Design and Construction Mediated by Software: Criticism and Opportunities

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Abstract—**The paper presents the results of a statistic evaluation of the effects about the relationship between what students do in software and how they understand the correspondent construction ("digital look" detached from the correctness of its technical solutions) and the relationship between the software-type used (mechanisms of knowledge) and building-type designed.**

Keywords—**design; construction, didactic methodology, students generation, creativity.**

I. INTRODUCTION

The research program presented was developed, during three years, in some Courses of Engineering about the design and constructions. The goal of the program was to investigate some possible digital automatism, inside the normal way of thinking design and construction by the students.

In the approach to the current field of constructions, ever more people (not just students) look like, definitely, "software filter mediated". May be there are, unconsciously, digital automatism inside the human cognition and we are obtaining construction that are already (in part) digital, made by students become digital, due to the continuous use of digital resources. Case studies: some test-experiences, made during the years, with about 260 students attending my Course "Building Design".

II. FIRST EXPERIMENTATION

Students must design free hand a facade of a building. In the two precedent years, they have used only digital resources, and now, students look like can not more be able to drawing avoid important errors.

Can be strange but most of the drawn lines are crooked and some proportions were completely wrong.

If the results come from the absence of hand drawing during the past, any way emerges also another very more important point, from the cognitive point of view.

The design gave back "a crushed" building, from the perspective point of view. For about the 75% of the students, the pressure of the hand was the same one in the different parts of the drawings. We know that it is an error at least from two points of view:

- the absence of diversity of signs, does not only mean that the parts of the design are indistinct, but, that the parts of the construction are indistinct, also. The fact that there are no obvious hierarchies between the signs, means that, for these students, there are no constructive hierarchies. The representation of a "detail" cant have the same sign of a block hierarchy from the constructive point of view.

- However, the different intensity of the graphical signs must represent, the various plans of distance from the observer and, therefore, of light exposure, of depth viewing. The students already in the previous courses have realized volumes in perspective, spaces and shapes on different plans, etc. Therefore, why these results in the hand drawing test?

According to the students' answers, the point is that they were not accustomed to thinking about the different grounds of representation, because, normally, in the past, they were accustomed to use a software that directly did it, using, for example, shadow effects, when they are modeling 3D architectures.

They were accustomed to seeing the models thus, but they were not minimally worried about producing the same effects.

The conclusion is not only that they saw the effects but they did not know the causes (for example, the theory of the shadows), but that they did it, without understanding: they saw without looking. Shortly, they have unconsciously linked the shadowing to the software and no to the building, no to the built architecture, as if the constructed architecture did not have a fundamental requirement as the game of the light in the space.

The automatic procedure of the software, had accustomed students to a sort of special effect. The shadowing data always present in front of them (into the monitor) did not move according their knowledge of the real attribute of the constructed architecture. An automatic procedure that had accustomed students introducing a sort of special effect.

The shadowing data, always present in front of them (into the monitor) did not exist, according their knowledge, as real attribute of the constructed architecture. From a specific software we obtain, automatically, a specific attribute of what? Of the representation of that building in the software, or of the real constructive components of the real building?

III. SECOND EXPERIMENTATION

The topic of the second experimentation, is a design work: the same architectural typology, but developed by the students, using one of some software resources that are very different: they can use a generic software (Computer Aided Design or Generative Components) or a specific software like Building Information Modeling. Please note that the work | was made

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Building Information Modeling. Please note that the work was made using the software continuously and only sometime the work was printed on a paper. At the end of the work the whole project (plants, elevations, sections, details, rendering,...) were printed. For the usual appraisals, the students of the first group, were asked to answer, thinking not only in order to explain the idea of design, but in order to clarify, also, how the construction could be really made.

To the questions about the reasons of the plan, the style, the shape compositions, the choose of materials, the students answered immediately, thinking more in theoretical way then in terms of the real construction. But when asked constructive and executive questions, the students showered an obvious embarrassment.

Thinking about the real construction hindered the answers or, better still, made them understand that, in many situations, they had not thought about the building from a constructive point of view (fro example, the facade of cotto without posing the problem about how the cotto components can be fixed, or a wide cantilever terrace, without to understanding the most appropiate structural system in order to support it.

Shortly, they had not thought constructively, but the rendering of the building were ... beautiful!

The second group of students, that used Building Information Modeling software, has obtained results that we can consider really different, with respect to the other one group.

From the constructive point of view, the technical solutions were really more correct. In addition they have understood much better a lot of aspects related to the possible future construction of the design. Often the choices were founded on a real vision of the construction problems; and that kind of vision has affected really the final solutions chosen by the students.

These design were really "buildable". On the contrary, the same design solutions were less evolved from a shape point of view, because designing "no standard" solutions was very difficult: in fact, the student could only use a limited choose of constructive parametric components, respect to the approach that is possible using generative components software.

Is there a relationship between the software they have used it, and the meaning of what they have learned [1]? Is it possible to assert that the design was just a activity of "representation of objects" for the first group of students more than the second one? Is it possible to assert that the design was a activity really predictive for construction for the second group of students much more than the first one?

All the students concluded that the type of the software they have used, has caused a strong influence on themselves. On the contrary, just few students, said that they were supposed to have known how to go about it, in order to design the building,

regardless of the software resources.

IV. RESULTS

From several years our tests with students, about the possible changes in digital design, offer contrasting results, even if always really significant. Our tests offer totally different results if students using generic digital resources (i.e. C.A.D.), and if they begin to use them at the first stage of design. In this case we observe bad effects, always the same.

First: students forgot (fast) to draw by the hand (they explain concept design in adult manner but draw it in "childish style").

Second: students work and work using screen as only interface (without printing any papers during the design process).... but the resulting vision of design does not become complete, does not become a "unicum".

The use of the digital environment, produces, a sort of "disorientation" with some recurring effects:
- an illogical "fragmentation" of the design idea during its develop;
- a loss of the hierarchy between the parts of the future construction;
- a difficult to understand a synthetic balanced vision of the design (particular aspects become the totality).

Digital can help shape surfaces that flow so well they fly away…they impress, they attract at first, but they leave no marks, they don't turn into experience, reflection, critical awareness. In several students designs, the building shape stands out, from the other design aspects, and prevails over its self function, on the consistency of the constructive decisions. A fashion leaning towards aestheticism: the power of digital representation prevail for the students over "the fact" it refers to (the correctness and operation of the architectural design).

The cases of study presented prove that something strange is going on in the relationship between resources we use for working and the results of our works themselves.

Is the digital opportunity a sort of new way to think the human activities and their footprint on the constructed environment?

May be is to much difficult try to give a direct answers: it is necessary to attend more time, or try to change the perspective of the questions.

V. CHANGE PERSPECTIVE

The Architecture should be originated from people's needs to improve the quality of life of them: in the current times of crisis, to obtaining this goal, can we still work in the "traditional" way or should we change our perspectives?

The answers to these questions are part of the current debate about the meanings of designing itself, and the level of technology that should become part of our cultural landscape.

Since Centuries, new technologies are constantly raising many challenges for the theory and practice of design and constructions and also in the theory of Architecture itself. Across the various Ages of the history, re-thinking the

technique (and the culture) of design and construction has offered new ways to answer the needs of people. Therefore, a correct question looks like be: "How, today, can we develop our traditional approach to the process-product to take advantages from the new technology resources?"

We know that majority of mistakes in the phase of construction comes from the design phase and this trend looks often like coming from a base concept aimed to separate the design activity from the construction activity.

In the past, in the European tradition, the phase of design and the phase of construction were strongly connected: thinking in terms of design meant thinking also in terms of construction.

Never the less, in the last decades, due to the qualifications of the competences and the increase of the number of the actors along the process-product, we have instead witnessed a progressive disarticulation of the design and construction process into individual steps, that result often, completely independent.

Especially in the field of public works, the results of a process-product divided into adiabatic phases lead to an increase of costs and a lowering of the quality of buildings.

The most negative effects were detected in terms of increasing costs and decreasing quality of buildings: this makes no sense. New methods, become possible, thanks to the development of the computational resources could enable us to obtain significant benefits in order to reach what we can not have using more traditional approaches. It is very interesting the case of the Information Modeling approach to the building: it is really possible to reduce times and costs because this method allows to reduce the gap between design, construction and management using process-product based on 3D object oriented models.

This method is so efficient for the field of construction, that a recent European Directive (2014) request to the Countries to use BIM [2] for the public works, even if that situation is completely new for majority of the people.

As we know, the culture and the technical approach to a totally new process-product, need to be assimilated, gradually, from the bottom. That means, evidently, a gap between the technical vision by the politicians of the European Union and its real possibility to be immediately applied, with respect to the current situation. In fact, as our experimentation have proved, we observe that for most people, BIM means something that imply changing mentality: a work is necessary to obtain this goal.

For example, in order to describe what's happening in Italy about BIM, we can use (and transform) a famous Italian historical sentence: BIM is made, now is necessary to make the "BIM people". Digital innovation can offer more then a method, a methodology, a model, a process: it can offer new dimensions to our work if we understand that some cognitive and attitudinal pre - conditions are necessary.

Work together using a effective collaborative dimension in the information modeling, means that people accept to think themselves like a one system and no like a confederation of singles: before a way to work together this condition represents a way to be together; to use BIM it is necessary to

be BIM. With the precedent premises becomes more easy to understand why the core of this method push to a holistic approach in order to solve the problems and to obtain the results.

But, we know how for everyone it is not so easy to think (therefore to design) in terms of unity, even if thinking about ourselves, we feel that is need of unity, because we are often fragmented in too many pieces.

VI. A DIDACTIC CHALLENGE

The research of the unity is one of the most important needs of the human been. The history of philosophy, wherever and always, is the documentation of the human researches to satisfy this need; to satisfy our whole human and not only some aspects of it.

Into a unitary vision, a real technical innovation can modify our vision and our interaction with the reality on the right way.

From this point of view, in the didactic field, looks like emerge a challenge: educate to the building fact, means to educate to an approach that must be "unicum". Therefore, it isn't any contrast between the traditional method and the digital method: in fact, a real innovation cannot exist without real tradition and "viceversa".

Thanks an osmosis process, using BIM, we are brought to think the reality in this holistic manner (and to think ourselves like a part of this reality). Pedagogical, cognitive and social aspects become immediately important, and we understand, especially, how they are not so took for granted for the majority of us. "Build as one" because is the way to understand how is important "be as one".

According the didactic dimension, to learn and to teach, means an exchange of experiences and not just a passage of knowledge. The new "digital generation" of students needs, dramatically, to learn a critical approach about the relationship between digital resources and design tradition.

For the students, it is necessary to have a continuing education about the digital resources for design, because these evolve continuously, also, like the Algorithmic Architecture [3]. Our tests about information modelling method in design, offers always a very good feedback from students: they affirm to understand better the design practice using these digital resources rather than using a traditional approach.

We would emphasize that students are really helped to thinking of the design as a "unicum", where all the aspects are linked in a combined manner.

In front of to the continuous develop of the new technologies, a important challenge looks like to educate the students to use the innovation to recover a deep meaning of design, as an expression of a single and simultaneous concept that imply structure, shape, materials, costs, times, maintenance, energy and so on.

In our didactic experience to obtain these results it is necessary to have a specific and rigorous scheduling during the phases of design.

1. students must drawing sketches in 2D and 3D of their ideas;

2. the sketches become technical drawings only with measures and dimensions in appropriate scale;

3. only after made these steps students can begin to use a digital information modelling resource.

This is a crucial step for students: they must to convert their drawings, thinking of an object oriented constructive components, according to the future logic of construction; what they think should be not only a geometrical model of the future building but a logical-functional model of it.

Through this mode to use digital, they change their mode to concept the "sense" of design and really improve their skills.

VII. CONCLUSION

To answer the question: "Why should design be (or not) digital"?, in our didactic and research experience, we starting from a considering: what should Architectural design be? Or, in other words,: could Digital help design and construction to be what it should be? The digital factor, generally speaking, is no more considered a revolution in the architecture design field: digital is definitely part of design thinking [4].

Any way, nowadays, it is not yet so easy to identify the value of digital, in our culture and practice of design [5]. Often some of the current theoretical discourses in Architecture seem to avoid the digital dimension). Please note, that on the contrary, the digital factor has a big influence on the design atmosphere of the students, even if they understand, often, this influence as a new aesthetic look, a new fashion not connected to the practice of the construction itself.

For the future, one of the main problem about the digital resources in Design and Constructions, will be an educational problem: how should digital be taught? For digital education, we think that it isn't fundamental to use digital or not, but, especially, how to use it, without forgot that design should be one-to-one with the construction. In the cases of study presented, about parametric design and information modeling are a research horizon, that demonstrate how it is possible to develop the new technology according to the most urgent needs of our contemporary society.

These resources allow to identify the Design of the Construction and the Construction of the Design and offer, continuously, challenges and arguments for didactic, research and practice, proving a positive interdisciplinary outcome.

The digital dimension affects the way designers works through the generation of new mode to perceiving conceiving and imagining the world of architecture and construction [6].

From a theoretical point of view, the digital didactic for architectural design evolves between two opposite risks: on the one hand, the digital as an obstacle to reality: the power of modeling as resource of the evaluation, could suffocate the concept of design itself, preventing the creativity.

On the other hand, the risk of the digital resources could be their use only for a fashion reasons, in order to give impact into the constructed environment and on the people [7]. We should work in order to remember that new digital resources can offer more then obtain just a new strange shapes of the buildings. The digital dimension can generates new cognitive spaces or new cognitive limits for the designer and "in" the designer and for the designing concept: it isn't reasonable to fear this dynamics [8].

The digital dimension turns a new "environment" where it is born and grows a new concept of an unusual form of interaction between the designers (subject) and the design (object). For researchers involved to transfer digital contents, becomes more and more important a didactic responsibility: students often still endure the digital, but they don't metabolize it. It is ever necessary to give to students critical criteria to understand and to sift, deeply, the "new".

The commitment is to give a contribute to explain the advantages of the digital in the world of design, also, in order to prevent its didactic and professional risks as realizations in the AEC field (Engineering Architecture Construction) that can be made only by a process more and more software mediated.

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