The Added Value of CAAD for Education

Leandro Madrazo
ETH Zürich
Switzerland

This paper summarizes a teaching project carried out at the Chair of Architecture and CAAD, ETH Zurich; its aim has been to integrate computers into architectural design education. Here the theoretical bases of the different courses are outlined and the exercises described. Some reflections based on the experience of teaching these courses are also presented. In all, this pedagogic work demonstrates the need to create an appropriate conceptual framework so that computers can be used in a meaningful way throughout architectural design education.

The Added Value of Caad for Education

It was not so long ago that educators in the field of CAAD claimed that in the near future, sophisticated computers would replace the drawing board and the model shop in Schools of Architecture. They contended that intelligent systems would guide the designer through the intricate maze of design decisions, and would formulate design proposals and decide by themselves the best ‘design solution’. These speculations have tended to set the debate on the role of computers in architectural education off on the wrong track. Moreover, they have diverted the discussion away from the issues that are crucial for architectural education onto other issues that, in the best of cases, might be a matter for research. Because, while on the one hand the imminent computer revolution in architecture was being postulated, on the other hand, computers were being used in the Schools mainly to draw and model what had been previously represented by traditional media. Thus a wide gap existed between what computers were expected to do and what they were actually being used for. To bridge this gap, what was needed was <u>not</u> more sophisticated tools, but rather an intellectual framework within which to make meaningful use of the existing technology in academic education.

Today, it might be more appropriate to speak about the **integration** of computers in architectural education than to keep postulating the advent of a computer technology that would automatically bring, in itself, a revolution in the way we understand and teach architecture. It seems more reasonable for us to see the computer tools as instruments that impel us to rethink and reframe our knowledge on such fundamental issues in the education of architecture, as the relation between conception and representation, space and perception, form generation and design process. This could be, in fact, the value that computers add to the education of architecture: by forcing us to confront the established body of the architectural tradition with a new conceptual framework, computers can contribute to a better understanding of some fundamental questions in architecture.

The teaching project that was initiated at the Chair of Architecture and CAAD, Zurich, in 1990, has pursued this type of integration of computers into architectural education (Madrazo 1992a). In the course of the past six years, we have striven to develop and implement a conceptual framework within which the use of computers can bring a new value to architectural education. This paper summarizes a part of the pedagogic work carried out in this six year period.

A teaching project to integrate computers in architectural education (1990-1996)

This teaching project was first conceived in the years 1990-91 and was later developed and implemented in the course of the five following years (Madrazo 1993). According to this project, a sequence of three courses would take place during one academic year, in the following order: 1. an introductory course, focused on the generation of abstract forms; 2. a second course, focused on the aesthetics of form, followed by 3. a design studio dedicated to the design of concrete projects.

1. Introductory course: Form and Structure

This introductory course was first implemented in the Winter semester of 1990 and was offered during each Winter semester until the academic year 1995/1996. The spirit of this course is somewhat similar to the one that inspired the work done in the celebrated introductory courses of the Bauhaus. Like in the *Vorkurs* of Johannes Itten, the purpose of this course is to make students aware that form creation with a computer is a process that combines subjective experience and objective knowledge[1]. Unlike the Bauhaus courses, however, in a *gestaltung* course with computers the material component in the form generation process plays no role. The form generation process with computers involves mainly conceptual structures, such as instantiation, hierarchical structuring or substitution. Thus the course focuses on the understanding and application of these conceptual structures in the generation of form.

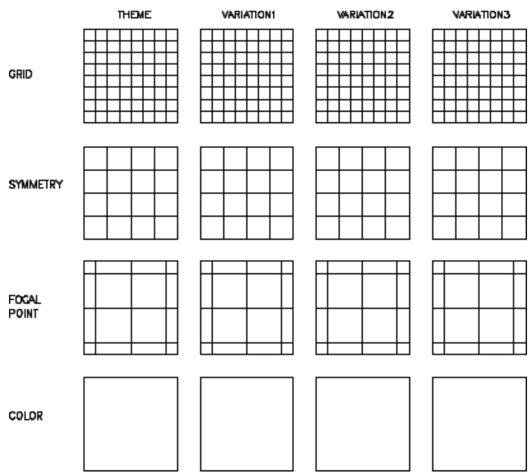
The distinction between **form** and **structure** is a fundamental part of the theoretical background of this course. A basic premise is that form and structure represent two distinctive aspects of design: while the conception and perception of form is an exclusive faculty of the mind, structure, on the other hand, is amenable to computer representation. By structure we understand the explicit representation of a relationship of the parts within the whole. This explicit relation can be captured by means of a variety of techniques provided by most computer graphic programs. The assumption is, that by reproducing the inner structure of form on a computer, a designer can gain new insights in the form making process.

[1] One of the basic goals of Itten's *Vorkurs* was to make students aware of the subjective and objective dimensions of form creation. The subjective side had to do with the inner creative power of the individual, while the objective had to do with the material and the methods used in the production of industrial objects. As Itten explained it later (Itten 1975), this was one of the three fundamental tasks of his Vorkurs: *"Für ihre zukünftigen künstlerische Berufe sollten den Studierenden die Grundgesetze bildnerischen Gestaltens vermittelt werden. Die Gesetze der Form und der Farbe eröffneten den Studierenden die Welt des Objektiven. Im Verlaufe der Arbeit konnten sich die subjektiven und die objektiven Form- und Farbprobleme in vielfältiger Weise durchdringen"*. (p. 7)

1.1. The exercises

The exercises have been conceived to allow students to do creative work from the very beginning of the course. After one week's introduction to the basic notions to the Unix operating system and to the basics of a general purpose modelling program, students begin with the first design exercise: a composition of two-dimensional shapes. In the following exercises they continue creating objects in three-dimensional space. These objects and shapes are not meant to have any architectural significance; they do not have to respond to any function or program, nor they need to have a particular scale. They are purely formal compositions in space.

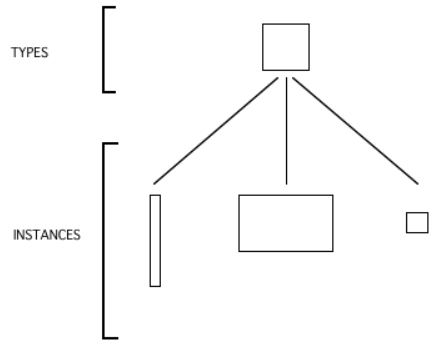
A fundamental component of the course is the computer tool we have designed to enable the students to do the exercises. The tool was conceived with the intention of giving support to the concepts formulated in the exercises. This tool is built upon the paradigm of types and instances. Basically, it consists of a hierarchically structured library of types and a graphic user-interface. A type can be selected on an icon menu, and inserted in the model. Attributes of the instances can be edited interactively or by entering values in a dialogue box. Instances of a particularly type can be replaced by instances of a different type in a direct and intuitive way, using the graphic interface. Individual instances can be grouped to create compound objects which also become part of the library of types.



The course work consists of four exercises dedicated to the creation of abstract objects (composition on the plane, objects on the plane, hierarchical structures and level of detail), followed by a final exercise in which the concepts previously learned are applied to the design of an architectural object. The format of the first four exercises responds to a basic idea: the paradigm of theme and variations. The layout of every exercise consists of a grid where the first column corresponds to the theme and the next three columns to the variations.

The format and description of the exercises was reviewed after each academic year to make them more suitable to the students' needs, incorporating the feed-back obtained from previous years[1]. This was the description of the exercises, as it was formulated in the Winter semester 1995/96:

first exercise: composition on the plane



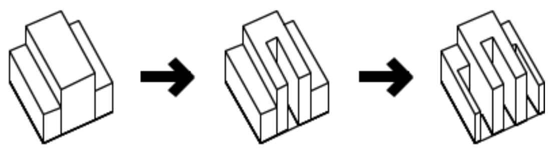
The notion of instantiation (the *types and instances* paradigm) is introduced in a simple manner. A library of two-dimensional shapes provides the design vocabulary, e.g. a collection of types that are then instantiated to make a composition. The themes to which the students are asked to give a formal expression are: grid, symmetry, focal point and color.

Fig. 2. Kim Riese, Winter semester 1994/95.

Fig. 3. Alexandre Zumbrunnen, Winter semester 1995/96.

Fig. 1. Yves Racine, Winter semester 1992/93.

second exercise: objects on the plane



[1] A detailed description of the exercises can be found in *http://caad.arch.ethz.ch/~madrazo/teaching*

The purpose of the second exercise is the composition of extruded shapes on a plane. Objects are created according to two different formal languages: the language of prismatic shapes and the language of parallel planes. The concept of substitution is introduced in this exercise: the variations of an object are created by replacing the individual components by instances of another type.

Fig. 4. Extruded shapes. Leo Bietry, Winter semester 1995/96.

Fig. 5. Parallel planes. Gerd Grohe, Winter semester 1991/92.

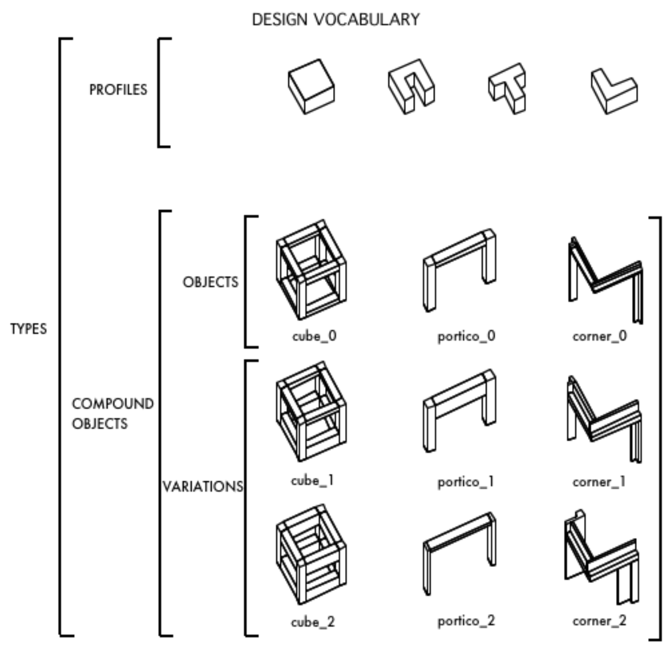
Fig. 6. Parallel Planes. Zbigniew Wiklacz, Winter semester 1993/94.

Fig. 7. Parallel planes. Thomas Caro, Winter semester 1994/95.

Fig. 8. Parallel planes. Kim Riese, Winter semester 1994/95.

Fig. 9. Substitution. Yves Milani, Winter semester 1993/94.

third exercise: objects in space



The third exercise focuses on the notion of hierarchical structures. The inner structure of an object is represented on the computer by means of compound objects and layers. The exercise consists of two themes: 1. frame and volume: creation of an object composed of a frame structure and a volume. 2. path in space: creation of an object by connecting points in three-dimensional space.

Fig. 10. Frame and Volume. Moreno Maconi, Winter semester 1993/94.

Fig. 11. Frame and Volume. Zbigniew Wiklacz, Winter semester 1993/94.

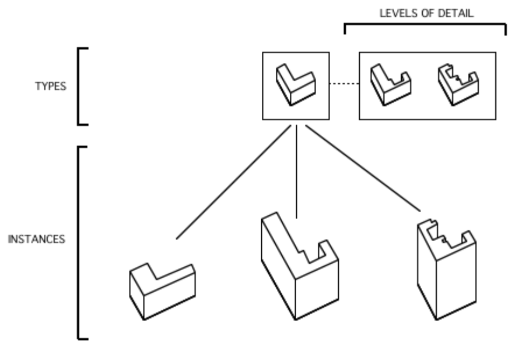
Fig. 12. Frame and Volume. Thomas Caro, Winter semester 1994/95.

Fig. 13. Path. Leo Bietry, Winter semester 1995/96.

Fig. 14. Path. Yves Milani, Winter semester 1993/94.

Fig. 15. Path. Christoph Huber, Winter semester 1994/95.

fourth exercise: level of detail



The fourth exercise deals with the notion of levels of detail, according to which the appearance of an object would change according to the distance between object and viewer. The notion of level of detail can be thought of as a corollary of the idea of substitution: in the computer model, instances of an object can be replaced by other instances with a different level of detail.

Fig. 16-18. Level of detail. Daniel Overhoff, Winter semester 1995/96.

fifth exercise: the architectural object

At the end of the series of short exercises, every academic year there has been a special final exercise. Some of the topics proposed have been: the design of a tower, a pavilion in the Parc de la Villette, and a facade. In the design of each one of these themes, students were asked to apply the concepts of instantiation and design vocabulary, hierarchical structures, and level of detail.

Issues of architectural representation, which were not relevant in the previous exercises, now become important in the design of an architectural object. For example, axonometric and perspective views might not suffice and plans and sections are needed to represent the object.

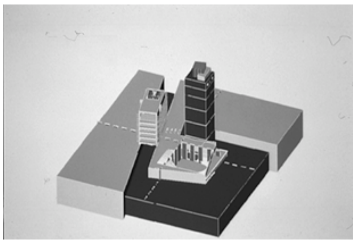


Fig. 19-21. Tower. Gerd Grohe, Winter semester 1991/92.

Fig. 22. Tower. Gerd Grohe, Winter semester 1991/92.

Fig. 23, 24. Pavilion in La Villette. Nicklaus Liechti, Winter semester 1992/93.

1.2. Some reflections derived from teaching the course.

The following are some reflections derived from the experience of teaching this course during six consecutive years:[1]

The course becomes a theme in itself. We realize that, after repeating the course for a number of years, this became a theme in itself, as if every new course were a variation of the previous ones. The exercises made by students in the previous years became the theme upon which new students create new variations. This can represent a risk of self-repetition, since some students tend to create in a rather mechanical way variations of themes that had been 'discovered' by previous students. In spite of this, the fact is that many students, year after year, have succeeded in creating their own personal interpretation of the themes we have proposed.

Generative modelling versus visual thinking. Although a quick look at some student work might suggest that they are exercises in generative

[1] A comprehensive collection of the most relevant student work created between 1991 and 1995 can be found in *http://caad.arch.ethz.ch/teaching/archive/archive.html.* The final presentation of the Winter semester 1995/96 can be found in *http://caad.arch.ethz.ch/teaching/caad/ws95/fp/*

modelling, the fact is that they are not. Both the theme and the variations have been created without the support of algorithmic representations. This warrants some explanation. Typically, an exercise in parametric design involves, in this order: 1. devising the algorithmic representation of a shape/object 2. generating the graphic representation of the shape/object after assigning values to parameters and 3. selecting the most appealing or promising shapes/objects from the point of view of the designer. To be sure, this is the most efficient way to create shapes (**shape**, not to be confused with **form**) in computer graphics. The problem is that the procedure followed to create those shapes is at odds with the way a designer creates form. In other words, while generative modelling has to do with generating *shape*, design has to with creating *form*.[1] Design, as Rudolf Arnheim and Paul Laseau had maintained, is basically 'visual thinking'. It encompasses the understanding of **form** through visual representations. Then, the reason why we ask students to make variations on a theme without the mediation of an algorithmic representation is because we want them to develop their visual thinking skills, that is, their design skills. We are not 'teaching the computer' to make variations of a theme, as some authors have sought to do,[2] but teaching architectural design to architectural students with the help of a computer.

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[1] Douglas Hofstadter has associated creativity with the creation of variations on a theme. In *Metamagical Themas* (Hofstadter, 1982) he contended for example that "Making variations on a theme is really the crux of creativity". But Hofstadter has refrained himself from identifying creativity with parametric variation. In *Gödel, Escher, Bach: an Eternal Golden Braid,* (Hofstadter, 1979) he related his frustration when after having written a computer program to create sentences, he realized that after a while the sentences fell within a given conceptual space and could not go beyond it. He writes: "At first it seemed very funny and had a certain charm, but soon it became rather stale. After reading a few pages of output one could sense the limits of the space in which the program was operating; and after that, seeing random points inside that space - even though each one was 'new'- was nothing new. This is, it seems to me, a general principle: you get bored with something not when you have exhausted its repertoire of behavior, but when you have mapped out the limits of the space that contains its behavior." (op.cit., p. 621)

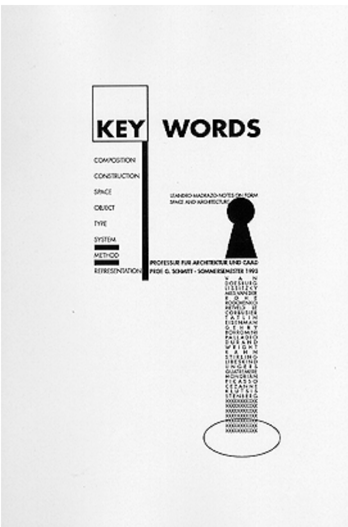
[2] George Hersey and Richard Freedman in *Possible Palladian Villas (Plus a Few Instructively Impossible Ones),* 1992, present a program that creates variations of Palladian villas according to the principles of parametric variation. The authors declare that "We have decided to teach a computer to design Palladian villas rather than doing it ourselves with pencil and paper." (op.cit., p.10). Robert Mc Kim, Experiences in Visual Thinking, 1972, wrote on the other hand: "Computers cannot see or dream, nor can they create: computers are language-bound. Similarly, thinkers who cannot escape the structure of language, who are unaware that thinking can occur in ways having little to do with language, are often utilizing only a small part of their brain that is indeed like a computer". We believe that this statement is still basically true.

The typological and non-typological modes of designing. From the different approaches adopted by students in the exercises, it is possible to distinguish two main approaches to form creation. First there is what we call the typological approach, according to which a designer would have in mind a strong *image*, *idea* or *type*, that serves as a guide during the design process. Only by being aware of this image, can a designer decide which formal transformations are appropriate for a given stage of the design process. In the second approach, which we call non-typological, the designer frees himself or herself from that strong image in an attempt to remain open to any sort of emerging form.[1] In reality, such a clear division between the two modes of creating form probably does not occur. In many of the examples, a form is the result of a mixed-process that combines both approaches, typological and non-typological.

The personal interaction. It is often taken for granted, that in a course with computers the most important issues are the computer tools and, eventually, the pedagogic method. By the same token, some basic aspects of education such as the capacity of the educator to motivate the students or the exchanges between students and teacher, are often ignored. However, at the risk of repeating the obvious, it must also be said that in a design course with computers the personal interaction is fundamental, and is as important, or even more important, than the method and the tools.

2. Keywords: The Aesthetics of Form

While the introductory course of the Winter semester is mostly concerned with the conceptual structures operating in the generation of abstract forms, the next course in the Summer semester advances towards more architectural issues. Now, aesthetic issues regarding form come to the fore. A basic premise of this course is that there exists a strong link between some fundamental principles of Modern Art and Architecture and the intrinsic representational capacities of the computer tools.[2]



typological and non-typological, has been formulated in in philosophy (the relation between the whole and the s (the different definitions of beauty from Vitruvius to t psychology (Arnheim's reference to 'organization from n below'), and in the field of design and computing ('top-om-up').

gman (Bruegmann, 1989) has referred to a possible tween the work of Russian constructivist artists and er graphics. He contends that the work of the Russian ov, "in which simple geometric 'primitives' are fairly simple operations, formed the basis of most ams designed for mechanical engineers -which in turn became the basis for many of the first programs for architects. Likewise Chernikov's use of brightly-coloured lines, frequently arrayed in dense parallel configurations or grids, is relatively easy to achieve on the computer". (op.cit., p. 142).

The course content is structured into eight *keywords*, namely, COMPOSITION, CONSTRUCTION, SPACE, OBJECT, TYPE, SYSTEM, METHOD and REPRESENTATION. The theoretical background for the course is contained in a script given to the students at the outset (Madrazo, 1992b). The following is a summary of the ideas developed in this text:

1. *Geometry as formal language*. The compositions of Theo van Doesburg and Piet Mondrian are pure combinations of lines and rectangles in an abstract space. Every formal configuration is presented as one among many others. Combinations are endless. A vocabulary of geometric figures and the possibility to combine them in endless ways is what characterizes any computer graphics tool.

2. *The concept of space*. A similar concept of space lies behind paintings, sculptures and buildings made by some of the leading artists at the beginning of the century. The *Counter-Constructions* of Theo van Doesburg, Gerrit Rietveld's *Red and Blue* chair and Mies van der Rohe's *Brick House*, are the expression of the same spatial concept: an abstract, Cartesian space that exists prior to the forms that are placed in it. Precisely, the sort of spatial concept which is built into any computer graphics program.

3. *Abstraction takes over reality*. In the early works of *avant-garde* painters, the traditional relationship between representation and reality began to change. The link that had kept them together since the Renaissance was broken. Representation no longer needed reality. Moreover, representation took over the place of reality. This was most clear in the work of Russian constructivists as, for example, in the early work of Tatlin or

Rodchenko. In Tatlin's *Selection of materials*, the objects are projected out from the canvas to become part of the real world. Similarly, the '*prouns'* of Lissitzky also reveal an exchange of roles between the abstract and the real. This exchangeability of the real and abstract worlds is intrinsic to computers.

4. *The abstract nature of modern architecture*. With a formal language based on simple geometric elements, came the retreat of architecture to the realm of abstraction. A building such as the Barcelona pavilion seems to belong more to the realm of abstraction than to reality: walls become abstract planes floating in an abstract space; reflections and transparencies contribute to give the impression that the building is not real. In the Barcelona pavilion, abstraction became an end in itself; the building itself being a 'materialized abstraction'. Other buildings of the same period started to look like enlarged models, for instance the Villa Savoye or the building of the Bauhaus. A transformation of architectural works into abstract objects is exactly what takes place as a result of modelling a building in the computer. In the realm of computers, architectural works are transformed into objects; architectural objects.

5. *The self- transforming objects.* Conceptually, some of the buildings of Le Corbusier can be understood as organisms made up of systems and subsystems. The Villa Savoye, for example, can be understood as a system made up of subsystems: a subsystem-*ramp*, a subsystem-*structural grid*, a subsystem-*circulation*. Considering it as an abstraction, the Villa Savoye can be compared to a living system in the process of continuous transformation. As in a living organism, an equilibrium between the different systems is never reached: there are tensions between the subsystem-*ramp* and the subsystem-*structural grid*. In principle, computers are bound to capture and to reproduce the sort of transformational process implicit in the Villa Savoye.

In the work of the artistic *avant-gardes*, the boundaries that separate painting, sculpture and architecture were consciously removed. What emerged instead was a new concern with the idea of representation. As a matter of fact, the biggest achievement of modern art was to make us aware that representation is the key question before any artistic creation, whether this is painting, sculpture or architecture. This awareness of the mediating role of representation in the process of creation is still a characteristic of contemporary art. Furthermore, the question of representation is the key issue underlying any creative work done with computers.

The course work

The course KEYWORDS took place in the Summer semesters of 1992 and 1993. The course work was structured in two distinct parts: one, limited to the first three *keywords* (COMPOSITION-CONSTRUCTION-SPACE) consisting of three short exercises; a second one, in which an architectural project was developed following the sequence of the remaining *keywords* (OBJECT-TYPE-SYSTEM-METHOD-REPRESENTATION).

Fig. 25. Composition. Balaji Bal, Summer semester 1992.

Fig. 26. Composition. Antonio Torres, Summer semester 1992.

In the first three exercises, original works created by artistic movements like De Sitjl, or Russian constructivism provided the aesthetic for the students to create new works. In the first exercise (COMPOSITION) students recreated the pavement design made by van Doesburg for the house De Vonk. The original design of van Doesburg consists of a vocabulary of color rectangles hierarchically organized. After making an interpretation of the rules of composition of the original design, students came up with their own set of rules which they used to create a new design. In the second exercise (CONSTRUCTION) the assignment was to create an object which could be both a sculpture and a piece of furniture. Rietveld’s furniture and some of the constructions of Klutsis were given as examples. In the third exercise (SPACE) the task was to create a three-dimensional space using a formal vocabulary of planes, as van Doesburg did in his counter-constructions.

Fig. 27. Construction. Miklos Gyarfas, Summer semester 1992.

Fig. 28. Construction. Herman Verkerk, Summer semester 1993.

Fig. 29, 30. Space. Miklos Gyarfas, Summer semester 1992.

Some reflections derived from teaching the course.

The provision of a conceptual space to create form. Modern art works provided a conceptual space within which students were able to create their exercises. These works have a enormous didactic value since they contain certain compositional rules that are easily apprehended by students. This was particularly important for students in the earlier semesters of the program who took part in the course. After grasping the compositional rules of the original work, these students could quickly invent their own work, often with remarkable results. On the other hand, students in the later semesters, who had already gained experience in design, were encouraged to create their own conceptual space, e.g. to develop their own aesthetic, and to forge a more conceptual relation between the works they created and the works of the artistic *avant-gardes*.

The aesthetic of the representation. One of the characteristics common to most of the work created by the pioneers of modern art is the conscious use of simple representational techniques (elementary shapes, elementary colors) to convey a strong conceptual content. Students were encouraged to apply a similar economy of representation with the computer tools they used. For most of the exercises, flat shading was the only representation technique. Properly used, this technique sufficed to achieve convincing results.

Art work and art work images. It is necessary to keep in mind the distinction between an original work of art and a digital image created after it. A composition based on a painting of Mondrian made with a computer graphics application, for example, is not necessarily comparable to the original Mondrian. They are indeed two different things. In one case we have electronic image displayed on the monitor; in the other is an original work of art materialized on a particular medium with pictorial techniques.[1]

Artistic principles and computer tools. Students responded favourably to the attempt to create a unified conceptual framework encompassing both the principles of modern art and computer tools. The discussion of ideas in the classroom proved to be inspiring for the students. The educator is fundamental for the success of this sort of courses. He or she needs to have a background in architecture and in computing, and be able to bring both worlds together.

3. Designing with Computers: The relation between conception and representation

The logical conclusion of this step-by-step strategy to introduce computers into architectural design is to apply them to the design of concrete architectural projects. The assignments have consisted of small projects: a tower, a private library. The sequence of *keywords* (OBJECT-TYPE-SYSTEM-METHOD-REPRESENTATION) provides the methodology for the design process. Students were asked to present a first scheme or idea at the volumetric level (OBJECT), and then explore variations of that scheme (TYPE) before committing themselves to a formal solution. At an advanced stage of the design, they were asked to consider this as a SYSTEM composed of different subsystems. Towards the end of the semester, the students were asked to trace back the design process they had followed and represent it in an schematic way (METHOD). In the whole design process, from the first sketch to the

[1] Regarding the relation between original works of modern art and works elaborated after them on the computer, it is necessary to keep in mind that the alleged mathematical character of certain pictorical compositions is not always true. This commentary on the work of Mondrian reminds us about this fact: "From 1920 on, Mondrian had struggled to correct the misconception that his art could be characterized as geometric. He insisted again and again that he did not work according to a system, but rather than intuition served as his sole creative guide. Neither friend nor foe seemed able to accept this entirely, and countless attempts have been made to decode the supposedly fixed and mathematically proportional relationships within his work. All such efforts have been fruitless, since it is demonstrably clear that Mondrian's compositional method was anything but systematic nor mathematical. The surfaces of his canvases are rich in subtle variations of texture and brushwork. Nothing was predetermined. Reworking, rethinking, and refining characterized his resolution of every problem". (Joosten, Rudenstime, 1994, p. 295).

final presentation, students were encouraged to seek a consistency between the design and its REPRESENTATION.

Fig. 31, 32. Kiosk in Paradeplatz. Christian Lauterburg, Summer semester 1993.

Fig. 33, 34. Kiosk in Paradeplatz. Herman Verkerk, Summer semester 1993.

Fig. 35. Kiosk in Paradeplatz. Herman Verkerk, Summer semester 1993.

Fig. 36. Private library. Zoran Zladoljev. Summer semester 1992.

Using computers for the purposes of architectural design raises the question of the relation between conception and representation. There is a strong tendency to use the computer to reproduce what has been previously created with other media (a sketch on paper, a line drawing, a mass model). In this event, the influence of the computer in the design is reduced to a minimum. At the other extreme, there have been attempts to carry out all the conceptual part of the design on the computer. Only in this way, it is claimed, is it possible to create really innovative forms that justify the application of computers in architectural design. In our courses, we have encouraged students to find a mid-way between both extremes: making extensive use of sketches and physical models while taking advantage of the capacities of the computer to model complex forms, to perceive the inner spaces, to understand the inner structure of the design, and to make representations of the final results.

Structures: Text, Shape, Object, Space, Light

This seminar has been carried out for the first time in the Winter semester 1996/97 in the postgraduate program, at the ETH Zurich. The purpose of the seminar is the understanding of what -almost paraphrasing Giedion- we might refer to as *fundamental facts*[1] of architecture, those that have to do with the conception and perception of form, space and light. The purpose of the course is to integrate *gestaltung*, architectural theory and computers in a unified theoretical discourse.

The central theme of the course is the notion of STRUCTURE, which is analyzed from the five different points of view: *text*, *shape*, *object*, *space* and *light*. Each one of these keywords is in fact a model of thought through which some fundamental facts of architecture can be revealed.

Fig. 37. STRUCTURES: on-line script and entry page of the Nachdiplomstudium of the Winter semester

[1] In *Space, Time and Architecture*, Sigfried Giedion distinguished between constituent and transitory facts in architecture. Constituent facts in architecture were for Giedion those "tendencies which, when they are suppressed, inevitably reappear" (Giedion, 1954, p. 18). He mentioned the undulating wall or the open ground plan as examples of such constituent facts. Transitory facts, on the other hand, were those that could only be valid for a particular period of time. We are using the expression 'fundamental fact' to refer to a series of issues that are common to the architecture of all times: the incidence of the light in the interior space, the inner structure of the form of a building, the opposition between object and space.

1996/97.L.Madrazo.(http://caad.arch.ethz.ch/teaching/nds/ws96)

It is common to refer to the structure of a text, or to the structure of a shape, of an object, of a space or even to the structure of light. In all of these cases we mean an inner order that can be intellectually apprehended, that is, a structure. Structure is then what all of these models of thought (text, shape, object, space, light) have in common. However, to define structure itself is a more difficult task, since structure, like other synonyms of form, is a tautological notion that eludes definition.

The course consisted of lectures followed by a two-week exercise. The script with the course content was published both in paper (Madrazo 1996) and electronically in the Internet (*http://caad.arch.ethz.ch/teaching/nds/ws96)*. The exercises were presented by each of the students to the rest of the class with an Internet browser projected on a large screen.

The following is a short summary of some of the topics discussed in each one of the five parts of the course and the description of the corresponding exercises:

TEXT. *Topics:* the evolution of hypertext and hypermedia; the relation between the structure of a text and hypertext and mental structures; Hume's notion of association of ideas; the relation between language and reality in James Joyce's *Finnegans Wake*.

> *Exercise:* the exercise consisted on the analysis of three manifestos by Mies van der Rohe, Theo van Doesburg and Le Corbusier. The task was to unfold the critical vocabulary in theses texts, to confront the use of similar terms by different writers; to associate images or/and texts to the critical terms; to make a personal reflection about the content of the text, and its relation to today's architectural problematic. Tools: Internet browser.

Fig. 38. Text. Cross-reading of three manifestos. Cristina Besomi, Winter semester 1996/97.

SHAPE. *Topics*: the process of figuration to abstraction in Modern painting; the notion of formal language in Mondrian's compositions; synesthesia of pictorial and musical compositions in Mondrian's *Broadway Boogie-Woogie*; the iconic and symbolic character of the pictorial sign in the works of Klee and Mondrian.

Exercise: analysis of Mondrian's *Broadway Boogie-Woogie* reproducing it with vector images and raster images; implementation of the inner structure of the composition by means of layers and blocks; application of the same formal language to create a different composition, in another context. Tools: vector based and pixel based programs.

Fig. 39. Shape. Analysis of Mondrian's Broadway Boogie-Woogie. Malgorzata Miskiewicz, Winter semester 1996/97.

OBJECT. *Topics*: three different formal languages of form generation: the language of the solid, the language of the plane, the language of the frame; the relevance of structural form in architectural theory: the theories of Vitruvius, Laugier, Viollet-le-Duc; the influence of structural form in the invention of a new art form: Russian constructivism; the role of the different formal languages in the invention of Modern architecture as well as in contemporary architectural creations.

Exercise: to create an architectural object, based on one of the three formal languages (solid, plane, frame); to experiment different translations between formal languages, for example, from frame to plane, from plane to solid. Tools: a general purpose three-dimensional computer program, sketches, physical models.

Fig. 40. Object. Translation from planes to solid. Cristina Besomi, Winter semester 1996/97.

SPACE. *Topics:* distinction between two notions of space: space as the abstract relation between objects, and space as the inner cavity or void; relationships between notions of space in architecture and other notions of space developed in other fields; distinction between space representation, and existential space in Renaissance painting; architecture as composition of spaces: *la promenade architecturale* from Le Corbusier; the concept of space in Kevin Lynch's *The Image of the City*.

Exercise: to create a composition of spaces, concentrating in the relation between space and motion. Tools: animation programs, slide shows, VRML.

Fig. 41 Space. Multiple spatial representa-tions. Malgorzata Miskiewicz, Winter semester 1996/97.

LIGHT. *Topics*: concepts of light as formulated in fields like philosophy, optics and physics; distinction between representation of light and light as a natural phenomenon: Renaissance painting versus the Flemish school of painting; the relation between scientific theories of vision and impressionist painting in nineteenth century; architecture as inner space and light; distinction between the conceptual and phenomenological dimensions of architecture: the work of James Turrell and Toyo Yto.

Exercise: to create an inner space, using light as *gestaltung* element. Tools: a radiosity rendering program, image editors.

Fig. 42, 43. Light. Shadows shaping space. Bettina Müller, Winter semester 1996/97

Fig. 44. Spiritual vs. hectic spaces. Albina Grzesik, Winter semester 1996/97.

Fig. 45. Three spatial ambiences: andante, allegro, vivace. Malgorzata Miskiewicz, Winter semester 1996/97.

Conclusions

The integration of computers in architectural education represents a big challenge for architectural educators. It is necessary to devise appropriate strategies, to create adequate conceptual frameworks within which the application of computers becomes meaningful for architectural education. Those educators willing to meet this intellectual challenge must not only be knowledgeable in computer technology but, also, be able to confront the whole complexity of issues that affect architectural education. This means being able to transcend artificial boundaries that separate the field of computer architectural design from other fields, like *gestaltung*, architectural design and architectural theory. Indeed, the most relevant contribution that computers can bring to architectural education today is the possibility of integrating in a unified discourse, different subject-matters that traditionally have been kept separate in the architectural curriculum.

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References

Arnheim, Rudolf (1977). The Dynamics of Architectural Form. University of California Press. Berkeley and Los Angeles.

Bruegmann, Robert (1989). ‘The Pencil and the Electronic Sketchboard: Architectural Representation and the Computer’. Published in Architecture and its Image. Eve Blau and Edward Kaufman, editors. Canadian Center for Architecture, Montreal.

Giedion, Sigfried (1954). Space, Time and Architecture. Harvard University Press, Cambridge. First published in 1941.

Itten, Johannes (1975). Gestaltungs- und Formenlehre. Otto Maier Verlag Ravensburg.

Hersey, George and Richard Freedman (1992). Possible Palladian Villas (Plus a Few Instructively Impossible Ones). The MIT Press, Cambridge and London.

Hofstadter, Douglas R. (1979). Gödel, Escher, Bach: an Eternal Golden Brain. Penguin Books.

Hofstadter, Douglas R. (1982). 'Metamagical Themas. Variations on a theme as the essence of imagination'. Scientific American, October.

Joosten, Joop and Angelica Zander Rudenstime (1994), Catalogue of the exhibition Piet Mondrian 1872-1944, Leonardo Arte.

McKim, Robert (1972). Experiences in Visual Thinking. Monterrey, California. Brooks/Cole.

Madrazo, Leandro (1992a). Design Education with Computers. Proceedings of CAAD Futures '91. Gerhard Schmitt, editor. Vieweg &Sohn. Wiesbaden.

Madrazo, Leandro (1992b). Keywords: Notes on Form, Space and Architecture. Publication of the Professur für Architektur und CAAD, ETH Zürich.

Madrazo, Leandro (1993). Entwurfsunterricht mit dem Computer: eine Methode. In New Realities-Neue Wirklichkeiten. Entwerfen im Zeichen des Computers. Museum für Gestaltung Zürich.

Madrazo, Leandro (1996). Structures: Text, Shape, Object, Space, Light. Publication of the Professur für Architektur und CAAD, ETH Zürich.