The architectural design machine: an interactive grid to (e-)learning

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The goals of Winds Research

This version of the Global Resource Information Database (GRID) system is a development of that drafted, as part of *Winds* research, by the Turin Polytechnic research team headed by Giancarlo Motta. When mention is made below to *"Winds Grid"*, we are referring to the results of our work carried out within the framework of *Winds (Web based INtelligent Design tutoring System)* research, financed by the European Community under the *5th Framework, Information Society Technologies programme, Flexible University key actions*, coordinated by Prof. Mario De Grassi of Ancona University.

Compared with the research hypotheses of the *Design Machines*, developed previously by our team in Turin, and their scope, construction of the *Winds GRID* took a further step forward, i.e. compare the problematic nature of architectural design to the functioning of a machine. From this point of view, it has been conceived within the more general context of systems and mechanisms that guide and address the solving of complex problems.

Further to the above, we considered it very useful to operate in close contact with studies addressing, as initial target, the application of e-learning systems to architectural design.

Participating in the *Winds* research project, we were convinced that working within a set of research projects on web-based teaching of architectural design, with the contribution of more than twenty European Universities in ten different countries, would play an important role in our studies on design machines. In fact, the significant progress made on these topics has been promoted not only by exchange with various Universities and researchers but, above all, by the work of our study group.

The tested-and-tried mechanisms of e-learning

Originally, Winds research was intended to develop and test distance teaching and learning of a subject or rather of a "practice" as we could more correctly define "architectural design". Our initial approach was to start with traditional design courses, without modifying their specific nature or usual methods of teaching, but simply adapting these to permit forms of transmission of knowledge and control of learning such as those gradually defined around the most widely-used methods of "offering" e-learning. The use of the Web network for teaching, the possibility of consulting theoretical and information material via *metadata*, direct querying and periodic checks, the fast speed of response of lecturers and tutors are all aspects that developed independently of the subjects involved case by case in the teaching offer; a sort of constantly-evolving, tested-and-tried format able to adapt to an ever broader range of subjects and teaching methods, especially those referring to humanistic and scientific subjects regulated by a disciplinary rules and characterized by propedeutic support that is widely shared also on an international scale and which do not, therefore, require any very particular knowledge transmission tools or specific methods of verifying learning and progress of individual work.

In these application environments, it could be concluded that the success of a University course based on e-learning can be measured according to the extent to which the results obtained are comparable with those of the same course based on conventional methods. Research applications intended to investigate the possible value added of e-learning compared with the reference discipline are few and far between.

The teaching of architectural design entails technical difficulties due to the peculiar characteristics of this type of teaching: these include not only the large number of figures, animations and drawings necessary to develop the various courses, but also the fact that students and tutors communicate by exchanging, in some cases, highly complex drawings. In order to "simulate" the direct, personal relationship between tutor and student in constructing the project, it was

considered necessary to use computer-based "revision" mechanisms that require use of particular software such as for example *Collaborate!* developed some time ago by Nemetschek for Winds. The real-time "revision" of progress of the work carried out traditionally at Universities will be "emulated" as far as possible (but, however, never achieved) using increasingly sophisticated information technologies and with as short as possible reply times by the structure that provides the service.
I do not think that this interpretation of distance teaching of architectural design can be considered effective except in cases in which it is necessary to provide this particular "service" to off-campus students unable to attend the University. In the case of the research we carry out and in particular in *Wind* research projects, it was not so much a question of establishing the facilities for a service to be provided but to research methods of transmission of knowledge, more precisely into possible innovation of theoretical assumptions and of the operating procedures as regards the teaching of architectural design.

Our position in Winds

Therefore, in our case, the research carried out was not directed towards solving the technical problems of distance teaching but rather towards investigating the procedures of thought inherent in the construction of the architectural project. Our inquiry was steered first and foremost towards defining the extent to which these are already characterized by high levels of mechanicity and therefore whether and how they are already pre-engineered to be rethought and relocated inside the construction of computer-based operating systems able to promote and accompany design as real machines.
Our interest in establishing an ever closer relationship between the inquiry into design and the topics of the machine is also to be attributed to our particular cultural background and, in particular, to the legacy of the school of Aldo Rossi. His teaching of design was characterized by a completely rational approach and by the major role assigned to the formulation of shared, transmittable principles; as opposed to the idea of considering design as a moment of personal expression and will, priority was given to the identification of already formally defined, constant elements such as architectural types and the use of almost mechanical mechanisms of repetition due to the importance of the references, but also to particular techniques such as copying and citation, recognized as positive steps in the construction of the project.
Furthermore, the hypothesis, which we developed in detail also following the Winds research, that the design machine is itself an architecture or a complex set of architectures, is rooted in this same cultural background. From Aldo Rossi's considerations regarding architecture as a theatre of life intended to accommodate various functions, as an appliance that is set to perform an action or so that an event takes place and develops, we moved to the hypothesis of viewing architecture as the set of structures and formal schemes that permits the formation and development of thought, as a device or machine in which memory, reasoning and imagination are organized and structured.
The research in which we have been engaged for some time now concerns architecture as a machine which, as it certainly participates in the construction of thought, can operate even more effectively for that particular form of thought represented by architectural design.
The fundamental stages of Web-based teaching of architectural design are based on the construction of a set of machine-modules, sub species constructions of architecture in which the various design operations are carried out "mechanically".
Obviously, this is not in contrast with and does not exclude the creative component of design, the individual contribution that cannot be taught, but which is an essential element of architectural production. These decisions are inserted in a context that applies high levels of necessity and of mechanicity in the conception and processing of the project. This does not guarantee the production of works of art, which is not the task of the school or of teaching, but makes it possible to achieve a higher quality of the projects.

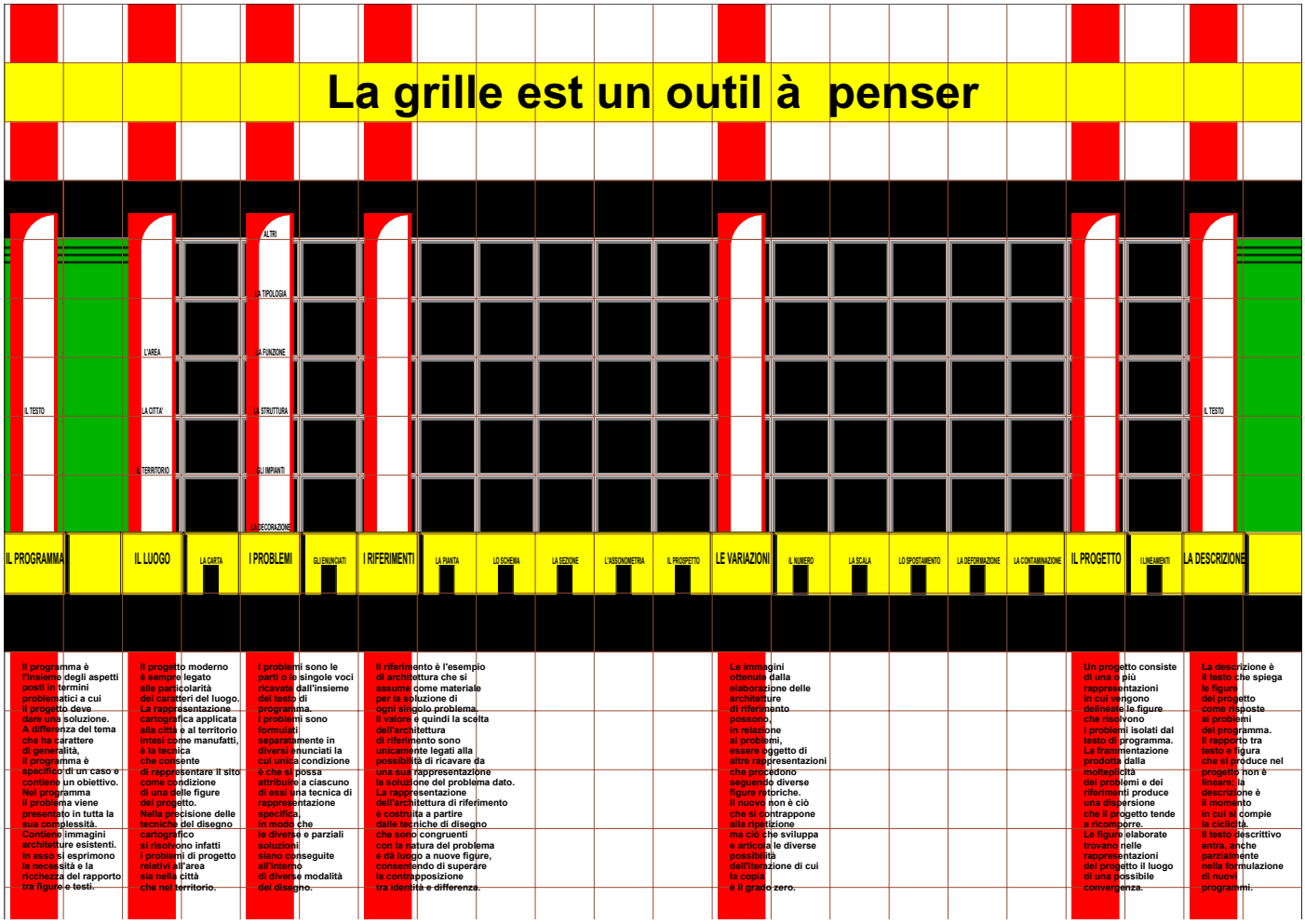


fig. 1 - La griglia elaborata in occasione del cinquantenario del CIAM del 1949 dal Gruppo di Ricerca diretto da Giancarlo Motta al Politecnico di Torino

The students relies on the lessons and the assistance of tutors only to learn how to use and control the machine, not for any maieutic type relationship of affinity or ascendance. Information technology disciplines and tools play an active part in carrying out the research and make it possible to control its complexity.
As the machine has the nature of thought, following the steps of the machine, the student learns how to refine his/her way of thinking.

The positive results of Winds

These were the underlying hypotheses of our work within the framework of Winds research; other groups, without the same interest in developing a design machine, have pursued other objectives. These were oriented mainly towards understanding the behavior patterns that are developed between teacher and student and how these can be classified and inserted inside the new web-based media thanks to the contribution, essential for this purpose, of the cognitive sciences.
The topic on which the entire research returned interesting results, at least in prospective, was the formulation and structure of the so-called *Concept index* instrument.
This is an index of keywords or concepts that are treated in different ways in the courses of the various researchers. Used as hypertext, they make it possible to move quickly inside the various texts of the lessons and to construct, via links, a personal learning path. The similarities with the procedure of composition applied by the student to the figures make this instrument particularly suited to accompany the design activity.
The proposed construction of this confirms that it can be become a real topic of research. In fact, the Concept index is one of the cases in which the complex, multifaceted research carried out inside the Winds experiment has succeeded in highlighting possible, promising paths of further

study that were defined also during joint discussions. They extend far beyond the systemizing of results developed in the platform carefully drawn up by Fraunhofer.
In the field of architecture, and even more so as regards architectural design, we encounter design teaching techniques that are highly personalized or referred to the figure of the teacher, to an uncertain regulation of the discipline or, for the most part, which are not so generally accepted as to be taken as a stable basis for new, unifying forms of transmission of knowledge. Its marked interdisciplinary character and poly-technical nature no doubt contribute to this difficulty. Therefore, for architecture, no shared basis exists except in groups with the same culture which are very often concentrated in single country of origin.
The final operation indicated in the Winds portal consisted in dividing the texts presented by each of the 28 groups of the 10 different countries into paragraphs, each attributed to a single item of the Concept index and in de-contextualization of the images from the reference texts. This involved a sport of "chopping" operation in which, passing all the material through a "mincer" paved the way to the possibility of moving away from an approach based on various cultural and methodological characteristics towards the possibility for the students of constructing individual paths, also in often unconventional or surprising ways. We do not know whether this expedient will make it possible to aim at more closely shared understanding of the theoretical and application aspects of the subject, but the breaking down of closed logics that seldom communicate with each other is certainly a first step towards new forms of knowledge.

The "Winds Grid" as experimentation in view of construction of a design machine

Construction of the design as part of a computerized and on-line system brings into focus more general theoretical questions relating to the relationships between the machine and thought, and the specifications of the procedures of architecture and the design disciplines which regard the possibility to accomplish a future potential development of an authentic "machine" that can build complete designs. Our sights have been set on this goal at least since the studies conducted on the mechanisms of representation, techniques and tools of cartography, the formal structure of the text and in particular, the program text.
The entire system of the various Winds research studies and, at least from our perspective, the experiments specifically conducted on the computerized grid developed during the research, supplement the matters already defined as the direction of the study (see G. M. and A. P., *L'orologio di Vitruvio, introduzione allo studio della macchina di progetto*, Milan, Unicopli, 1998). In the hypothesis that a grid, perceived as a simple "tool for thought" and a guide to operations that were for most part entrusted to personal elaboration, these experiments confirmed that it is indeed possible to advance to construction of a much more elaborate and complex machine, designed and constructed according to the architectural design, but that also, we believe, can be posed as a significant model and important result, which must be achieved in respect of the studies whose objective is construction of intelligent machines or at the very least, some of their components.
From this perspective, the strategic value of the design machine lies in the fact that architectural design is one of the most complex forms of thought, a form that employs all the mental faculties, from memory to reasoning to imagination, and yet is one of simplest and most elementary. Perhaps it is also the one that is easiest to translate into an orderly series of procedures in which very distinct operations are carried out, each of which features a high level of individualism. This is why future studies on the machine, initiated as part of the architecture and which we conducted as part of the Winds research, foresee the contribution of other disciplines such as philosophy, psychology and cognitive sciences, CAD, computers, and research applied to artificial intelligence, on this very theme.
In reference to just one of the disciplines mentioned above, we noted that the study of design and the resulting relationship between machine and thought is shaped in a way that is common

to contemporary philosophical thought, which interrogates the nature of thought and what it means to think. The question has always been central to philosophy and was posed with clarity in relation to the question of the machine and alternatively, to the philosophy of the subject of Heiddeger in *What it means to think*, taken from M. Foucault especially in *The Archaeology of Knowledge*, by Deleuze, almost in all of his writings, and by Derrida who, in this text as well as *La Grammatologie*, poses the question on the presence of the machine and structures assimilated to it. The first of these is writing, perceived as "gram" in the production of thought if not even in the most basic possibility of its existence, laying out a line of research and a tradition that had its most important precedents in the writings of Kant, *Was heißt: sich im Denken orientieren?*. This question is destined to have very important repercussions as regards construction of a theory of design. The shrinking importance of the subject and the shift in attention from the figure of the artist, perceived as the source from which the work derives, to the various machines (cinema and literature, for the authors mentioned above, or the "blank page" by Mallarmé) where thought is produced as an event that leads to very deep modifications in the project and more generally, in the design of architecture. This ceases to be viewed as a manifestation and concretization of a thought which is formed primarily in the mind of the architect and is the expression of his cultural tradition, his background, and his vision of history; the design already lies in the grid even if only by virtue of the projects that we can come up with to meet the instrumental capability of the grid.
While one of the main theoretical objectives of the WINDS research was to shed light on design procedures and to focus the investigation on its mechanisms, namely what is achieved, certainly in the work conducted by us, it is because only in this way is that aura of ineffability and mystery which it is often associated with it removed. The astonishment diminishes, the sense of mystery disappears and the need to resort to terms such as "creativity" gives way until we are finally able to consider thought as an activity that has no origin, because in a certain sense, everything already existed and was contained in that part of the machine which is its memory and which the project dips into each time, producing the singularity and the novelty of the responses.

What was partially achieved during the Winds research and in relation to the matters discussed, beyond the results effectively reached, was the possibility to define, at least in its general configuration, a design machine. This machine aids work in the area of the construction of architectural designs through fixed procedures that can be replicated and coded. Like all machines, it is a tool that controls and verifies the rationality of the procedure, acceleration of production and elevating the quality of the results. A machine like this, as in all other cases, does not replace thought because it is not the other side of thought or its opposite, but rather, it is an enabler to development, enhancing and accentuating its capability.
Two characteristics have been identified, defined in their importance and contained in the final form of the interactive grid as it has been constructed in view of the design experiments for the Winds research and which we believe should be considered vital and therefore constantly present in any subsequent research developments whose objective is construction of the design machine. The first is the machine (in the previous case, the grid) is also an architecture, the second is that, since it is part of the system of machines that guide to problem solving, the design machine must respect one of the main characteristics which is what must be constructed for components or modules each of which is designed for solution of particular problems.
The idea that a thinking machine has the characteristics of architecture and the semblances of one or, more likely, a complex set of buildings, is related to the fact that architecture has always had the ability to build and give shape to places in which the various methods of thought are produced. Since ancient times, speculations and theories have sought to define the various capabilities of thought (memory, reasoning, and imagination) and have done so using the construction of architecture as a frame of reference or by making use of different types of buildings. In truth, the interactive grid we've formulated is presented as architecture, yes, but the architecture is present

at a nearly symbolic and very "superficial" level, just a bit more than the simple geometric chequered pattern. However, it noted the possible development of construction of the machine which, making use of the capabilities offered by information technologies in constructing virtual spaces, configured as a complex set of buildings, each time destined to fulfil the specific phases or methods of thought and in which the virtual, physical and personalized path – each time fresh and new - that winds through the plethora of places and spaces, will correspond in the end to the intellectual thought of the construction of the design.
The second characteristic of the interactive grid constructed as part of the Winds research is construction by modules. This structure depends on the fact that a machine conceived for architectural design can be inserted into a system of machines that guide in problem-solving. If the programme can be considered as the text that contains the general and complex formulation of the problem, the project is the answer and the relationship is the text that provides the explanation; the bulk of the work of the machine lies between the first and the last time. The structure of the grid splits up the complex problem represented by the programme into a series of smaller problems. Based on a sort of upended engineering, in which the various functional components that come together to build the project are isolated, made autonomous and subsequently woven together, the grid is traced back module by module, each of which functions like a small machine designed for the solution of a specific, individual problem.
If the great machine of the architectural design is developed from the research concluded here, it will be comprised of a group of machines: text machines, representational machines, memory and data file machines, logical procedure machines and combinatorial machines. Each of these or any parts of it will be constructed on an architectonic model, just as the whole design machine, emerging from an elementary prototype of the intelligent machine, will have a rich, multiform, and complex aspect of a *Theatrum architectonicum*, perceived as the exposure and unfolding of the architectonic fact in all of its many aspects: from the simplest linear outlines, to two- and three-dimensional grids, to the types, the cross-sections and the spatial simulations. The design machine will be a sort of architectonic virtual reality. A world like the city of Benjamin guides thought, teaches how to navigate the roads, and, by differentiating itself from the natural world of the forest, can make its digressions productive and getting lost useful.

The interactive Winds Grid

The interactive grid produced for Winds research represents the next step in our previous grid, based on the design procedures and constructed especially for the fiftieth anniversary celebrations of CIAM of Bergamo in 1949 (fig. 1), during which the Grid was introduced, conceived in the preceding years by Le Corbusier with the Ascoral group. Unlike this early experience, which was inspired by the studies on the design machine and established its image and the contents in a graphic environment of an architectonic nature (fig. 1), the Winds grid was developed like a hypertext web environment, accessible from a main grid that takes the form of a building. This first phase gives access to an integrated system of data and lessons in which the main theories are explained, that guide the various steps of the design and the related operations to carry out. In addition, the student is required to locate and give order to the design documents. In this way, the grid holds a double value: theoretical, by providing the student with the lessons and the explanations related to the exercises; and a second more applied nature which allows the student to execute a full-blown design in which he must describe all the logical steps carried out by positioning the documents produced in the grid.
The web pages which make up the system are essentially three types: the pages that include the data (a design programme, the cartographic documents of a site, the reference architectures, the model, and the rhetorical structure) which are variable and are thus added to the system gradually; the pages that are a stable part of the programme, in this case deals with lessons or their abstracts and act as key words; and finally, the pages created directly by the student in placing his or her design in the grid.

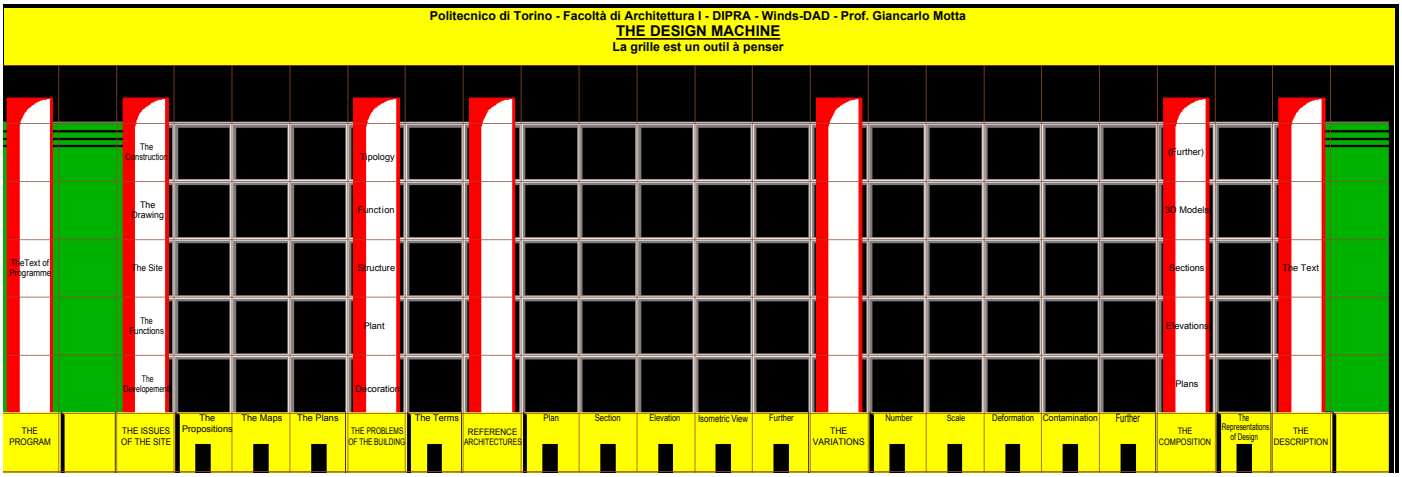


fig. 2 - La griglia interattiva *Winds*

Giving an orderly space to the design operations, the grid acts like a Building of Memory that shows the logical structure of the design and the order of its steps in the form of spaces inserted into architecture. Using a building to represent the movement of thought or to help the conservation of the memory is an age-old tradition in which the Winds grid belongs completely, proposing yet again - and in one case, particularly emblematic as it is the one of teaching the design - the role of architecture in the functioning of thought. This is why the grid was designed as a machine that must teach how to design architecture and thus is presented as an architecture.

- The structure: the base, the columns, the wall and the framework. The grid is presented as a building viewed in elevation and made up of a base, columns, walls and structural framework. Some of these architectonic elements feature words which link to other web pages of the system. The words regard the steps making up the design procedure. The bases of the columns show the names of the main links: the programme, the place and the problems related to it, the architectonic problems and the references that resolve them, the composition variations, etc. The column shaft lists the possible examples for each of the steps indicated: for example, the problem column is divided into typological, decorative and functional problems, etc. Between one column and another, the structural framework forms cells where the student must use links to introduce his or her designs to other pages, whether these are texts (as in the case of the complicated formulations), or involve graphic documents (as in the case of the design documents). The horizontal base includes the data supplied by the design machine; the vertical elements such as the wall and columns provide the problem data (programme and references), the black cells of the framework are exclusively designated to the student's work.

- The rooms: the web pages. The depth and the architectonic space, albeit virtual, of the grid are only inferred here by the presence of other web pages, directly accessible from the main grid. The main pages relate to the programme text and are accessible from the bases of the columns of the first grid, which contains the operating units with the lessons, the abstracts and exercises. All these pages are graphically connected to the design of the main grid with respect to which they are presented as components.

- Distribution: the links. All the pages are connected together by links ordered vertically according to the hierarchical structure of the system and horizontally between the pages of the same level.

- The pathways: The interactivity and multiplicity of access ways. As an architecture, the grid does not propose a structure fixed in time. Since it is essentially a sequence of spaces, it enables movement without having to follow a pre-ordered and hierarchical pathway. As regards theoretical and practical learning, the student is free to choose his or her own learning path and to perform the exercises proposed.

As mentioned, with respect to the architecture of the grid, all these web pages can be assimilated to the same number of rooms in which the topics are presented. It should be possible to access all the others from each one and thus, visit the entire architecture complex of the designing thought, but this is an objective that we have set for ourselves by opening up the research on the construction of the design machine to contributions offered by other disciplines such as cognitive and information sciences.

Sections and operating units

The Course is made up of four educational sections, each of which is divided into two different operating units: the first of a more theoretical nature and the other more directly connected to design exercise. In every case, all the units are composed of lessons and exercises.

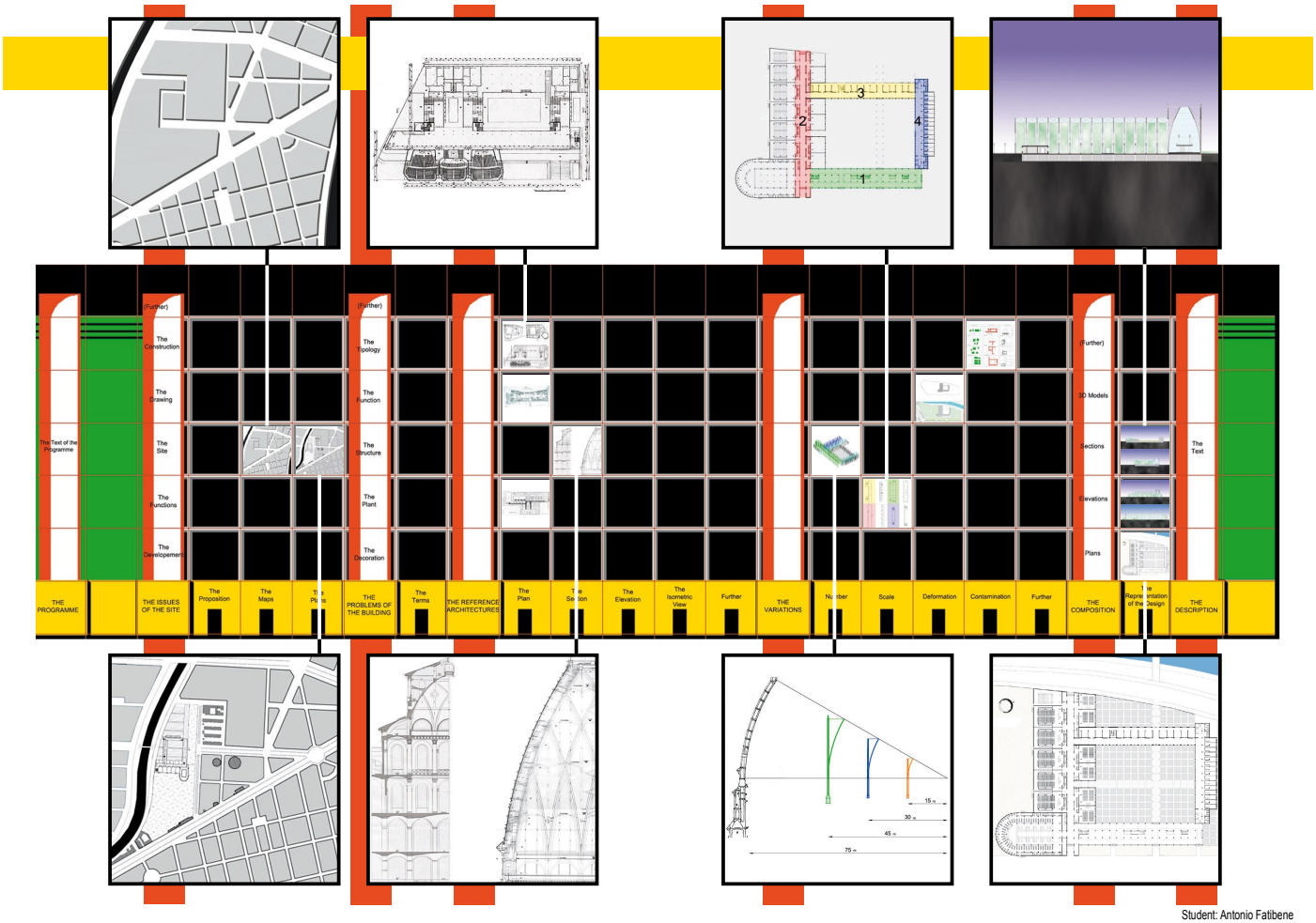
- **The first section** is devoted to the operation of the design in general (first unit) and redrafting and building the programme (second unit). The first unit includes the question of the design machine in its general terms, considering it as a machine of thought and positioning it in the tradition of the writings and theories that have historically involved architectural design. In the second unit, the student is encouraged to formulate a personalized design programme, intersecting two types of text: texts of a primarily problematic nature that involve the requests formulated by the University offices and texts that contain the descriptions of some buildings that are university campuses; both are associated with outlines, figures and representations that will be play a role in the project documents. The construction operation of the programme serves mainly to clarify the ties that connect the text and the figure and the prescriptions and the descriptive texts. A well-constructed programme is demonstrated to be very useful machine for the production of design figures.

- **The second section**, dedicated to issues regarding the place, allows the student to respond to problems related to the area, expressed by the design programme. The third operating unit is theoretical and introduces the cartographic aspect in its relationships with architectural design. The fourth unit is applied in nature. In the scope of the programme, formulation of these problems is accompanied by a series of theme sheets that illustrate the formal consequences and aspects related to the design of the sites. To the degree in which it already contains figures that conform to the choices defined, the sheet is made up of a real design construction machine. While it is a stable characteristic of the cartographic tool in general, we add to this the characteristics of superior operability that come from its stratification into separate layers, distinguishing features of computerized cartography.

- **In the third section**, the Course takes a rational and precise approach to developing the opportunities that emerge from the use of reference architectures to solve design problems. The fifth operating unit describes procedures of analysis and design, generally considered opposing, as belonging to a single procedure that is taken in one direction in one instance and reverses direction in another. The exercise conducted by the student in the sixth unit consists of taking the figures derived from the architecture design and reusing them in his or her own design. Also in this case, a quasi mechanical derivative relationship is established from the problem to its solution, represented in this case by the unusual representation of the reference architecture.

- **In the fourth section**, finally, the student tests his or her skills against composition techniques that, beginning with the themes laid out in the text of the programme, are applied to the figures that were extracted in the third section. The seventh operating unit investigates the diverse characteristics that architectonic composition assumes in relation to the other relationships that are established with other disciplines, outside the scope of architecture. To the degree that these are formalized and therefore, have some sort of internal architecture, they represent precise, yet still random models of composition, applicable to construction of the design. Since the composition of the literary text and the rhetorical figures have supplied one of the models most commonly followed by architects, the decision was made to build this fourth part of the grid by partially using the rules.

The computerized grid makes for a more complex path and allows us to work with the computerized materials available. In the current grid, we cannot access places where several operations appear automatically. For example, given all the necessary information related to the layout of a building, the various representations intrinsic to the layout are reinstated, such as the typological, functional or structural, or given a figure, they allow automatic production of the variations, the deformations to multiply the figure or set up other figures. The grid is not yet able to automatically carry out any of the operations that must be manually executed, as foreseen in the design path and what's more, lying outside the spaces of the grid.
This is why the history of this experimentation does not conclude with an explanation of the results achieved, but rather, with the developmental prospects of a theme that, initiated as the simple desire give some order to design operations in view of its teaching to students, sets even more ambitious objectives. The centrality of the architecture is the assumption of interdisciplinary relations whose purpose is construction, but it would be best to say the architectonic design, of the machine for elaboration of the architectural design, perceived as the first model of an entirely and fully thinking machine. The title could be: "Architecture is the thinking machine".



Student: Antonio Fatibene

fig. 3

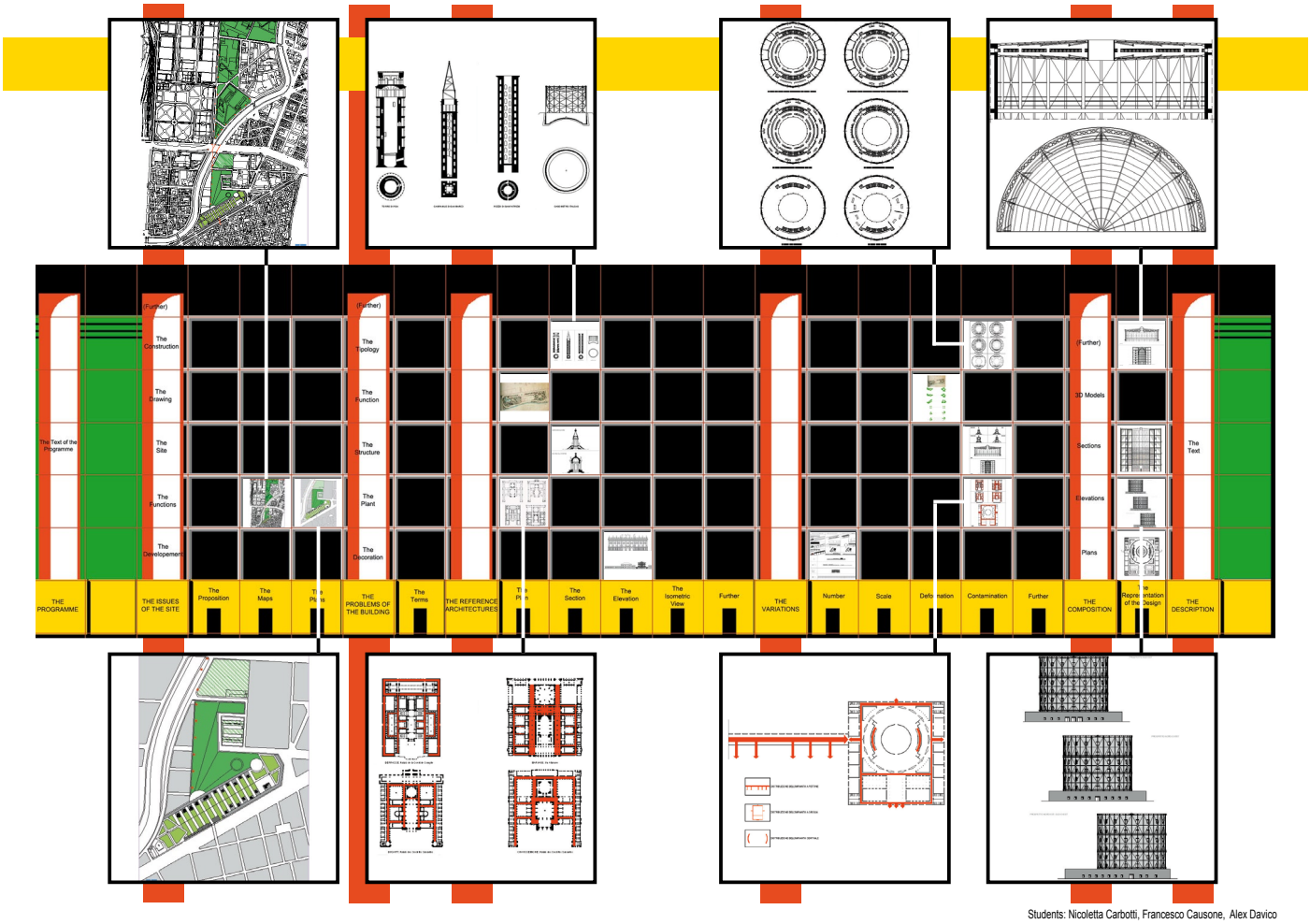


fig. 4

The initial formulation of the grid (fig.1), the interactive Winds Grid (fig.2) and two examples taken from the experiments made as part of the course (fig.3, fig.4)