Digital design of reconstruction proposals in Chile

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Abstract. After the earthquake and tsunami occurred in Chile on February 27th 2010, the Technical University Federico Santa Maria was asked to contribute with reconstruction proposals for the commercial infrastructure destroyed in the town “San Juan Bautista”. Located 600 km (~370 mi) away from the continent, this town is not just the home of several endemic species, but is also located next to a National Protected Area and UNESCO Biosphere Reserve. Within this context, the design problem consisted on the development of a component-based strategy and prefabrication requirements, and to reduce to the minimum the implied logistics and environmental impacts of the new buildings. With a Studio of 23 final year students and the support of the Architecture Firms Association, 11 projects were developed using digital tools such as visual programming and digital fabrication. Finally, technical documentation was produced and delivered to the local and government authorities.

Keywords. Visual programming; post-disaster reconstruction; prefabrication; constraint-based design; building components.

INTRODUCTION

Scenario
San Juan Bautista is located on the Juan Fernandez archipelago, 600 km (~370 mi) away from the Chilean coast in the Pacific Ocean (33.61S - 78.83W). From time to time, a family wants to build a small extension for their house, usually made with a traditional wooden balloon- or platform-framing system. They do not have to study the building and planning regulations only, but also to coordinate the implied logistics efficiently. After a satisfactory design decision they ask for building materials to the Chilean Navy, which send the materials, food and other supplies from the continent to the island on a monthly basis. Hopefully the family will not forget any detail; any missing building element has to wait another month for being purchased and delivered. Also, all of them must be found in traditional construction stores and achieve basic sea transportation conditions, such as humidity resistance, easy-to-handle size and weight, minimum volume and a fast installation. Usually the family will build the extension themselves; there is not skilled workforce within the town’s population of 600, who mostly exploit a fishing and tourism-based local economy.
After the earthquake occurred in Chile on 27th February 2010, inhabitants in the affected districts realized that any place can suddenly become a fragile place. Workplaces, housing developments, historical places and urban areas were lost or seriously damaged during the 8.8 earthquake which was felt by more than 70% of the country’s population, and pushed 500,000 below the poverty line. In Juan Fernandez, the earthquake was not felt, but the subsequent tidal wave destroyed -without previous notice- the coastal infrastructure and the city centre (Figure 1). They not just lost every commercial, touristic and fishing infrastructure, but also under the sea the bay was crowded with rubble. Within this context, Chilean Universities were asked to contribute with reconstruction proposals to replace the destroyed buildings in several cities, as well as to create links with government agencies and local authorities for its delivery and evaluation.

**Educational approach**

This was a unique opportunity not just to work with a Studio in a contingent design problem but also to face, within an academic environment, a real-world context involving design critiques from external agencies, a challenging physical context and the final production of deliverables. In the Technical University Federico Santa Maria (UTFSM) there is a tradition of setting Architecture Studios within non-traditional geographical contexts (Hormazabal, 2007), from the northern desert to the design of antarctic stations (Taylor et al, 2000) and in many cases, students are aware of the site conditions by travelling to those locations and using outdoor spaces as workplaces and workshops during teaching activities (Serrano and Gonzalez, 2009). Our proposal entailed the design of the city centre’s commercial infrastructure, considering 6 buildings. For some of them students developed 2 design alternatives (Table 1). This Studio was also complemented by other educational activities such as the design of fishing infrastructure in northern Chile, the design and construction of 11 geodesic domes for emergency response and its DIY fabrication guidelines, and a Studio for designing emergency shelters for future disaster scenarios.

<table>
<thead>
<tr>
<th>Program</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>01 Restaurant</td>
<td>100 sqm</td>
</tr>
<tr>
<td>02 Fishing and diving equipment</td>
<td>80 sqm</td>
</tr>
<tr>
<td>03 Small scale Commerce</td>
<td>100 sqm</td>
</tr>
<tr>
<td>04 Medium scale Commerce</td>
<td>250 sqm</td>
</tr>
<tr>
<td>05 Medium scale Commerce</td>
<td>250 sqm</td>
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<tr>
<td>06 Medium scale Commerce</td>
<td>250 sqm</td>
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Without any doubt, architectural education must consider, learning outcomes that belong to the domain of the professional practice. However, there is indeed a gap between the technologic innovations and tools used in academia, and its implementation on the practical realm. In computer-aided architectural design (Turk, 2001), bridging this gap requires the transmission and adoption of operational and reusable knowledge related to real constructive processes and the tools involved.

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*Figure 1*

Pictures of the destroyed city centre in San Juan Bautista. Source: MINVU, 2011.
in each one (Larsen et al, 2007): so far, the time span between the formulation of a technical innovation and its adoption in the practice has been determined in 25 years by Gropius (1956), and lately in 17 years by Larson (2000) in the context of the housing market. Nevertheless, this approach considers the delivery of technical knowledge, without considering the acquisition of soft skills that belong to our profession and which, in most of the cases, are deeply rooted within local practices, i.e. to keep relationships with clients and colleagues within a collaborative environment, to develop response capabilities against unexpected modifications and evaluations during the design and construction process, or to develop response capabilities against unexpected changes in the social, political, urban or economic context of a specific project. It is still necessary to debate about the benefits of these soft-skills within academic environments (To which point should we practice these in academia?, How to deliver that knowledge?), however the competence-based educational model for architecture programs in Latin-America points toward these skills (Beneitone et al, 2007):

• Competence 17: Ability to form part of interdisciplinary teams deploying different intervention techniques to improve degraded and/or disputed urban and architectural spaces
• Competence 20: Skill at leading, taking part and coordinating interdisciplinary work in architecture and urban development.

The delivery of these skills is quite a challenge for academic environment, as it requires not just the formulation of technical learning outcomes but also academic exercises as a ground for its development. In this Studio, we were required to face some experiences which are quite commonplace in the practice but are usually not considered in the curricula, such as the existence of a real “client” and unexpected changes on the design conditions due to the parallel work of other Universities and government agencies.

STUDIO

Digital design approach
Considering this context, and the particular conditions of the workload, the main challenges of the Studio were established as:

• to develop and explore an architectural building systems by using object-oriented models, considering prefabrication alternatives, size and transport restrictions, and
• to develop and explore different space planning alternatives without significative amounts of additional workload.

Although there is an active discussion about the pertinence of teaching programming tools to architecture students, there is evidence that this tools could help us to accomplish those objectives. At the time of facing it with standard text programming
tools, visual programming has proven to be more user-friendly, allow students and lecturers to discuss about one design solution at the time, and let the designer to visualize and deeply comprehend the design problem (Donath and Gonzalez, 2003). Visual programming is a 3D modeling technique that allows the user to develop small applications during the design process, in order to explore design solutions without requiring previous knowledge on hard programming. As such, a visual interface is used to inter-relate parameters and geometries (Figure 2), revealing the very parametric nature of the design problem and letting the designer to easily modify the problem structure in order to look for different design instances. For the Studio purposes, the students used the node editor “Xpresso” embedded within MAXON’s Cinema 4D software. None of the 23 students had previous training on visual programming, but already had training in the use of 3D modeling and drafting softwares. Some of them has experience in fabrication of physical prototypes.

The mere fact of visualizing design information allows the designer to declare explicitly how the design exploration will be undertaken and the constraints that define the solution space. A contribution to creativity can be outlined; according to Dorst and Cross (2001) creative events may occur during a retrospective insight, where the designer -or an observer of the process- can identify a point during the process at which key concepts emerge. Therefore, a registry of an explicit design structure can lead to creative discoveries, usually hidden under a complex cognitive process. The same authors conclude on their work that an appropriate definition of the design problem and its framing is a key aspect of creativity, even more than the choice for any specific design process. Of course, visual programming is not an intention to imitate on a diagram-based approach the complexity of design phenomenology, but is indeed a useful aid to refine both the problem and the ideas on an iterative process, allowing different instantiations of the design solution within a finite solution space.

**Definition of building components’ geometry**

The first exercise was to pull out the geometric relationships between the constructive elements of typical balloon framing and platform framing systems. By an extensive literature review students were able to develop a quite logical understanding of the function of constructive elements and their geometrical
relationship by using topology diagrams and basic geometric definitions: “above”, “next to”, “attached to”, among others. The second step was to translate this information to a set of design constraints, by developing a logical and/or mathematical model which was lately translated into a visual programming interface. Those constraints were built considering the geometry of commercial building elements, in order to define components within a valid design solution space (Figure 2). Students programmed small assemblies and panels in order to produce building components based on commercial wood and plywood dimensions and modules. Basic definitions for a productive chain were achieved in many cases, and some physical prototyping exercises were made in a laser cutting machine (Figure 3).

**Definition of the space planning**

A similar method was used to explore different space planning alternatives. The main requirements, such as area, location, and orientation were previously given by the client, but several changes were made during the 4 months process though. During the Studio, two main approaches to the space geometry arose. Some students designed wide open spaces and building components that could fit in different configurations, leaving the final layout decisions to the builders. Others opted by designing the layout completely but considering specific spaces for flexible uses. In both situations, the sanitary core was fixed in a specific location in accordance to the feedback and the new city plan layout provided by the Association of Architecture Firms and the Ministry of Housing and Urbanism (Figure 4).

**PRODUCTION AND DELIVERY**

The overall production of the Studio comprises a set of 5 buildings for the reconstruction of the touristic and commercial infrastructure in San Juan Bautista. In term of impact on its surroundings, the building should not just accomplish sea transportation conditions following a component-based building system, but are also located within the area that could be potentially flooded by future tidal waves.

During the design process, students faced 3 major changes on the context conditions, referred mostly on the parallel master-planning process undertaken by the Association of Architecture Firms: changes on the built surfaces, changes on the pedestrian pathways, and the uncertainty on the budgets that will be considered during their technical and economical evaluations. Despite this, the early definition of a solution domain and its correspondent object-oriented structure allowed students quick explorations of the solution space and hence, to rapidly produce new design alternatives and to finally produce deliverables.

By July 2010, 11 selected projects with their technical documentation were fully delivered to local authorities and the Association of Architecture Firms for evaluation and presentation purposes. So far, high-priority buildings are still under development: school, city council, and a new housing project for the town. Despite the devastation after the tidal wave and the lack of supporting infrastructure, the surrounding of the town did not lose its condition of National Park and UNESCO Protected Biosphere Reserve.
CONCLUSION
This Studio offered the opportunity to both involve students on an office-like environment with de presentation and basic development of its corresponding soft skills, and to proof the usefulness of visual programming as a way to face real-world design problems in two different types of problems: building components and spatial planning.
As a contribution to design cognition, the most important feature of visual programming was to elicit the parametric nature of design by relating on single diagrams both geometry and its parameters. The construction of the solution space and its exploration was made iteratively, grounding a fertile soil for creative ideas (Dorst and Cross, 2001). In this context the student’s role was closer to a solution explorer rather than a solution-developer. On the other hand, as a contribution to the professional practice, visual programming might lead the way to the fabrication of “preference and design engines” (Larson et al, 2001), were the user requirements are translated to geometric information and then explored by the designer in a mass customization context. Therefore, visual programming interfaces can be also understood as intermediate instances between the pure virtual modeling techniques and physical prototyping. This relation between both virtual and physical models is currently being explored as a part of the first author’s doctoral research.

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