Operating within Fragile Environments

A Hybrid Design Model of Intensifying Urban Performance

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Abstract. As the architectural community becomes more and more “aware” of the ecological problems that our environment faces, digital tools gain a prominent position in the attempts to inform the design process with environmental sensibilities. However digital tools could provide more than the means to evaluate the energy efficiency of a design. The paper discusses the possible ‘digital-to-analogue’ design methodologies that are developed through the use of advanced computational techniques, alongside with material explorations, through example-projects designed and constructed by the students of the School of Architecture of the Aristotle University of Thessaloniki during an intensive, one week workshop.

Keywords. Responsive Action; Digital & Analogue Processes; Design Protocols.

The discussions concerning the ecological problems that threaten the life conditions on the planet have reached the architectural community within the last 10 years. In this context issues like the incorporation of the microclimate of a place in the design process and the recycling of materials become crucial in contemporary architectural design strategies. Yet, most practices in this direction tend to approach ecology in a restricted way. They either deal with the relation of the designed object to the natural environment, as an issue that validates design proposals, or they incorporate energy efficiency technologies, as a fashionable implement.

However, ecological thinking suggests a much more broad and extensive approach. This has to do firstly with the relation of the subject (where as subject we can understand either a person or in our case the designed object) to its environment, both natural and artificial, then the relation of the subject to other subjects, and finally the relation of the subject to itself (Guattari, 2000). This involves a sensitive and responsive attitude according to which design has to be seen more as action taken in order to bring balance between these fragile relations rather than a decisive method of superimposing a novel assembly upon an existing setting. If we want to approach design in an ecologically aware manner, we need to employ tools that help us to interpret and control the delicate environmental conditions. More importantly, we need to adopt a new way of thinking that initiates from these conditions and relies on bottom-up design processes, rather than to apply a high level conclusive concept (Vergopoulos & Kalfopoulos, 2004).

In the urban context, a designer has to take into account the multiple conditions that are layering modern urban situations. Economy, memory, culture, environmental and technological matrices are only some of the fields that need to be studied and mapped along with the inter-relations between
them. Today, digital technologies provide the necessary means in order to map the flow of information regarding the above-mentioned elements, and to direct it in order to shape design decisions. Yet, while it might be easier to imagine such a process in relation to parameters that have clear quantitative values, the same undertaking becomes vaguer when it comes to parameters of a more qualitative nature. For this reason, it is important to understand the nature of digital tools and see how we can use them in order to develop design protocols that will direct both qualitative and quantitative flows of information towards design decisions; where protocol is understood as “a language that regulates flow, directs netspace, codes relationships, and connects life-forms” (Galloway, 2004).

The paper focuses on these issues through the work developed by students at the School of Architecture of the Aristotle University of Thessaloniki, during the Urban-Performance Workshop, organised in during the spring semester of 2010. The aim of the workshop was to use waste materials (like empty water bottles, used CDs, plastic forks) as building material for site-specific installations that are formed and defined through mapping of conditions met at each of the selected sites.

There are several examples in the architectural practice where waste objects are becoming the raw material for an architectural intervention. However the workshop proposes a novice approach. Waste materials, being usually industrially produced objects, are homogenous and undifferentiated. Therefore their use as a building element tends to produce equally homogenous results. The workshop explores the design of the connecting devices, through the use of advanced computational techniques and digital fabrication, which control the positioning and/or the transformation of the base material. That way, a waste product of mass production becomes manipulated by the means of mass customization that the new technologies provide, creating a highly differentiated final product. At the same time, it is the flow of information that is mapped on each site that directs and informs the ways in which this differentiation occurs.

The work produced during the workshop is discussed in relation to the progress of each project and the digital tools that were used each time. There is an attempt to locate and identify the processes and tools that better accommodate the external information and incorporate it in the process of shaping objects with very specific material properties. These tools and processes are subsequently used in order to create installations in equally specific locations throughout the city. This discussion relies on a design model consisting of four parts, two of them digital, and two analogue: The first part is the recognition and the comprehension of the material qualities of the initial waste objects. This is accomplished by physically manipulating each object and trying to detect its potential to reveal a new identity and acquire new qualities; not anymore as a complete object but as a component of a much wider and complex system. Part of this process is the definition of the connection principles. The next part is implemented with the use of digital tools and refers to the development of a protocol, a set of rules that are put in place by the designer according to the information that is manipulated (Gourdoukis, 2010, 2011). In this part, the coding of those rules (through computer programming) becomes an essential element. The third part is the simulation of the protocol, still in a digital environment. Simulation does not aim to “specify unknown variables” but rather “at finding similarities or analogies across time in complex processes for which the precise actions of variables remain unknown” (Hookway, 1999). This allows for larger environmental patterns to become visible and the properties of the model to emerge in a bottom-up fashion. At the same time, simulation is not used as the repetition of an already defined process: Simulation does not copy something that already exists. It utilizes instead the protocol defined in the previous stage and reveals its potentialities becoming that way not an evaluating but a generative process. (Vergopoulos & Gourdoukis, 2011). The final part of
the design process is the construction of a physical model according to the results of the previous stages in order to evaluate the ways in which the design interacts with the physical space. Between these four stages a feedback loop is developed that becomes the generative force in the design process.

This design model attempts to apply the principles of ‘bottom-up’ processes (as these are defined by Benyus in the context of biomimetic architecture) to methodological aspects of the development (Benyus, 1997). Benyus suggests that a top-down process initiates from an abstract concept and subsequently continues to the specification of the form, then the structure and finally the material of a construction. On the other hand, in a bottom-up process (particularly in nature) the structure and consequently the shape of an organism rely on its material. In the context of digital design, a lot of bottom-up approaches define the interconnecting relations of a structure as the initial point of an assembly, but only a few try to approach materiality. As the following description of examples of student projects shows, this is one of them.

The first of the projects we are going to describe here used paper cupcakes as its building element. Initial explorations were both digital and physical. Physically they were based on the transformability of the material. Being able to bend or skew, it was able to produce in its repetition both curved and straight surfaces. At the same time using glue as the connecting material, the students managed to produce a wide variety of formations with a different degree of rigidity: Larger glued areas produced more rigid results while smaller connection areas more transformable ones. At the same time, in the computer, initial experiments were based on the geometry of the paper cupcake and the ways in which it could be multiplied. The first digital attempts were made in Autodesk’s Maya employing built-in animation techniques. That is, the multiplication and transformation of the component was achieved through animation dynamics: particles and force fields.

This first round of experimentations was marked by an almost total incompatibility between the digital and the physical models. Connections and assemblies made physically were impossible to

![Figure 1](image.jpg)

*Figure 1* Initial animation experiments of the ‘paper cup’ team.
Figure 2  
Basic growth algorithm of the paper cup project.

Figure 3  
The results of the used script.

```plaintext
// add a range attribute to the locators
for ($i=0; $i<6; $i++) {
    string $locatorName = "attractor" + ($i+1);
    select -r $locatorName;
    addAttr -shortName rn -longName range -defaultValue 10.0 -minValue 0.001 -maxValue 200.0
}

for ($i=0; $i<5; $i++) {
    for ($j=0; $j<=i; $j++) {
        for ($k=0; $k<6; $k++) {

            // select the seed, duplicate it and move it to its new position
            select -cl;
            select -r theSeed;
            string $seedName;
            $seedName = "myDuplic" + $i + "$" + $j + "$" + $k;
            duplicate -rr -name $seedName;
            move ($x=$i) ($y=$j) ($z=$k);

            // create name for the blendshape
            string blendShapeName = "blendshape" + $i + "$" + $j + "$" + $k;

            // add extra blendshape
            for ($l=1; $l<6; $l++) {
                string $extraBlendShapeName = blendShapeName + "$" + $l;
                global proc constructBlendShape()
                if ('window ~exists blendShape') {
                    deleteUI blendShape;
                }
            }
        }
    }
}
```
be matched digitally in order to explore their potential in larger assemblies, while formations achieved digitally were practically unbuildable in the physical model. This discrepancy led to a change of strategy in relation to the digital processes. Maya was still used but the built-in animation techniques were replaced by much simpler, in the beginning, scripted operations. That proved to be a much more efficient method in order to simulate digitally the observations made in the physical model. By setting simple initial rules in order to specify the ways according which the components were connected to each other and multiplied, the students were able to recreate formation that were initially modelled physically and consequently able to alter and transform these formations in manners possible to be reproduced manually. While there were still differences between digital and physical models, there were enough common properties to allow the students to move back and forth between the digital and the physical in order to develop the project. In fact it was those small differences that became the creative force: They were small enough to allow the passage of certain properties from one model to the other, but big enough to make each step not a replication of the previous but a new transformation in a line of consecutive alterations. The final project was a sheltering structure, placed in a specific place of the city used equally by humans and pigeons as a meeting point. The structure accommodates the needs of both groups promoting an idea of symbiosis.

A second group used plastic forks as its building component. While the initial approach was similar with the first group (experiments both digital and physical), the digital tools were different: the students employed Rhinoceros 3D and Grasshopper as the means to explore the possible formations. In this case, the digital experiments were investigating
the possible formations of several different aggregations of components, where the fork was reduced essentially to a simple line representing its length. At the same time, the physical models were focusing on the study of possible ways to connect the forks with each other: In the beginning using its own spikes, then using rubber bands and finally employing metal screws. The different joints were providing different degrees of flexibility with the screws being chosen finally as the most appropriate one. It is interesting, however, that in this case digital and physical models were able to be developed in parallel without significant discrepancies between them. While in the previous example the whole processes was a series of steps, where each one was transforming and developing the previous one, in the case of the plastic forks project the relation was complementary. The digital model was testing aspects difficult to explore physically, like the aggregation of large numbers of forks, while the physical models were focusing on aspects like the connection joints. In other words, the digital models were ignoring the problems faced in the physical ones (assuming that the forks are going to be connected in a way) and were dealing with the larger scale (the formation of the construction in total). At the same time the physical models were presupposing the result of the digital ones – the forks will eventually form a larger assembly – but were solving local issues – the connection joints. The final project was a network structure used in order to signify the existence of some ancient ruins in the city of Thessaloniki that are currently rather
Figure 6
Basic configuration of the ‘forks’ project.
ignored because they are in a lower level that the rest of the city.

One conclusion that we might draw from the previous examples is that there seem to be two ways to implement the four-part process described in the beginning of the article. In the first way, as in the case of the paper cups project, each part is a re-interpretation of the previous one: First the material properties are observed in the physical model. Then a protocol is developed in order to encode digitally those properties. Subsequently the protocol is simulated in order to see the possible results. Finally some of those results are build physically. However, each part alters the previous by adding information and consequently by changing the direction of the project while ensuring, at the same time, that the alterations will not be too big, as that would result in the loss of connection with the step that follows. In the second way, as in the case of the plastic forks project, each of the four parts does not interpret the previous but it rather focuses on different aspects or problems. The initial physical model tests the material properties and explores possible solutions in the local level. A digital protocol is developed in order to establish relations that will define the 'global' properties of the construction. Then the protocol is tested so the global possibilities are explored. Finally the physical construction is made combining the results of both local and global scale.

Of course those two distinct ways are perceived as such only in a theoretical level. In practice the process followed is always a mix of the two. However it usually tends towards one of them, as in the examples of the urban performance projects. And

Figure 7
Photographs of the building process.
Figure 8
Photomontage of the ‘forks’ project on site.
thus each of the two has different properties. The first one, where each step is a transformation of the previous, can accommodate much easier qualitative properties that cannot be described in terms of numbers. The second one, where each step complements the other, is much more precise and can incorporate quantitative data in a very efficient way. Finally, an important aspect of both processes is that the more we follow a digital-analogue paradigm, the more we realize that predefined processes in existing software are ultimately inefficient. In order to be able to bridge the two – physical and digital – we need to develop custom tools that each time respond to the specific situations encountered. Therefore, a useful direction for CAD might be the development of software that does not provide solutions, but the means to create processes defined by the designer, something that is supported by the current spread of software like Grasshopper that focuses exactly on this aspect.

As a closing comment, it is important to point out that, although the digital model is the starting point of the design process, it is the physical model that deals with the material qualities of the designed object, as well as its fragile relation to the urban environment, and that this interactive design operation triggers further design rearrangements. This particular aspect connects the whole undertaking to research towards analogue and digital hybrids in design.

THE URBAN PERFORMANCE WORKSHOP

The Urban Performance Workshop took place in May 2010 at the School of Architecture of the Aristotle University of Thessaloniki. Below is a list of the people involved in the workshop:

**Visiting Professors:**
Heather Woofter, Sung Ho Kim (Washington University in St.Louis)

**Teaching team:**
Stavros Vergopoulos, Dimitra Chatzisavva, Dimitris Kontaxakis, Vassilis Papadiamantopoulos, Spiros Papadimitriou, Anastasios Tellios, Dimitris Gourdoukis, Katerina Trifonidou

**Organization:**
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**Students:**

*LoveMeTender:* Plavou Vasiliki - Maria, Samara Aliki, Smoukis Fotis, Papakonstantinou Vasilis, Chiou Maria, Koroni Dimitra


*ReflectingBites:* Arvanitakis Giorgos, Dalamaga Vassiliki, Diamanti Vassiliki, Mavropaidi Christina

*PlastiCity:* Gkoumas Vaggelis, Iakovidis Nikos, Karaoglanian Anait, Kasimati Efi, Mpoutoulous - Patsios Ioakeim, Panagoulia Eleanna

*RainbowGenerator:* Kotsanis Giannis, Konstantinidou Athina, Loukidou Anna, Rakintzi Dimitra,
Stergioudis Vasilis

_EggCellter_: Georgaka Anthi, Keki Adamantia, Papayianni Maria, Loukaidis Giorgos, Kaminidis Romaios, Melikidis Ivan

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