BIM STRATEGIES
IN ARCHITECTURAL PROJECT MANAGEMENT

Carlo Biagini
DICeA - Dipartimento di Ingegneria Civile e Ambientale, Università di Firenze (I)
cbiagini@dicea.unifi.it

ABSTRACT

Nowadays terms such as “parametric CAD”, “Building Information Modeling” (BIM) and “interoperability” of software, seem to be the keywords to the latest developments in the field of informatic applications dedicated to architectural design. Besides the great interest shown by the media, the application of new software to great projects and construction processes of international architectural works has become a popular marketing operation for a wider range of users. But this new offer of IT products for architecture suits only a few professional organizations able to feed-back their specific needs; instead more frequently the personal expectations of single designers meet with unsatisfactory results. The interest of big software houses for University didactics has greatly increased, especially for Design and Drawing subjects, being considered a favourite channel for the diffusion of the new info-graphic practice. This poses some questions regarding the most correct levels of teaching permeability for a continuous offer of implementing new codes in building project management. The following considerations are the result of a teaching experience at the Civil and Environmental Engineering Department of Florence University, on the occasion of an innovative teaching program during workshop activities using IT tools, finalised at providing an approach based on subject integration for building project management in each phase of decisional process.
Keywords: parametric CAD, Building Information Modeling, interoperability, constructability.

RESUMEN

Los términos “CAD paramétrico” e “interoperabilidad” entre software parecen hoy constituir las palabras llave para interpretar los últimos desarrollos en el campo del las aplicaciones informáticas dedicadas al proyecto en arquitectura. Más recientemente la notable resonancia que ha tenido en los “media” de sector la aplicación de nuevos software a los grandes procesos de proyecto y construcción de obras internacionales de arquitectura, se ha traducido en una martillante operación de marketing hacia más amplias fajas de usuarios. Con respecto a esta nueva oferta de productos de IT para la arquitectura, solo pocas estructuras de proyecto están en condición de constituirse como terminales de proceso de feed-back para la formulación de específicas exigencias; más frecuentemente el síngulo profesionista responde sobre la base de expectaciones personales no siempre correspondientes en el plano de los resultados. También a nivel de atención de las grandes casas de producción de software hacia la didáctica universitaria, sobretodo para las disciplinas del Dibujo, consideradas como canal privilegiado de difusión de las nuevas proceduras infográficas, resulta notablemente aumentado, planteando interrogativos sobre más correctos niveles de permeabilidad del enseñamiento a la continua oferta de implementación de nuevos códigos para la gestión del proyecto de arquitectura. Las siguientes consideraciones derivan de una experiencia didáctica desarrollada cerca el Departimiento de Ingeniería Civil de la Universidad de Florencia, en ocasión de un programa de inovación didáctica, que se proponía en el ámbito de las actividades de laboratorio la utilización de un aproche basado en la integración disciplinar, finalizado e la gestión del proyecto edil en cada fase del proceso decisional.

Palabras llave: CAD paramétrico, Building Information Modeling, interoperabilidad, constructabilidad.

1 Some questions posed by Information Technology in teaching

In recent years there have been profound changes in Information Technologies to support decision and management processes for architectural projects that progressively involve each phase of the development of the project in the different levels of specification.

To a growing demand for automation in each operative and disciplinary sector, the informatic applications were not always clear and univocal and sometimes failed to meet the users expectations in terms of efficiency and performance. It is clear that innovative rapidity represents one of the peculiar features of Information Technology, thus avoiding the typical sedimentation of other technologies which have longer periods for the accumulation of knowledge, selection of technical solutions and dilation of learning times.

One of the major difficulties in decoding the informatic market orientation is the actual relation between the declared potentiality of an automation proposal in a specific project phase and the effective performances that the software can really offer. It is a fact that new informatic products have frequently represented no more than a promise of a result, to which only successive revisions have assured a real operative application.

A further element of uncertainty in IT as regards the construction sector, is represented by the highly fragmented offer mainly composed of single applications related to specific phases of project development, whose numerical codes are not always able to ensure the exchange of information needed between different applications.

But it appears from the most innovative software applications for architectural design, that there is an attempt to manage the whole process by creating just one working environment in which it is possible to operate with continuity until construction phase. This trend appears more and more in recent “parametric” and “interoperable” CAD products called BIM (Building Information Modeling).

Information Technology enters into university teaching in different ways essentially depending on the complexity levels of software used, with a positive transfer of knowledge and operative tools from the research sector where the applications have highly specialised contents.

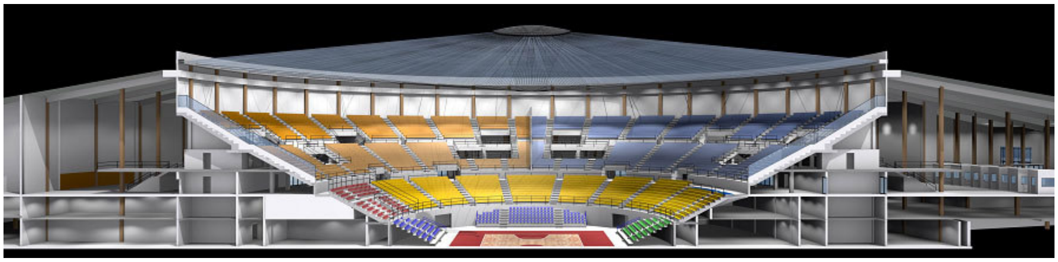
The case is different for computer tools that support the basic competence of a building designer, where on the one hand the range offered becomes larger and considerably diversified, and on the other hand the choice of a specific software is largely affected by aspects of managing the entire project process by each of the professional organizations.

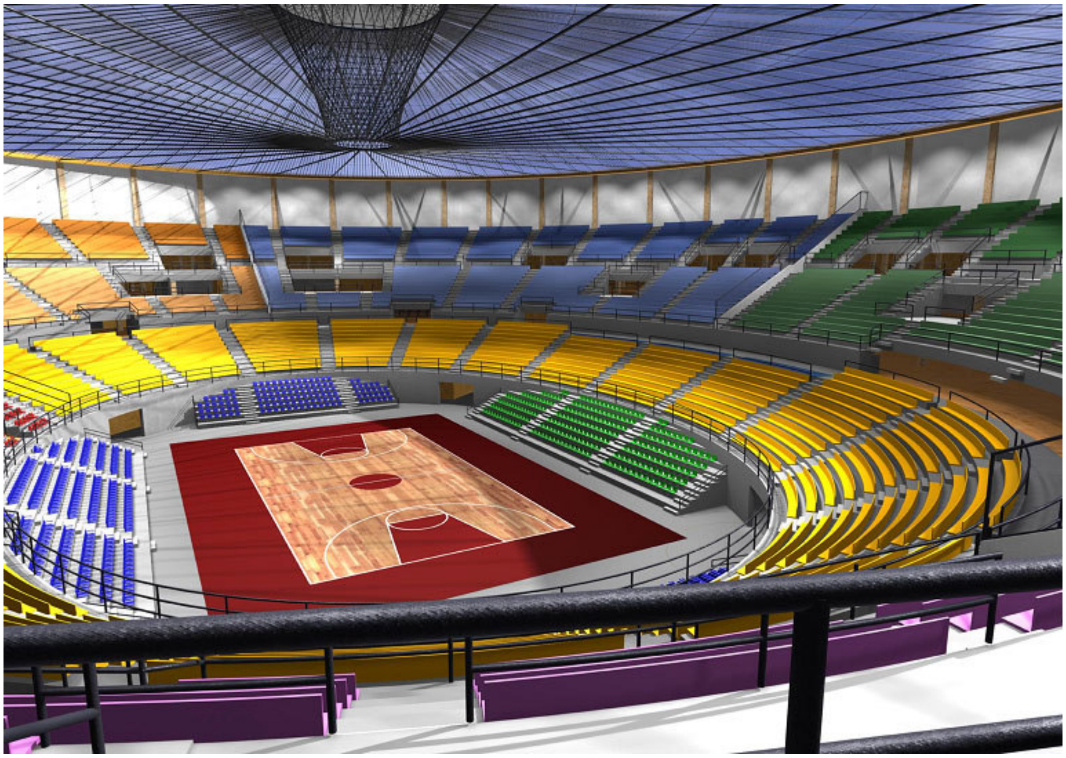
The interest of the big software houses for university teaching is great, especially for Design and Drawing subjects, being considered a favourite channel for the diffusion of the latest info-graphic procedures. In particular, the business policy of cheap “educational” licences addressed to students has also favoured the extensive appearance of informatic platforms of remarkable complexity. Therefore, one needs to ask oneself a few questions about the most correct levels of teaching permeability for the continuous offer of the newest code of implementation for building project management, and the actual relation between educational contents and the operative tools which allow for their exchange.

Teaching approaches supported by IT tools can be various, either in the organization of teaching methods clearly based on their employment, or in the simple use of graphic outputs for project analysis at the lowest level of teaching interaction. But even other specialised subjects may need teaching forms of “visual computing”.

So the fundamental references on which one should formulate an organic hypothesis of didactics supported by IT tools, have to be searched for in the educational aims set as a base for various Degree Courses in which every teacher has to work: in subjects that characterize them, in order to connect the same subjects in paths of teaching providing a close integration of the specific contents. In these years “integrated courses” and “didactic workshops” are held in Italian Universities to have an integration of disciplines.

The following considerations are the result of an experience made at the Civil and Environmental Engineering Department of Florence University, in the course of an innovative teaching program during workshop activities with IT tools aimed at providing an approach based on subject integration for the management of building projects in each phase of decisional process.





Figures 1, 2. Digital drawings of final didactic workshop

2 Recent Information Technologies orientations in building project management

One first of all needs to ascertain which lines of development have been followed in the last few years in IT research for building and in particular what changes have been introduced in project processes and technical information communication. We can identify some research fields of Information Technology which have had a significant fall in terms of innovation in many sectors of the construction industry [6].

An important ambit is represented by *organizing context* where operators work with different integration requirements: large engineering or construction companies need to regulate the information flow between staff and external contractors differently from temporary associations of architects, who form a virtual organization engaged in a single project.

Another sector is *software technology* which is able to introduce new languages, numerical applications and standards for data exchange. Through the development of new IT "architecture systems”, they allow many users to share the same communication ways on homogeneous platforms.

Project and technology constructions are application fields in which IT acts directly on architecture semantic, affecting the decisional process and communication of information.

As for IT applications relating to the field of construction, it is possible to find some sectors in which research of solutions for building process automation is concentrated: on tridimensional modelling, management of technical document design, calculation and testing of building performances and its components, topography and survey.

The problem of modeling can be identified as the problem of “representation of construction information”, and so relates to the real ways of percepting architectonic space.

From this aspect, the concepts elaborated by scientific visualization and developed by computational graphic, have provided a useful method of approach to the conversion of numerical data in images [8].

“Visualization turns symbols into geometry, allowing researchers to observe their simulation and computation ... Visualization studies those human and computer mechanisms that enable them to perceive, use and communicate visual information” in conformity”.

Nevertheless, a digital tridimensional model upsets those mechanisms of natural transposition of ideas in drawing, which is explained through auto-reflecting mental processes of logical identification of a “sign”, making graphic representation a simple post-processing product of a numerical reality expressed in bit sequences. But “paradoxically the condition where numerical drives the visual offers representation potentialities much more similar to natural ones and a complete description in object representation” [8].

The hypotheses which accompanied the first informatization of project representation, based on improvement of efficiency of already codified processes through CAD tools, now appear outdated. Instead 3D building digital models are data structures accessible through visualization proceedings, able to manage information in every phase of the project process.

A fundamental passage in architectural project management is the software progress of *tridimensional modelling* towards *parametric modelling* systems.

In a simple 3D modelling software, a building is made by assembling primitive geometric forms which transform themselves into “significant” complex forms referring to “signification” of architectural elements.

Other *rendering* functions allow the strengthening of iconic reference of the digital model, applying realistic images to surfaces, simulating real building material features of texture and colour.

Not so different from maquette, these digital models set in a logic of a “representative order” [7] of architectonic space, strengthened by dynamic visualization possibilities, come surprisingly near to the perception of experiencing actual reality.

From a functional point of view, a model made inside a project process falls within the decisional and communication phases of building morphology explaining in an iconic way the relationship between formal code and architectonic language articulation.

This limit is connected to the inefficiency of simple tridimensional modelling in managing geometric features of the various elements forming the model related to geometric and positional relations arising between them.

Instead, parametric modelling overcomes this difficulty, allowing any geometric and dimensional change of a single element of a 3D model to recalibrate the transformation over all elements connected with the first one and to reconfigure them according to newly introduced forms and dimensions.

This paves the way for a series of enormous potentialities in architectural project management, because the connection of such models with relational databases makes the construction of an integrated informative system possible, capable of organizing dynamics of building processes.

The 3D model elements are no more characterized just by their geometry but by features specifying technical and technological properties composing a significant relationship structure that simulates the real technical performances of building sub-systems.

A building is made in a virtual space in analogy of a real site, beginning from foundation elements, pilaster and beam elements, floor elements, etc. By virtue of the parametric type of geometric properties, positional and functional relations established between each other, each point of variation in a model element corresponds to an automatic update of all occurrences of the other components.

Such an approach to making a tridimensional digital model is called “parametric modeling”, and it marks the pass from traditional CAD to BIM software for integrated planning (Building Information Modeling).

In these years BIM softwares have begun to spread into professional organisations of both middle and small dimensions, but their potentialities have still mostly to develop, being limited to a better coordination of project documentation (particularly in management of plans, sections, views, executive details, etc.) and to an automatic update of representation code of technical drawings in changing the scale.

Nevertheless the effective innovation which can reasonably be expected from BIM, has to be found in the possibility of developing a more efficient management of different project levels also in relation to temporal sequences of investigation involving various specialised services allowing operators to act inside the same working model on the basis of different degrees of priority fixed by the project manager.

In particular solutions are found to recurrent problems of congruence and interference among various technological sub-systems and a global update of technical documentation in every project modification at one of the planning levels.

In this context there is a need for *interoperability* among software, or to guarantee free data exchange among applications through a standard system of description and classification of different objects making a building internationally recognized and usable by various software. The IFC standard (Industry Foundation Classes), developed in IAI ambit (International Alliance for Interoperability) pursues this aim [10].

3 Architectural project management in professional training

The educational aims of the Degree Course in Building Engineering Sciences, activated by the Faculty of Engineering at Florence University, define a profile of graduates able to work in different professional ambits in relation to phases of programming, planning, realization and management of building systems. The course is particularly aimed at providing methodological and operative tools for setting and solving problems related to "technical feasibility" of buildings.

This statement, which is the basis of the didactic organization of the course, stresses some methodological issues concerning architectural design culture in polytechnic schools, which can substantially be expressed as:

- an interdisciplinary "simultaneous" approach to project process;
- a unitary form of relationship between project and construction in the process of realization

3.1 Simultaneity

Architectural project has nowadays reached complexity levels, preventing exclusive management entrusted to the personal skills and experience of a single designer. The outline of great international works of architecture shows more and more the determining role in new formal achievements of technical and technological innovation and especially of project simulation process and construction phases planning. The project quality, therefore, measures itself not only in its creative items but also in its capacity to be an efficient tool for the change control.

In industrial fields the problem has been confronted for some time with project management methods, which try to overcome the usual separation between *concept* and process *engineering* by an approach called "concurrent": "concurrent or simultaneous engineering consists of a systematic, integrated and simultaneous conception of products and their connected processes with consideration to all the elements of the life cycle of the project from conception to delivery to users, to finding a satisfactory solution as to quality, costs, time, safety and environmental impact" [3].

A significant aspect of this approach consists in overcoming the traditional decisional process of the project of the additive-sequential type, to attain a definition by anticipating all decisions from the beginning, although only summarily, verifying them later by investigating their congruence step by step. From this point of view, concurrent engineering tends to exalt integration items of the project process and team-work in decisions made and consequently reduce the projects different needs to just one aim.

In building projects the thematic areas that can find useful integration are multiple. In more recurrent cases, these refer to typological features of building definition in which generally the specific competences of operators involved in project process are united. it is possible to find the following types of factors: *urbanistic and environmental factors, geometric and dimensional factors, technical factors, formal factors.*

Integration methods of various thematic areas of building project are characterized by the great variety of relations among specific competences regarding building typology, economic and productive context, evolution level of technologies and building processes, etc..

The prevailing trend today is that one develops a project process distinctly divided into competence areas, in which every operator works separately, eventually seeking coordination with the other process actors only in a test phase for proposing solutions; therefore congruence and compatibility problems sometime become insuperable through the simple updating of the working plan.

It is clear then that the prospect of *integrated project* (or concurrent engineering) represents an approach able to innovate the project process especially in systematic relations among different operators, in quality analysis for solving problems, in levels of communication and participation of project choices.

3.2 Processuality

It is possible to characterize a building project into two great operative ambits, that essentially regarding the solutions of technical aspects on one hand, and that of organizing the management of building process on the other. A great part of building production of recent years was actually based on principles of separation between concept and construction, which is an element of great weakness in the decisional process system and of unstableness in constructive ones.

The project must therefore not only be able to communicate information related to the spatial and technical configuration of building through a definition of costs and expected performances, but also become the tool leading the production processes. To reach this aim there must be a management of building "constructability" from the first phases of concept.

"Constructability means that design, detail development and planning take into consideration the problems of the construction process in order to get the expected result in safety and at the lowest possible cost" [1].

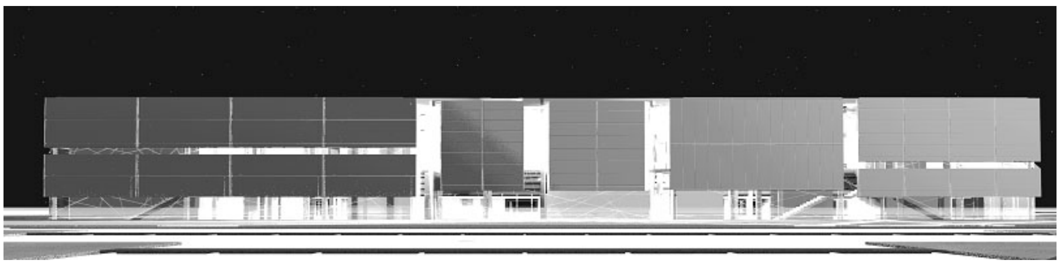
The problems, which are recorded either in the construction phase or in building management, because of insufficient analysis of constructability in the project's concept phase, are manifold and can regard aspects relating to lack of careful study of the executive project and especially of reciprocal interference between technological sub-systems, and inadequate forecast of times, costs and ways of executing work.

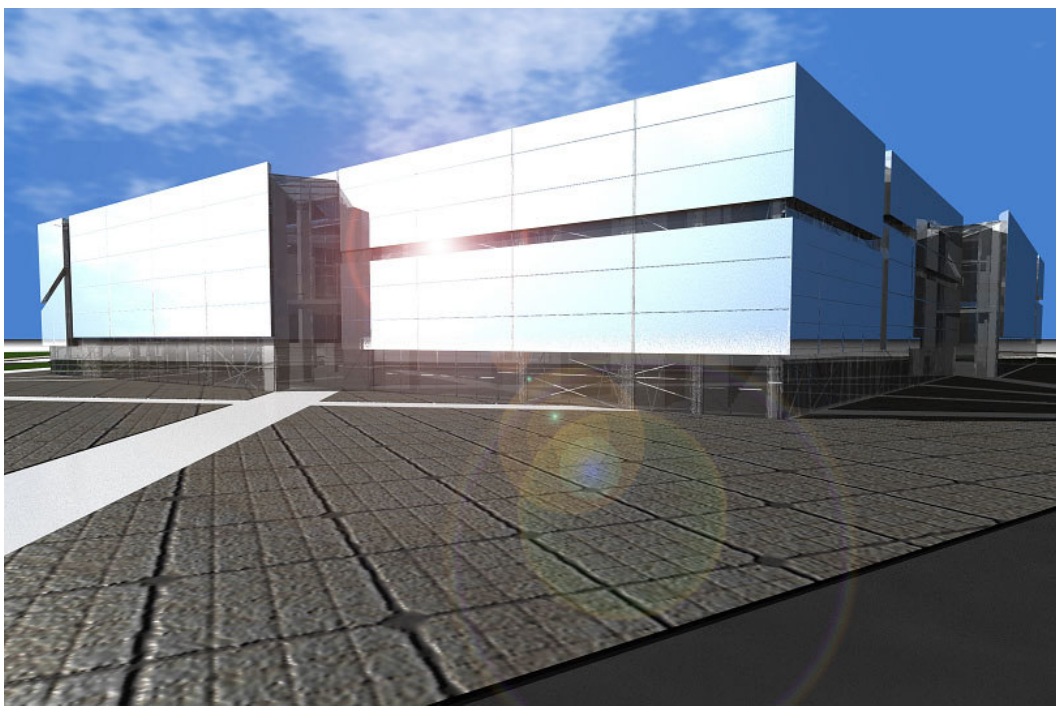
We can list some among these: contradiction and incongruity among project documents, insufficient development of executive details, ambiguity in graphic representation and wrong interpretation of elaborates, unforeseen physical interferences among technical elements of building (structures, installations, finishing, etc.), lay-out and tolerance problems, inadequate valuation of practice for laying and assembly of components also in relation to safe management on site, etc. [4].

Therefore the constructability management in the project process presupposes a widening of performances expected from the project besides simple architectural concepts, extending to phases of planning, detail development, times and costs analysis, and organization of construction phases.

For this reason the graphic representation of the technological project, codified in "Technical Drawing", becomes one of the most effective tools leading the construction process, of which we can briefly summarise the principles in the following statements:

- constructive details must be accurate and without ambiguity;
- constructive details must be able to be realised with simple assembly operations;
- constructive details must be well thought out, seeking to get maximum use of manpower, tools and equipment use and foreseeing their reciprocal interactions in the realization phase.





Figures 3, 4. Digital drawings of final didactic workshop

4 Towards an approach of concurrent engineering

The comparison between the new orientations of IT in architectural project and the didactic aims in professional training of building engineer, evidences significant convergences about methods and disciplinal approaches to management of building system complexity.

The improvement of project processes needs new forms of integration of organizing systems, either of an horizontal kind through the development of the capacity of simultaneous action, or of a vertical kind by definition of tools for "diachronic" management of construction processes. The solution of problems of reliability of the flow of information between various operators of the construction process and management of technical documentation is therefore at the centre of every integration strategy.

From a teaching point of view, an approach of concurrent engineering in a building project may represent an operative methodology that can develop manifold aptitudes in students to: find solutions to technological sub-system integration, work in teams, understand complex multidisciplinary problems, recognize roles and competences inside the project and building process. Therefore new prospects offered by parametric software BIM, according to IFC standards for data exchange, seem to verify the working hypothesis of more efficient approaches to building project management: interoperability, parametric modelling, technological integration and operative simultaneity are the most innovative items of parametric modeller that meet the needs of student training in the teaching of architectural design.

References

[1] ILLINGWORTH J.R., **Construction Methods and Planning**, E&F Spon, London 1993.

[2] MECCA S., MASERA M., CASALS CASANOVA M., BIAGINI C., BAZZOCCHI F., CAPONE P., **Comporre, convergere, concorrere**, Tip. Palagini, Pisa 2000.

[3] MECCA S., **Ingegneria concorrente e governo del progetto**, in MECCA et al., pp. 9-30, 2000.

[4] MASERA M., **Progetto, costruibilità e costruzione**, in MECCA et al., pp. 31-46, 2000.

[5] BIAGINI C., **Information Technology e automazione del progetto**, Firenze University Press, Firenze 2002.

[6] MASERA M., MECCA S., **Ingegneria concorrente e scambio dati nel progetto di costruzioni**, in BIAGINI, pp. 59-90, 2002.

[7] DE FUSCO R., **Il piacere dell'arte**, Editori Laterza, Bari 2004.

[8] GAIANI M., **Dal numerico al visuale: strategie di rappresentazione rendering-based**, in BIAGINI, pp. 21-57, 2002.

[9] PRATELLI A., **Codici del disegno di progetto**, Forum, Udine 2006.

[10] CAFFI V., **Le IT per il disegno di progetto**, in PRATELLI, pp. 453-67, 2006.

[11] CLINI P., ***e*ARCOM 07. Sistemi informativi per l'architettura**, Alinea, Firenze 2007.

[12] BIAGINI C., **L'IT nella gestione del progetto di architettura: quale didattica?**, in CLINI, pp. 132-7, 2007.