makes diagnosis, analysis, forecast and control more complex at the stage of planning choices first, and then in the whole lifecycle of the building, including environmental costs of direction and maintenance, as far as casting off costs and methods. Moreover, as everybody knows, costs and environmental impact must be studied as regards pollution and electrical input of materials and products used.

This means drawing one's attention to a longlasting and complex process to be controlled on the whole. As a consequence of that computer science can offer precious aid.

It is clear that the whole system of resources of computer must be systematised with a view to what it can supply throughout the course of the process of intervention, use and maintenance of what one designs and carries out.

At the moment computer is used little and badly in schools of architecture, resorting to it as a form generator (object representation), and at most, having recourse

to any kind of calculation programs, applied like dots. On the contrary everything regarding information acquisition and management is much neglected, even though it is currently a very interesting aspect, since handbooks are virtually unserviceable and sources of information from production are too filled with advertising to be reliable and taken as they are. On the other hand, sector databases are more often than not produced for different purposes and with very few references to practical use for those who deal with building planning and environment.

Of course we cannot study this subject in detail here. I just want to outline that for people who are involved in construction teaching, computer science instruments in their multiform manifestations are one of the most innovating areas whose importance has not been fully evaluated so far.

This is a line of research we should devote our time to and care in future, not so much by getting specific skills in the subject (personally I would be terrified), but nor leaving it alone to those who have a mathematical kind of computer skills or in a particular area (structural calculation, physico-technical calculation, environmental assessment programs, and so on). This would emphasise the gulf, currently remarkable, between overall objectives at the base of planning and a harmonious targeting of the instruments which are about to form. In other words, we ourselves must get and let students get, the attitude and the language suitable to interact with the new extra-expert, in the same way as it has been necessary to interact with various consultants and professionals who contribute to the right conception and feasibility of what is planned. I feel we are late anyway.