**Abstract**

This research work is being financed by the "Instituto de Ciencias de la Educacion, I. C. E., Universidad Politécnica de Valencia, U.P. V. and currently taking place at the "Taller2 de Proyectos Arquitectonicos." We have placed CAD systems on drafting tables, so students can learn to apply different media and tools, both digital and traditional, in their design processes. To integrate CAD systems into the design studio we have developed a methodology upon which to relate the "Mechanics of the digital tool," with the often elusive and seldom explicit, "Mechanics of designing".

We see architectural design as a process that can benefit from the use of computer systems through modelling (representation), and rendering (static or dynamic visualization). Digital modelling tools are powerful instruments to simulate and visualize (perceive) formal and spatial arrangements, under certain conditions of superficial appearance and light. GEOMETRY COMPOSITION, TEXTURE, LIGHT PROJECTION; RENDERING and ANIMATION, are the keys to understanding a digital modelling system as an extension of our design process. We introduce and explain each one of these categories, as it applies to architectural design and to three dimensional CAD systems. We present samples of student work following this method.

**1 Introduction**

Schools of architecture have long struggled with the need to introduce CAD education in their curricula. The answer to this question is taking place at every institution in a different way, depending on human and material resources. The "Departamento de Proyectos Arquitectonicos, E.T.S.A., U.P.V.," is working to introduce digital modelling systems as an active tool in the learning of architecture. Our efforts follow two directions: developing a method that helps us relate CAD and architecture, and locating computers where students do their designing.

This experience started three years ago to offer students the possibility of a digital design studio, where exercises would be the same as any other studio’s. However, the focus of the learning experience is on conceiving and representing architecture with digital systems, without disregarding other graphic media. What follows is the explanation of our approach, and some pictures that show what students obtain as a
result. Classes rely on lectures and slide presentations, required readings that highlight relevant points of view towards computing in design, and extensive individual use of digital systems.

2 Methodology

CAD systems are design tools, and we must define their role when we apply them in a studio environment. We share a point of view that sees four main roles of computing in architectural design, according to the different capabilities of the system we favour. (ref.: Martin, Elaine and Milton, John "The Role of computing in the teaching of Design" ACADIA Newsletter, 10 (4), 1991 pp. 14-17)

- We might explore a digital system as a general tool, essential to many tasks of present day professional practice, and conclude that students should "know about computers." In this case our goal would be to understand how these systems operate in their main areas of symbolic manipulation: textual, numerical or graphical.
- We could regard a digital system as a graphic presentation tool, and explore its effectiveness as graphic media appropriate in architectural thinking and representation. In this case, we might benefit from the systems’ capabilities of plastic manipulation. The process of design is, however, independent from the role of the system, even though supported by it.
- If we focus on the possibilities of a digital system to generate alternative compositions, we might work out an educational strategy. This point of view might encourage students to incorporate this capability in their design processes. Geometrical composition is an important part of architectural thinking, but it does not explicitly address light and space as we perceive and live in them, which are the main realms of this art.
- We might interpret a digital modelling system as a tool that allows the perception of architectural form and space, supporting architecture while being conceived and represented. Computers, as a result, play an active role in the design process, highlighting its fundamentals. This is an advantageous point of view to integrate CAD in a design studio setting. We have been working on this basis to develop our method for CAD and architectural design education.

We teach students how to build and manipulate a digital model of the architecture they think. Computers take and produce information. If we give the system a description of architecture (we build a model), the computer will present graphically this information (we visualize a model).

Modelling is a process that we describe with the aid of four categories: geometry, composition, texture and light. Visualizing a model is a process with two categories: projecting and rendering the information contained in the system. Visualization can be static or dynamic, which brings us to think about the virtual reality systems, not available to us yet, but may be sooner than we think.

- Geometry-architecture and a digital model of it are both based on the idea of geometry. We must understand space and geometry as essential to architectural design. Creativity takes place in a design world (ref.: William J. Mitchell "The Logic of Architecture", 1990), where we will be able to define and manipulate several types of geometric elements, a vocabulary of basic components with zero, one, two or three geometric dimensions. Elements can be transformed or combined (union, intersection, subtraction) within a Boolean algebra. The possibility to consider a solid as space (when we subtract it) is very important, if we think of architectural form and space as the positive or negative of one reality.
- Composition-architecture is seen next as a study of relationships amongst geometric elements. Laws of architectural composition guide formal and spatial development of a design, whose structure or hierarchy will be equally represented in a digital model. Similarity induces to think about types of elements, where every element of a type shares certain properties with any other element of the same type. Shape creation and instancing, and parametric designs are discussed. We might study the spatial or topological relationship between two elements, and we might analyze the idea of rhythm, where axis, repetition or symmetry are intrinsic to architecture.
- Texture-we might think of texture as an additional code of information on our design, or digital model. Texture is created and then applied to geometry so it responds to light accordingly, influencing formal and spatial expression of architecture. Textures represent material or constructive
schemes of architectural ideas, to a certain degree of realism or abstraction.

- Light-architecture is all about light and the way it brings form and space alive. The possibility to interrogate architecture accounting for light behaviour is the most important factor to relate a studio experience with digital modelling. We manipulate light sources in a design world, bringing us to the classic definition of architecture by Le Corbusier in "Vers une architecture" as "the masterly, correct and magnificent play of masses brought together in light."

Geometry, composition, texture and light are the four categories that we shall take to build a digital model of architecture. Once built, we can visualize or animate it, which is a process we describe as the following three categories:

- Projection-CAD systems allow the existence and observation of a model through views of space projected on a flat surface. The possibility to observe this space sustains the metaphor of creation and manipulation of geometric elements, architectural compositions, textures and light within the digital space. We study orthographic and perspective projections, and their application in architectural design, to produce floorplans, elevations, sections, and perspectives.

- Rendering-once we have built a digital model we can generate static or dynamic pictures, of its structured geometry, under certain conditions of superficial appearance and light. These renderings are like photographs that exist in electronic media. Rendering is the mechanism that allows a computer to present architecture.

- Animation-a digital model allows us to simulate the passing of time which adds a new dimension to the three geometric dimensions so far considered. We can generate an animation of a model, a sequence of pictures that if projected at a fast enough rate, will result in an appearance of smooth movement. We can animate geometry, composition, texture, light, projection and rendering.

In summary, this method is based on a vision of the design process understood as a static or dynamic compositional game of form and space; characterized by geometry, texture and light.

We try to explain the syntax of digital media without referring to a specific grammar of

3 Digital Design Studio

The excellent results that we have witnessed are certainly due to the enthusiasm and dedication that both our students and E, T.S.A., U.P.V., have shown for this discipline. It has been difficult to select particular projects amongst the many ones that show high conceptual and plastic quality. We have included some of the renderings that our students produce to inquiry within themselves and to express to us the result of their design process.

The first exercise that students face in the Digital Design Studio is the representation and analysis of architecture, designed and built by someone else. This exercise takes place during the first quarter of the year and no prior computer experience is required. For most students it will be the first time they will be using CAD as a three dimensional modelling tool, as a design tool, which poses some special conditions on our educational strategy. The student must learn several skills: to analyze and decompose architecture, to learn the specific grammar of a CAD system, and to build a model of architecture with it. The houses the academic unit chose last year are: Llina’s house by Jose Llinas, Moratiel house by Jose Maria Sostres, Farnsworth house by Mies Van der Rohe, C’an Pep Lluis house by Victor Rahola, lake Iseo’s house by Giorgio Grass and house for his mother by Le Corbusier.

The second exercise involves the design of architecture under a simple functional excuse. Every student designs individually a small pavilion for exhibitions. The designs are expected to execute a design as a digital model building process. The pictures we present here are designs by Jorge Navarro Carpio, David Miguel Navarro, Juan Regojo Zapata, Jorge Gil Martinez and Fernando Delgado Toledo.
Fig. 1 - Llinàs house (José Llinàs)

Fig. 2 - Moratiel house (José María Sotres)
Fig. 3 - Farnsworth house (Mies Van de Rohe)
Fig. 4 - C'an Pep Lluis de Sa Rota house (Victor Rahola Aguade)
Fig. 5 - JNC (Jorge Navarro Carpio)

Fig. 6 - DMN (David Miguel Navarro)
Fig. 7 - JRZ (Juan Regojo Zapata)
Fig. 9 - FDT (Fernando Delgado Toledo)

References


