NEW TECHNOLOGIES IN THE STUDY OF ARCHITECTURE: LEARNING BY MAKING VIRTUAL MODELS AND DIGITAL FABRICATION

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Abstract

New technologies are expanding and collaborating with quality and reliability in the process of academic education. The ease to obtain the results of the projects by using graphics from Build Information Modeling’s (BIM) software platform (for example, Revit/ArchCAD) and generative modeling software (such as Rhinoceros / Grasshopper), have shown positive changes in student's project activities of the course of architecture and urbanism at Mackenzie Presbiterian University.

A positive aspect of the course, beyond the simulation at the virtual environment, is offering the tangibility of the virtual models with rapid prototyping. The research aims to report the importance of experimentation in the learning process through new technologies. The experiment consists on researching hollow elements used in brazilian architectural walls, just as the existent "cobogós" (hollow elements) in the projects of the architect Oswaldo Bratke (1907-1997), identifying it's historical and cultural process. By means of the 2D and 3D graphics software, students will analyze the existing geometry on components and propose new models of "cobogós", thus understanding the structure of the models surveyed. Finally, the new "cobogós" will be prototyped by 3D printers and laser cutters. As a reflective learning process for the students, there shall be held a comparative analysis using parameters and criteria of the results obtained through digital modeling and manufacturing of new "cobogós" built by laser cutter and 3D printer.

Keywords: architecture teaching, digital manufacturing, parametric modeling.

1 INTRODUCTION

Before the ornamentation of the Arab culture components initially created by artisans through intertwined wooden laths created without no nails to fixate them, besides the control of lighting and ventilation, the muxarabis main function was to preserve the women's intimacy, restricting the masculine glances, pointing to a strong cultural evidence.

Cobogós are walls with hollow elements and they offer several options for lightning and ventilation control, standing out for its geometrical diversity and efficiency when it comes to modularity. The name comes from the initials of the surnames of three engineers: (co) Amadeu Oliveira Coimbra, (bo) Ernest August Boeckmann and (gó) Antônio de Góis. In the beginning of the XX century, they were working in Recife, northeast Brazil, where the climate variation (tropical, semi-arid and equatorial humidity) demands the necessity of a thermal control in the constructions. The first models were executed by mooring the bricks in a way that generated spaces, producing uniform openings.

Figure 1. Detail wall cobogó (SESC Pompéia, 1986, Lina Bo Bardi, Brazil)
It is possible to identify in the Brazilian modern architecture the authorship by the hollow elements. For instance, the architect paulista (from São Paulo city) Oswaldo Bratke (1907-1997), in which the hollow elements in his projects became his personal work brand. As an example, the Vila Serra do Navio (1956) and also Renata Sampaio Ferreira Building (1956).

![Figure 2. Details hollow elements (a) Vila Serra do Navio, (b) Renata Sampaio Ferreira](image)

Two projects in the international architecture that comprise the same theme and that are examples of the technological appropriation are described in the Institute of the Arab World (1987) in Paris, projected by the architect Jean Nouvel. The geometrical composition of the translucent south front was composed by two (2) components with different dimensions. The geometrically square modules have similar articulations of the diaphragms openings of the analogical cameras, which are controlled by photosensitive sensors. Thus, the results are internal environments with filtered light, similar to the present muxarabis in the Islamic culture.

In the sustainable city of Masdar, in Dubai, where the work begun to be done in 2006, the architect Norman Foster participated in the construction of the complex. In the laboratories and residential accommodations of the Institute of Masdar, it is possible to identify a variety of social spaces and meeting points with areas destined to community, mainly academic. At the apartments, the windows of the residential buildings are overlaid by a contemporary reinterpretation of the muxarabis through perforated prefabricated components in concrete in the color terracotta, in which the panels are positioned at the balconies, collaborating with people’s privacy and lighting control.

![Figure 3. Details hollow elements, (a) Institute of the Arab World, 1987, Jean Nouvel, France, (b) Institute of Masdar, 2006, Norman Foster, Dubai](image)
In the pedagogy of architecture teaching, a big approximation of the disciplines of project, graphic computation and digital manufacture became necessary. The digital tools are no longer taught as a specific topic isolated from each other and many disciplines of the course, beginning to have a decisive role in the process of thinking about the project, where the physical spaces destined to this teaching are transforming quickly, and now the project atelier shares its physical space with laser cutters, 3D printers and CNC.

The pupil begins his experiments with help of the physical model, which thus allows him to understand systematically the geometry in development. This investigation is straightly harnessed to the sketches that register in the physical support several stages that set his solutions out.

The digital model produced in a computational program acts like an extension of our cognitive capacities, which its interactivity is fundamental to spread out our reasoning capacities during the project process. Through the means of the use of graphic tools, it is possible to create architectural elements that could be intricate or even impracticable by the traditional ways, that is, for the production of physical models and through digital manufacture.

It is pupil's responsibility to make the decision and identify the limits of the available ways for the development of his activities. This diversity of the physical and digital ways as resources in the production of project and the whole graphic representation in the architecture course transformed and it continues to influence pupils' behavior in the current days. The factors of time, multitask, mobility and media are consequences of the current technology, which is present in the whole society.

Figure 4. Experimentation digital manufacture, (a) cutting laser, (b) printer 3D

2 METHODOLOGY

Besides the use of models of systems and graphic programs for the development of collaborative projects, another technological resource that is becoming more accessible and necessary in the process of management of projects: the new technologies and digital manufacture. The experiment carried out by the author allowed to identify hybrid processes as for the means of manufacture.

The preparation process of a quick prototype (PR) begins with the creation of a three-dimensional geometrical model developed in programs CAD and BIM. Subsequently this archive is converted in a triangular meshes in generally called archives "stl" (stereolithograph) for production of the component ones in printer 3D and archives "dxf" (Drawing Exchange Format) in order to produce the component using the cutting laser. It is through the archive "stl" that a specific program manages the piece's impression.

He analyses the characteristics of the archive checking the possible mistakes of triangulation, resulting in a status that shows time of impression and volume of used material. The impression begins with the program manager sending to the prototype machine is information about the "stl" archive, layer by layer. The components obtained through the laser machine were made by extraction of lines, which are sequentially used for cut and carving.

The result of the archive comes from the sequence of commands flatten (to convert component from 3D to 2D), finishing it with the command overkill (to remove superimposed lines).
In the presented experiment was used Cliver 3D Printer and Glorystar Cutting Laser. The components used for the production were chosen under the criteria of time production of the structural and its complementary. As an example, it was previously simulated the impression of an activity in analysis (3D paving stones). The time predicted was approximately 5 hours. In order to optimize the impression from the structural component, it was decided to confection it in a cutting laser, which estimated the cutting time in approximately 2 minutes.

The experimentation comes from the contextualization of the existent modeling of the emptied elements in Oswaldo Bratke's projects, Building Renata Sampaio Ferreira (1956) and Town Saws of the Ship (1956), modelled in computer, in which the geometrical analysis is fundamental with the view to understanding the process of modeling and digital manufacture, encouraging the pupil to develop new geometrical variations of the hollow elements.

The understanding of the geometrical composition, the modularity and the present thought about how to build were the structuring directives of the activity.

3 RESULTS

The experiment was carried out by two methods of quick prototyping:
A. production of the components with cutting laser:

- the specific model in 3D was extracted from the component one projected in the Revit. Whereas the cutting laser does not understand objects in 3 dimensions, so Autocad flatten commands (it transforms 3D in 2D) comes in order to make it possible and overkill (it puts superimposed lines out), enabling to paginate the component ones projected by the pupils;
- the applications program that controls cutting laser understands archives in the format dxf (drawing exchange format) and unity of measure in millimeters;
- the components were cut in the scale 1:20;
- paper leather 2mm used in the component's production;
- execution time of the impression was 6 minutes and 59 seconds;
- the cutter used was Glorystar.

![Figure 7. Manufacture with Laser Cutting Glorystar, (a) configuration laser cutting, (b) process of manufacture](image)

Problems detected during the manufacture:
- error in quantity of printed components;
- no rationalization of the component's pagination for it's better use;
- superposition of model lines resulting in the burning or imperfection of the parts;
- error in the thickness between lines, being recommended 1mm.

B. 3D print of the cobogós:

- the geometry was extracted through photographic registers of the fronts by using AutoCAD program. The component was elaborated in 3D as an solid object in Rhinoceros program;
- the software of 3D print control understands archives in stl format (StereoLithography) and uses millimeters as measure unity;
- the cobogós were printed in 1:10 scale;
- the used filament was TIP (synthetic polymer thermoplastic);
- it took 3 hours and 19 minutes to print out two components sequentially;
- the 3D printer used was Cliever Printer.
Problems detected during the digital manufacture:

- elevated impression time demanding the whole process to be planned before it's execution, so that there are no unforeseen;
depending on the bulk of the component, the necessity of the impression of the sustenance support will increase the execution time.

4 CONCLUSIONS

The reflection in the academic experimentation, the new technologies and the digital manufacture are tools that aim to the improvement of the integration between at several extents of the process of tangibility of an architectural work, from the small prototypes, the mockups and component in real scale when the construction was destined.

The intention, more than simply to present a case of the resources of digital, it is effectively to allow what initial objectives, there are creative, conceptual, technical, functional they, with intention in promoting reflection on new languages in the architecture teaching. In this context, the digital manufacture seems to be essential for the taking decision in all the stages of the process of project and of his execution.

It allows to simulate physically constructive details (FLORIO, SEGALL and ARAÚJO, 2007), to produce new component and families of similar component ones or even wombs promote the elements mass production still not available in the market through the pieces conception between others.

As decisive factor, the geometrical analysis of the component ones analysed by the students, contributed satisfactorily in the process of the digital manufacture, when there are optimizing the experimentation and the discovery, inherent the cognitive actions (SCHON, 2000) in the experimentation and teaching of architectural project.

It is possible to end what the new technologies in the process of teaching of architecture, it contributes with efficiency in the reduction of the propagation of mistakes of project, since both the visualization and the tangibleness of the physical product reduces the abstract character and very often ambiguously of drawings and two-dimensional images, making easy the understanding of the architectural proposal, adding in a spirit collaborative in the academic territory.

REFERENCES