International Journal of Design Sciences & Technology

Volume 19 Number 2

ISSN 1630 - 7267

Editor-in-Chief:
Reza Beheshti
Khaldoun Zreik

Carrara, G. (2012). Retrospective collaboration in the architectural design process, International Journal of Design Sciences and Technology, 19:2, 123-136

Europia PRODUCTIONS

ISSN 1630 - 7267

15, avenue de Ségur,
75007 Paris, France.
Tel (Fr) 01 45 51 26 07 - (Int.) +33 1 45 51 26 07
Fax (Fr) 01 45 51 26 32- (Int.) +33 1 45 51 26 32
E-mail: ijdst@europia.org
http://www.europia.org/ijdst

Retrospective collaboration in the architectural design process

Gianfranco Carrara*
*Sapienza University of Rome, Italy. Email: gianfranco.carrara@uniroma1.it

The paper discusses over the reasons and nature of collaboration in the architectural design process showing why it has become both more necessary and difficult than in the past. The first step in facilitating collaboration is the recognition that different worldviews exist. Subsequently, a more comprehensive and semantically richer representation of knowledge used by any of the professions involved in the design process is needed. To overcome this problem many efforts have been done by the international scientific community, presented in several conferences and seminars. The paper thus makes the point on Europia 13, one of the most recent and complete conferences focused on collaborative design, where wide ranging subjects concur to present a general view of the complexity of the field.[1]

Keywords: architectural design process; generalization/specialization; collaboration; cross-disciplinary interaction

1 Crucial aspects of collaboration in architectural design

Any building, as a result of an architectural design process, is a complex system in account of the many functions it has to fulfil, of the many technical implications in its feasibility, of the many values and symbolic meaning with which it is charged, of the formal and aesthetic character typical of the cultural environment where it is conceived and built.

The design of such a complex system has evolved over time through a process both of specialization and generalization, although at first these two terms may appear to be antithetical.

As a matter of fact the present increased complexity of the built environment - technically, socially, financially, legally - requires, more than in the past, at the same time both specialization and generalization: specialization is needed to master the intricacies of each one of the many issues involved in designing a building, while generalization is needed to ensure that all pertinent issues are addressed.

Specialization is the by-product of our ever-increasing knowledge of a particular problem domain: each profession strives to discover and develop better understanding, improved methods and refined processes for accomplishing its tasks. This pursuit of knowledge inevitably increases its quantity, as well as its quality. Hence, it takes longer to master the profession. Herbert Simon estimated that once a profession reaches the point where it takes 10 years to master, it tends to break up into specializations.[2]

Our educational and professional systems promote and reward specialization: once composed of general practitioners, medicine, law, and engineering are now bustling with hundreds of specializations. Even architecture, the most 'general-

1 **EuropIA 13** International Conference entitled "Connecting Brains Shaping the World: Collaborative Design Spaces" that explicitly addressed collaborative working environments for architectural design. The conference, held in Rome at the Faculty of Civil and Industrial Engineering (8 to 11 June 2011), was organized by the Department of Civil, Building and Environmental Engineering of the Sapienza University of Rome, the University of Paris 8, Delft University of Technology and Design Research Foundation.

2 **Simon H.A.** (1969). The sciences of Artificial, MIT Press, Cambridge, MA

3 **Robbs R.W.** (1996). Leadership through collaboration, AI Architects, Volume 3, pp 11

ist' of all disciplines, has succumbed to specialization (witness the proliferation of PIAs (Professional Interest Areas) within the AIA: health care, codes & standards, construction management, housing, etc.).

Yet, knowledge required in designing a building is more than the sum total of all these specializations. Moreover, the responsibilities of each area of specialization overlap those of other areas, and impact the decisions that are made in those areas.

At present one of the major problems of design, I would say the basic one, is thus how to get the best of any specialists while getting the best of their thorough interaction.

Since we cannot reverse the specialization trend, and yet need to bring together in an overall integration all the specializations in order to fulfil the building design goals and requirements, we are left with only one option: collaboration.

Collaboration is defined as the agreement among specialists to share their abilities in a particular process, to achieve the larger objectives of the project as a whole, as defined by client, a community, or society at large.[3]

In a building design process collaboration is based on the presence of different specialists (actors) with different cultural and professional backgrounds. Each of them has to be able to study the design problem by his/her own point of view, to elaborate - according to his/her cultural and technical education - his/her own design solution, to generalize it in order to make it understood by any actor, and to transfer it to any other actor.

Collaboration is then the capability of any actor to integrate in his/her disciplinary and cultural domain other actors' solutions and to judge both the effect they have on his own solution and the way the whole system works, pointing out inconsistencies and/or suggesting proposals. Therefore collaboration in architectural design is based on the following cycle: communication, interpretation, understanding, elaboration, suggestion / proposal, discussion and agreement.

In the traditional design process this cycle took place through a direct exchange of knowledge by means of meetings among the actors. By this way it was possible to exchange and integrate low semantic level information (drawings, computations, texts etc.) with high semantic level one, such as concepts, reasoning, deductions etc.

Today, in our "globalized" society, design process is characterized by actors' delocalization, general use of ICT tools requiring formal languages, "desynchronization" of information exchanges; all this makes more complex the problem of communicating and, above all, of interpreting and understanding information. Design collaboration today is therefore more difficult than in the past, although its bases are almost the same.

The question, therefore, is not whether to collaborate, but rather how to collaborate. What is the best way in which specialists can put their separate, but complementary, knowledge together? What are the impediments to collaboration? Could we devise better ways to collaborate, which will yield the desired benefits and overcome the impediments?

The answer to these questions is not simple. In particular, three impediments hinder collaboration: technical, professional, and social impediments. Some can be overcome through technological innovations. Those are the "easy" ones. Professional impediments can be alleviated, if not overcome, through education. But the most difficult are the social impediments: those that are rooted in the psyche of the participants.

Collaboration is based on communication. The participants in order to collaborate must have access to shared, or shareable, project information. There are three problems in providing such access:

Semantics: information developed by one professional may not be comprehensible to others, due to the particular language and conventions each profession uses to code and represent its work. Solutions to this problem involve comprehensive databases that include information addressing the needs of more than one discipline. Such databases have been under development since the 1970s, but only recently have they attained wide acceptance in the form of Building Information Modelling (BIM). Still, such databases mostly address the properties of building components and subsystems, rather than their semantics. As such, a specific term may make sense to one professional, but not to others. Or worse, the same term may have different meanings for different professionals, leading to misunderstanding and conflicts. More recent attempts to overcome these impediments include ontologically-based building information models, where the terms are explicitly explained to avoid misinterpretation.

Synchronization: design information is developed incrementally and a-synchronously as the design of the building evolves. Hence, the information one professional needs to get from another professional, on which to base his work, may not yet be available. To avoid delays, the first professional may have to make decisions on matters that have not yet been fully considered. Or, the second professional may fill in the gaps with assumptions, which may or may not prove true.

Communication: the professionals involved in the design process use different methods and notational forms to record and communicate their work. Some use drawings of different kinds, others use numbers, and still others use shorthand references to standard materials or products. Typically, one professional is not versed in reading another profession’s representations, which can again lead to misunderstandings and errors.

Such technical impediments may be overcome through technical solutions. They are, therefore, the “easy” ones to overcome. Professional and social impediments, on the other hand, are more difficult to overcome, for the reason given below.

In their seminal book The Social Construction of Reality, Berger and Luckmann discuss the processes by which any body of knowledge comes to be accepted and recognized as *reality*.[4] They argue that “reality” is not an objective, value-less, fixed phenomenon, shared by everyone. Rather, it is a product of social systems through which human knowledge is developed, transmitted, and maintained. It is, in many ways, a matter of belief (witness, for example, the power of the Aristotelian view of the cosmos, compared with the Galilean one).

Likewise, there is no shared, objective basis for the design and evaluation of buildings (or any other product, for that matter). ‘Goodness,’ by any definition, can only be understood within the socially constructed reality within which the term is used. This reality, or worldview, is different for each one of the participants in the process of designing, constructing, and using buildings. It is developed through professional education and practice – the process of socializing

4 **Berger P.L.** & **Luckmann T.** (1967). The Social Construction of Reality, Anchor, New York

5 **Khun T.** (1962). Structures of Scientific Revolutions, University of Chicago Press, Chicago

leading to a specific way of thinking and acting: professionals are trained to understand the world in a particular way. Professional education teaches a 'right' way of seeing the world, and instils faith in that way which, over time, like a religion, eventually reaches a point where it can no longer be challenged.

Architects, engineers, construction managers, facilities managers, building owners, and end-users all have different worldviews. In general, architects emphasize the aesthetic quality of artefacts over the processes of making them. Engineers tend to emphasize the function or purpose of the artefact, placing less emphasis on formal qualities. Construction managers are interested mostly in the process of making, whereas facilities managers are interested in the process of maintaining. Owners and end-users are usually interested in the process of using the building, in as much as it enhances their activities and the achievement of their personal or institutional goals (i.e., how well the place supports the education of students, the manufacture of goods, or making people well).

To collaborate, participants in the design process need to develop a shared understanding of the qualities of the product and the many goals it strives to achieve. One way to instil such shared understanding is through collaborative education, in which students from one discipline work together with students from other related disciplines in order to experience the worldviews that guide the conceptions and work of others. Efforts to develop collaborative courses are under way in many universities.

Still, given that all the participants in a building enterprise have been educated in their own ways of seeing, understanding, and valuing the world, it is inevitable that there will be conflicts between their different socially constructed realities.

The first step in resolving such conflicts and facilitating joint action in the design, construction, and use of buildings is simply to recognize that different worldviews exist. Yet, it is surprising to see how often such recognition is hard to come by! The second step is to develop a tolerance and accommodation regarding worldviews other than one's own.

This is hard to do: it requires an initial suspension of judgment when considering the 'evidence' – the building, the phenomena that operate on it, and its uses. Suspension of judgment is difficult for everyone. It is even more difficult for design professionals, who are explicitly trained to evaluate and to judge, and to immediately seek actions that ensue from their observations, while discarding information that does not appear to be relevant to the actions being considered. Design professionals are trained to search for congruence between what they observe and the theoretical constructs of their respective professions, which they have come to accept as truth. Professionally, neither architects, nor engineers, nor construction managers are rewarded for suspending judgment, or for allowing other worldviews to alter their own.

Collaboration among different professionals, involves a meeting of differently constructed realities. According to Thomas Kuhn,[5] this condition is akin to a conflict between different paradigms. These paradigmatic conflicts can be resolved by: 1) persuading one side in the conflict to adopt the position of the other side; 2) striking a compromise between the beliefs inherent in both sides' paradigms; 3) jointly arriving at a new 'super- paradigm,' a process which requires a leap of faith on the part of the parties involved in the conflict.

Accepting either the first or second conflict resolution strategies involves the risk of reducing commitment by one or both parties, through diminished ownership or influence on the results. True collaboration thus requires a more expansive understanding of the worldview of the ‘other side,’ and a willingness to look for the ‘super-paradigm.’

True collaboration requires free choice, as well as an understanding of the pitfalls of assumed collaboration. The first requirement pertains to commitment and ownership of the results. If one of the parties is coerced into collaboration, the results will be unacceptable. The second requirement identifies relationships which seem collaborative, but actually are not. For example, assuming the role of an ‘expert,’ or a ‘helper,’ as is often done in professional practice, can easily destroy the collaborative model.

To achieve true collaboration, participants must establish conditions that are conducive to commitment and vulnerability. They must be willing to challenge their own professional and personal ‘rights’ and ‘wrongs’. This, in turn, is antithetical to their professional education, since it increases vulnerability and the risk of failure.

Collaboration, therefore, is much more than sharing data, ideas, and views about a joint project. It is a state of mind: a willingness to listen, as much as it is a willingness to talk. Furthermore, it is a willingness to open oneself up to the possibility of discovering and joining in the formation of new paradigms, as well as to risk failure.[6]

6 **Shibley R.G. & Schneekloth L.** (1988). Risking Collaboration: Professional Dilemmas in Evaluation and Design, Journal of Architecture and Planning Research, 5:4, pp 304-320

As stated earlier, the first step in facilitating collaboration is recognition that different worldviews exist. This means that design representations, of the kind used by each of the professions, must be inclusive of the information used by the other professions. Hence, a more comprehensive - and semantically richer - representation is needed.

The second step is to try to understand different worldviews. Translated into practical terms, this means the ability to predict and evaluate the consequences of design decisions from many different points of view, and the ability for them to be communicated among the professionals involved in the process. Since professionals rely on assumptions to complete the prediction and evaluation of any given product, these assumptions too must be shared.

The third step is to develop a tolerance and accommodation for different, competing assessments. This means the ability to perform tradeoffs, and the ability to evaluate the performance of the product as a whole, rather than individual performance aspects.

One of the conceptual difficulties of collaboration results from the ‘quality’ of information exchanged. In the “globalized world”, where several designers (operating as actors) that have to collaborate within a design process are delocalized and do not directly interface, design is carried out through complex networks and sophisticated software systems.

Nevertheless software usually treats low semantic level data, so all actors consequently deal with simple information that cannot be associated to any explicit knowledge nor fully understood. Such a problem is not only a technical one, but is what basically hampered the possibility of actually defining any Computer Supported Cooperative Work (CSCW) environment.

For achieving this goal actors have to interact at a high semantic level requiring explicitly formalized knowledge exchanging, in order they can understand each other directly on the design object itself while it is defined and proposed. By this way the knowledge and expertise of actors can be put together in a systemic design where the final result may be more that the simple sum of competencies. But, more important, actors should have a mental habit to reconcile their own needs, otherwise every application programs and design process methodologies fail.

Let us acknowledge this state of affairs: no primacy of one interest on another, one discipline on another; the only way out is an overall view in time, both in a narrow environment and in broader horizons to see these interconnections develop and emerge clearly. From this standpoint, each contrast is characterized by a wider context that is exclusively aimed at focusing on specific problems and so collaboration emerges as a key word, the paradigm of paradigms in our age.

In the closing years of the last millennium this term was used by more sensitive researchers,[7] first vaguely and then more and more explicitly until it gradually spread, with various ups and downs, to all aspects of science, research and society.

Not just a buzzword, therefore, but a key to unlock blocked situations that will accompany us for some considerable time in this new age.

2 Main research fields of architectural design collaboration: Europia 13 conference

Due to its theoretical and practical significance, the area of collaboration in architectural design has recently become the field of several research activities both of industry (BIM, IFC etc.) and universities. Major and most interesting results have been presented, as usual, in seminars, conferences and congress, contributing to the birth of a "*culture of collaboration*" in architectural design, as it was done some time ago in industrial fields such as aeronautics, special industry, ICT, etc.

One of the most recent, interesting and productive events in this field was EuropIA 13 International Conference entitled "*Connecting Brains Shaping the World ⇒ Collaborative Design Spaces*", explicitly addressing collaborative working environments for architectural design.[8] [9] The Conference was subdivided in six sessions corresponding to main arguments they deal with, and reflect the hottest and most promising fields of research at the moment:

- *Design Theory and Process Modelling*
- *Collaborative Management and Modelling for Design*
- *Generative and Parametric Design*
- *Sustainable/Green Design and Construction System*
- *Ontology, BIM and IFC Representations*
- *Collaboration in Case Studies*

The subjects of the first session, *Design Theory* and *Process Modelling* represents the core of the problems inherent in collaboration as the latter resides on how design knowledge is transferred and understood along the whole design process. In this session tree papers on *Collaborative Design Theory* were presented for the discussion, providing a broad and inclusive vision of design, a deep reflection on the role of trust in a design working environment and on epistemological and methodological studies applied to design in Architecture. The session highlighted the potentials offered by the state-of-the-art of ICT knowl-

7 For instance J.S. Gero, T.W. Maver, T. Kvan, I. Petrovič, G. Carrara, K. Papamichael, J. Pohl a.o.

8 **EuropIA 13** (2011). ibid

9 The EuropIA International Conferences series focus on "applications of Artificial Intelligence, Robotics and Image Processing to Architecture, Civil Engineering & Urban Planning", and aim at "promoting the advancement of information and communication technology (ICT) and effective application of ICT for the building and construction industry.

edge-based methods and technologies linked to the analysis of the way designers operate and to building models.

Antonio Fioravanti, Gianluigi Loffreda and Armando Trento referred to the multidisciplinary nature characterizing building design processes, that corresponds to the distribution of knowledge among the various specialists involved in a project.[10] It showed how the profound differences in the cultural and technical background of any actors, due to the wide variety of their professional and training experiences, are reflected in the widely varying modes in which they understand and consider the entities involved in the building process. The scenario in which the outlines and guidelines of a building project are delineated is symbolically expressed by the four 'poles' of a Knowledge Tetrahedron representing the different domains of knowledge involved in a building design process: product, context, actors and process. Knowledge Tetrahedron Model is a symbolic expression for a conceptually new kind of design representation that considers building design as an integration of several knowledge domains where interaction among actors can be made on entities at higher semantic levels instead of low level data sharing.

Jean-Pierre Briffaut started from the assumption that *mutual trust is the cornerstone of cooperation*, all the more so in virtual contexts. In his seminal book "Descartes' error", Damasio explains how emotions and feelings impact our beliefs and attitudes.[11] Beliefs are a key factor to foster trust and shun mutual fear.[12] Applying these concepts to virtual collaboration results in recommendations to supplement the conceptual model already designed by Carrara and Fioravanti to share knowledge in building projects. These supplements refer to reporting procedures to let each actor involved in a project know whether other actors' words are kept and their commitments fully and timely fulfilled. Otherwise withdrawal of cooperation turns to be the sanction.

Caroline Lecourtois presented an epistemological work on *scientific methodologies of architectural design studies*.[13] It compares *Cognitive Ergonomics* and *Applied Architecturology* as two different points of view on Architectural design. It uses a specific French research in which these two points of view are applied to explain the new kind of knowledge built with *Architecturology*. The specificity of architecturological research is to endeavour describing the cognitive activity of design with an applied methodology based on an *a priori* scientific language. The used applied methodologies confront scientific abstract concepts with empirical cases in order to describe their conception and, to pursue the scientific knowledge of *Architecturology*. The research referred to by this presentation is called *CoCrea* (Creative Collaboration); the purpose of which is better know the complex mechanisms of collaboration in digital architectural design space.

In the second session the broad themes of *Collaborative Management* and *Modelling for Design* were treated in four presentations.

Edwin Dado and Reza Beheshti assumed that physical testing and laboratory experiments are undoubtedly indispensable for the production of the best construction materials and the best building products.[14] This is due to the ever increasing demand for better quality, safety and sustainability required by new (EU) building regulations posing challenges for the Building and Construction industry. In this regard the authors developed intelligent virtual testing environments (VTEs) in order to use more modelling (calculation and simulation) instead of physical

10 **Fioravanti A.** et al (2011). An innovative comprehensive knowledge model of architectural design process, International Journal of Design Sciences and Technology, 18:1, pp 1-18

11 **Briffaut J-P.** (2011). Contribution of neurosciences for understanding the role of trust in IT-supported collaborative design environments, International Journal of Design Sciences and Technology, 18:1, pp 19-29

12 **Damasio A.R**. (1994-2006 revised). Descartes's Error- Emotion, Reason and the Human Brain, Vintage Books, London

13 **Lecourtois C.** (2011). Architecturological and epistemological research on collaborative design, International Journal of Design Sciences and Technology, 18:1, pp 31-45

14 **Dado E.** & **Beheshti R.** (2011). Towards development of an intelligent virtual testing environment for building products. In: Carrara G. et al eds (2011). Connecting brains shaping the world ⇒ Collaborative design spaces, Europia Productions, Paris, pp 41-52

testing and prototyping of construction materials and building products. The presentation showed some already concluded research projects trying to formulate the prerequisites for the development of intelligent VTEs.

Daniel Zignale, Gilles Halin and Sylvain Kubicki described the approach of the authors aimed at improving Computer Supported Collaborative Work (CSCW) in the particular context of construction projects.[15] In this context, numerous actors work together, assuming their own role and business tasks, depending on the nature of the project. According to these specificities, services proposed by groupware-tools cannot be generic but have to fit real needs. The authors propose a method for analysing and modelling role-specific business practices and identifying usages of groupware-tool services. The objective is to build an inventory of such practices and usages, based on model-driven approach.

Alcínia Sampaio, Ana Gomes, Augusto Gomes, Joana Santos and Daniel Rosário observed that the maintenance model allows the visual and interactive transmission of information related to the physical behaviour of the elements.[16] To this end, the basic knowledge of material most often used in walls, anomaly surveillance, techniques of rehabilitation, and inspection planning were studied. This information was included in a data base that supports the periodic inspection needed in a program of preventive maintenance. The results are obtained interactively and visualized in the virtual environment itself. A second prototype based on VR technology with application to construction planning, was implemented. The VR technology is used and presented as an innovative visual tool in supporting the fields of construction planning and of maintenance of buildings; it helps to establish a collaborative network between partners in a building.

Tomás Dorta, Yehuda Kalay, Annemarie Lesage and Edgar Pérez observed what designers do to ideate and to exteriorize a concept: mainly they talk and put qualitative and ambiguous mental images in external representations.[17] Verbalization on its own or combined with these representations drives ideation and is the most common means of externalizing design intentions in collaborative settings. It is presented in detail the different elements of the design conversation in a remote setting: Collaborative Ideation Loops, Collaborative Conversations and Collaborative Moving. They occurred while using the interconnected *Hybrid Ideation Space* (HIS) in the context of a multidisciplinary ad-hoc project between two universities located in different countries. The authors ran a research protocol in the format of a design “charrette” where two teams (team a: two architecture students, team b: two industrial design students) participated in the ideation of a bus shelter.

The third session**,** *Generative and Parametric Design,* had the highest number of presentations than the others, as it is probably one of the most promising and pervasive technologies in architectural design fields: shaping, façades, structural solutions, prototype construction, rapid manufacturing, etc.

Chiara Tuffanelli described the geometrical studies underlying the design and manufacturing of a 15 m multi-spherical mirrored sculpture.[18] Digital form-finding techniques that simulate gravity force, explicit history tools together with the study of sphere packing and curved mirror reflections, they allowed to develop a geometrical model that could adapt and change accordingly to the design and structural progress from the initial stage to the construction phase.

Anne Filson and Gary Rohrbacher described the design process of a series of

15 Zignale1 D. et al (2011). Modelling practices and usages to improve adaptation of groupware-tool services. In: Carrara G. et al eds (2011). Connecting brains shaping the world ⇒ Collaborative design spaces, Europia Productions, Paris, pp 53-66

16 Sampaio A. et al (2011). Maintenance and construction of buildings supported on interactive models, International Journal of Design Sciences and Technology, 18:1, pp 47-63

17 Dorta T. et al (2011). Elements of design conversation in the interconnected HIS, International Journal of Design Sciences and Technology, 18:2, pp 65-80

18 Tuffanelli Ch. (2011). Parametric design and construction: the “Tall Tree and the Eye” sculpture. In: Carrara G. et al eds (2011). Connecting brains shaping the world ⇒ Collaborative design spaces, Europia Productions, Paris, pp 97-110 digitally fabricated, customizable furniture and casework objects.[19] The furniture system leverages social networking and parametric technology to recast the roles of designer and user from a scenario where design is handed down to one where it can be offered up. The project investigated how directing the architect's professional expertise and intelligence toward collaborative and participatory design, can achieve a balance between controlled outcomes and open source design.

Thierry Ciblac focused on the development of non-standard architecture combined with the use of standard elements, particularly useful for economical and/or sustainable reasons.[20] The introduction of standard elements adapted to geometries far from parallelepipeds and freely designed raises a specific problem: the aim of the author was to explore some ways offered by computing tools in order to help architects in the design process of non-standard shapes using standard elements. He thus proposed an approach for a specific typology of systems composed of constant length elements. The used method is based on parametric modelling associated with constraint resolution algorithms.

Manuela Irlwek and Achim Menges assumed that parametric-algorithmic design processes enable design methods to extent.[21] Based on Horst Rittel´s methodology dealing with wicked problems, computational design methods transfer argumentation into dynamic processes. Each design problem is built up of a bundle of wicked problems. Design processes are complex and effect different disciplines simultaneously; problems on different levels of a design process are modified at the same time. Computational design allows high flexibility and exploration within a huge amount of data. It is important for the finite result to know which parameters remain flexible, which should be fixed and which will be obsolete during a process. The design process generates not only one method, but many methods. The target is to define new methods in parametric-algorithmic design processes and their behaviours and impacts on design operations.

Next to the possibilities of digital form-finding strategies, parametric design and computational visualization techniques, Marco Hemmerling focused on Rapid Prototyping and Rapid Manufacturing that allow today for the direct translation of the digital model into the physical world.[22] Against this background the academic project BOXEL tries to connect digital design strategies with appropriate construction principles and methods of assembly as well as ecologically worthwhile material usage to achieve significant spatial qualities. The role of computation can be seen more as a connecter and amplifier of various aspects rather than a predetermining form-generator. In that respect the project uses computation as light innovation in the architectural process. In order to establish a consistent and connected process including designer, engineer and producer the project exemplifies the need of managing interfaces between the different participants within the process.

Giuseppe Pellitteri and Raimondo Lattuca showed a system able to generate three-dimensional models of buildings, directly within a 3D *geo-browser* such as Google Earth TM.[23] To this goal the authors developed a prototype of parametric application that allows designer to handle the architectural shape by using main constraints belonging to urban regulations. The system integrates two different research topics: modelling in geo-referenced environment and constraints modelling. Referring to related works already existing in Building Modelling, within

19 **Filson A.** & **Rohrbacher G.** (2011). Design intercalated: The AtFAB project, International Journal of Design Sciences and Technology, 18:2, pp 81-93

20 **Ciblac Th.** (2011). Non-standard architecture with standard elements using parametric design, International Journal of Design Sciences and Technology, 18:2, pp 95-105

21 **Irlwek M.** & **Menges A.** (2012). The Extension of Rittel´s Methodology in Contemporary Parametric Design, International Journal of Design Sciences and Technology, 19:1, pp 1-25

22 **Hemmerling M.** (2011). An experimental pavilion for the Campus Emilie. In: Carrara G. et al eds (2011). Connecting brains shaping the world ⇒ Collaborative design spaces, Europia Productions, Paris, pp 159-166

23 **Pellitteri G.** & **Lattuca R.** (2011). An architectural generative design process, International Journal of Design Sciences and Technology, 18:2, pp 107-120

geo-referenced environment, the shown application is the first Generative Design System based on of urban constraints that may be used as powerful Decision Support System (DDS), useful at the early stage of city planning as well as of architectural design.

Hans Hubers, pondered on some crucial aspects of today Digital architectural design and specifically observe that it is dominated by Building Information Modelling (BIM) and parametric methods, which are not always compatible with IFC, the ISO standard for BIM.[24] A possible way out of this paradox could be that a multidisciplinary team from the start designs a full parametric conceptual IFC-based BIM database located on a server with discipline specific software in a combination of co-location and video-conferencing, using scripts that only create objects if they are not already in the database and otherwise only adapt their properties.

The fourth session discussed issues on *Sustainable/Green Design and Construction Systems*.

Maria Antonietta Esposito and Irene Macchi reported the research results of the TxP (Technology for Project) Group which analyses the communication processes in low carbon collaborative design and Life Cycle management in airport projects.[25] The analysis was focused on the communication processes requirements and was conducted by using a structured questionnaire based on technical standard reference. The problem to be solved is how to face complex relationships within the design team which is formed by different organization, based in various sites or countries and using different languages, but, most important, being culturally different. The results of the research show many interesting elements: i.e. quality standard certified organizations often neither plan, nor check and act properly communication processes.

Frida Bazzocchi, Vincenzo Di Naso, Giuseppe Grazzini and Aurora Valori showed the first results of a research on the definition of new residential building types that implement strategies and design criteria for the construction of environmentally sustainable developments. A simplified method for defining the morphology of optimal and sustainable residential buildings intends to explore the possibility of designing new types of buildings.[26] The proposed method is based on an analysis that takes into account the main features of solar radiation and the total energy behaviour of the building. It was chosen to perform dimensional analysis since it allows describing and simplifying the interpretation of a physical system by reducing the number of variables of the system by bringing them together in a series of dimensionless numbers. In this way the method can obtain comparable parameters giving the magnitude of the problem allowing the designer to identify the best design solution.

Anna Osello and Enrico Macii discussed a method to define a smart energy efficient strategy in existing buildings by IT tools that aims to develop an efficient and user-friendly Facility-Management process based on Interoperability and leveraging on human awareness and competence.[27] The case study is the Politecnico di Torino campus, with the aim at obtaining a theoretical model that can be applied to wide typologies of existing buildings in Europe. In the first stage of the research, innovative software tools were tested that indicate that there is a possibility of obtaining smart solutions if a holistic approach will be clearly defined.

24 Hubers J.C. (2011). Collaborative parametric architectural design. In: Carrara G. et al eds (2011). Connecting brains shaping the world ⇒ Collaborative design spaces, Europia Productions, Paris, pp 177-185

25 Esposito M.A. & **Macchi I.** (2012). Low carbon airport projects development using the design gap risk threshold approach, International Journal of Design Sciences and Technology, 19:1, pp 45-62

26 Bazzocchi F. et al (2012). Design strategies for sustainable residential buildings: a quantitative method for morphology optimization, International Journal of Design Sciences and Technology, 19:1, pp 63-82

27 Osello A. & **Macii E.** (2012). A BIM interoperable process for energy efficiency control in existing buildings, International Journal of Design Sciences and Technology, 19:1, pp 27-43

In the fifth session entitled *Ontology, BIM and IFC Representations* some research issues discussed that are very relevant for design and planning by enhancing the knowledge of product/process support tools used by collaborative actors (humans or agents).

Nuno Montenegro, José Beirão and José Duarte described a "Public Space Patterns" ontology including its related rule-based model used as a basic structure of a "City Information Modelling" (CIM).[28] This model was developed within a larger research project aimed at developing a tool for urban planning and design. The main purpose is to provide computer-readable descriptions of patterns for urban space planning so as to make programming strategies and design options available to the participants of an urban development process. An ontology implementation of concepts was shown, describing a public space and the relationships established by means of transitive properties which allows the system to infer new relations amongst other patterns that were not previously evident, fostering the awareness of underlying implicit patterns.

Paulos Wondimu, Hamid Hassan, Rasmus Rempling and Mattias Roupe, showed a punctual overview of the BIM practice that can ensure the development of detailed information and analysis at an earlier phase of the construction process.[29] Furthermore it showed how BIM facilitates decision making, reduces downstream changes and in turn results in better quality, lower costs and timely completion of projects. Swedish building and bridge sectors are studied to show the extent of current BIM practice and proposals have been extended regarding various methods of expanding its benefits by identifying the major barriers in BIM adaptation. Semi-structured interviews with BIM experts supported by literature review are used for the study. The overall analysis of the interviews has led to the conclusion that building sector is benefiting up to a reasonable extent from BIM and its applicability.

Ahamad Rafi, Azhar Salleh, Yun Yi, Dita Octavia and Aliff Afiq reported the results of a research project of *e-Warisan SENIBINA* aimed at experiencing architectural heritage in virtual environment (VE) by developing a knowledge management system that represents the repository of virtual heritage (VH) information.[30] The developed metadata structure of the information was based on the World Heritage guidelines that encompasses culture and heritage dataset useful for most of virtual heritage application. Concepts were highlighted of knowledge management system for real-time architectural visualization to represent ancient historical buildings.

The sixth session, entitled *Collaboration in Case Studies*, dealt with several real cases: how to exchange data among various domains, the usefulness of small display (Smartphone and Pad) for project management and how eLearning tools can support knowledge management.

Gabriel Wurzer considered data exchange among the most challenging problems during planning projects.[31] Recent tendencies strive to support a diversity of involved domains by introducing semantically rich data models which promise a seamless transition of data from one field to the other and back again. Often, this interchange is facilitated by using only a subset of an otherwise complex data structure (e.g. specified by IFC). A specification concerning "which data to include and which to omit", however, remains non-standardized, subject to internal agreements among modelling package vendors and may not be available for out-

28 Montenegro N. et al (2012). Planning open spaces: how to describe and locate public open spaces in urban planning, International Journal of Design Sciences and Technology, 19:2, pp 91-104

29 Wondimu1 P. et al (2011). Building Information Modelling: Major adaptation barriers in Swedish bridge sector. In: Carrara G. et al eds (2011). Connecting brains shaping the world ⇒ Collaborative design spaces, Europia Productions, Paris, pp 247-259

30 Rafi A. et al (2011). Knowledge management system for architectural virtual heritage: e-Warisan SENIBINA experience. In: Carrara G. et al eds (2011). Connecting brains shaping the world ⇒ Collaborative design spaces, Europia Productions, Paris, pp 261-270

31 Wurzer G. (2012). Towards use cases in sparse architectural data exchange, International Journal of Design Sciences and Technology, 19:2, pp 83-90 side parties. The author exposes also an orchestration part that would help improve the quality and reduce the time spent with the implementation of data exchange.

Lucio Campanelli investigated the visual features that should be incorporated in a small display interface from a user's perspective.[32] Five project managers were interviewed and asked to describe their tasks, resources and processes. Data collected from the interviews was analysed, identifying three themes related to project management information. Users were then given a survey to analyse 12 screenshots of four relevant mobile application interfaces. The results demonstrated that a project management interface would be beneficial on a small display if it incorporates the five measures evaluated by the users. In addition, the study confirmed previous researches suggesting that the use of the five visual measures during interface design increases usability and is useful for identifying other features for project management software visualization.

Umberto Nanni and Marco Temperini began with a general observation that energy and environment concerns and budget cuts are determining an increasing complexity of requirements, constraints, and regulations in the field of Architecture, Engineering and Construction (AEC), as well as in other domains, such as aeronautics, automotive, and more.[33] As a consequence, the amount of information required to take an aware decision and for a reciprocal understanding among actors increases accordingly. The collaborative activity delivered in the framework of an AEC project may suffer for mutual misconceptions and incomprehension of participants in different roles. Participants play interchangeable roles of teacher (explaining own methods and necessities) and learner (importing the teaching-colleague's knowledge into her individual settings, being then able to "teach the former teacher" about her own methods and needs, starting from a closer perspective). In this paper eLearning methodologies and technologies support knowledge management in collaborative architectural design. This mature field offers the tools to allow each actor to collect information in a standard format in a private design workspace and makes the mutual awareness experience more supported and more reusable.

32 **Campanelli L.** (2012). Evaluating project management interface visualization on small display devices. In: Carrara G. et al eds (2011). Connecting brains shaping the world ⇒ Collaborative design spaces, Europia Productions, Paris, pp 285-297

33 **Nanni U. & Temperini M.** (2012). eLearning for knowledge management in collaborative architectural design, International Journal of Design Sciences and Technology, 19:2, pp 105-121

3 Conclusions

What has been proven by the Europia 13 Conference is the extent to which collaboration within architectural design has become a major field of interest for the international scientific community. In fact the aforementioned papers on the whole demonstrate the abundance of new approaches and creative potential in the domain of 'Collaborative Architectural Design', depicting a bright future for it.

The stimulating discussion following these reports showed the potential, limitations and benefits both to research and practice that necessitates further investigation and development. Moreover it emerged from almost all reports that education and training is a crucial factor for developing collaboration among the many a specialist designer. Many technical applications have been developed in order to facilitate collaborative design and both academia and industries are striving to conceive and produce new methodologies and tools.

However it is to be considered that first of all collaboration is a cultural phenomenon and a state of mind and to this aim education is crucial, from the first

steps of professional training. Together and beyond the use of appropriate ICT tools and collaborative methodologies, designers have to learn to understand the potential but also the limits of their specialized education, and to search for their own fulfilment in the integration with others' specializations. All this takes time and willingness.
All in all, we still need at present a complete model of collaboration and of the required knowledge.
This is a technical problem; many people are working at it and undoubtedly it will overcome the problem.
The problem that will never be overcome is that prerequisite for a well designed work of architecture is talent. Garbage in garbage out, computer scientists say, and this is also, and above all, valid for architecture. But this is not enough: unassuming behaviour is at the same time expected from any actor/designer that is the condition for a true and profitable collaboration.

Bibliography

Bazzocchi F., **Di Naso V.**, **Grazzini G.** and **Valori A.** (2012). Design strategies for sustainable residential buildings: a quantitative method for morphology optimization, International Journal of Design Sciences and Technology, 19:1, pp 63-82
Berger P.L. and Luckmann T. (1967). The Social Construction of Reality, Anchor, New York
Briffaut J-P. (2011). Contribution of neurosciences for understanding the role of trust in IT-supported collaborative design environments, International Journal of Design Sciences and Technology, 18:1, pp 19-29
Campanelli L. (2012). Evaluating project management interface visualization on small display devices. In: Carrara, G. et al eds (2011). Connecting brains shaping the world ⇒ Collaborative design spaces, Europia Productions, Paris, pp 285-297
Ciblac Th. (2011). Non-standard architecture with standard elements using parametric design, International Journal of Design Sciences and Techno-logy, 18:2, pp 95-105
Dado E. and **Beheshti R.** (2011). Towards development of an intelligent virtual testing environment for building products. In: Carrara G. et al eds (2011). Connecting brains shaping the world ⇒ Collaborative design spaces, Europia Productions, Paris, pp 41-52
Damasio A.R. (1994-2006 revised). Descartes's Error- Emotion, Reason and the Human Brain, Vintage Books, London
Dorta T., Kalay Y., Lesage A. and **Pérez E.** (2011). Elements of design conversation in the interconnected HIS, International Journal of Design Sciences and Technology, 18:2, pp 65-80
Esposito M.A. and **Macchi I.** (2012). Low carbon airport projects development using the design gap risk threshold approach, International Journal of Design Sciences and Technology, 19:1, pp 45-62
e-Warisan SENIBINA experience. In: Carrara G. et al eds (2011). Connecting brains shaping the world ⇒ Collaborative design spaces, Europia Productions, Paris, pp 261-270
Filson A. and **Rohrbacher G.** (2011). Design intercalated: The AtFAB project, International Journal of Design Sciences and Techno-logy, 18:2, pp 81-93
Fioravanti A., Loffreda G. and **Trento A.** (2011). An innovative comprehensive knowledge model of architectural design process, International Journal of Design Sciences and Technology, 18:1, pp 1-18
Hemmerling M. (2011). An experimental pavilion for the Campus Emilie. In: Carrara G. et al eds (2011). Connecting brains shaping the world ⇒ Collaborative design spaces, Europia Productions, Paris, pp 159-166
Hubers J.C. (2011). Collaborative parametric architectural design. In: Carrara G. et al eds (2011). Connecting brains shaping the world ⇒ Collaborative design spaces, Europia Productions, Paris, pp 177-185
Irlwek M. and **Menges A.** (2012). The Extension of Rittel´s Methodology in Contemporary Parametric Design, International Journal of Design Sciences and Techno-logy, 19:1, pp 1-25
Khun T. (1962). Structures of Scientific Revolutions, University of Chicago Press, Chicago
Lecourtois C. (2011). Architecturological and epistemological research on collaborative design, International Journal of Design Sciences and Technology, 18:1, pp 31-45

Montenegro N., **Beirão J.** and **Duarte J.** (2012). Planning open spaces: how to describe and locate public open spaces in urban planning, International Journal of Design Sciences and Technology, 19:2, pp 91-104

Nanni U. and **Temperini M.** (2012). eLearning for knowledge management in collaborative architectural design, International Journal of Design Sciences and Technology, 19:2, pp 105-121

Osello A. and **Macii E.** (2012). A BIM interoperable process for energy efficiency control in existing buildings, International Journal of Design Sciences and Technology, 19:1, pp 27-43

Pellitteri G. and **Lattuca R.** (2011). An architectural generative design process, International Journal of Design Sciences and Technology, 18:2, pp 107-120

Rafi A., Salleh A., Yi Y., Octavia D. and **Afiq A.** (2011). Knowledge management system for architectural virtual heritage: e-Warisan SENIBINA experience. In: Carrara G. et al eds (2011). Connecting brains shaping the world ⇒ Collaborative design spaces, Europia Productions, Paris, pp 261-270

Robbs R.W. (1996). Leadership through collaboration, AI Architects, Volume 3, pp 11

Sampaio A., Gomes A., Gomes A., Santos J. and **Rosário D.** (2011). Maintenance and construction of buildings supported on interactive models, International Journal of Design Sciences and Technology, 18:1, pp 47-63

Shibley R.G. and Schneekloth L. (1988). Risking Collaboration: Professional Dilemmas in Evaluation and Design, Journal of Architecture and Planning Research, 5:4, pp 304-320

Simon H.A. (1969). The sciences of Artificial, MIT Press, Cambridge, MA

Tuffanelli Ch. (2011). Parametric design and construction: the “Tall Tree and the Eye” sculpture. In: Carrara G. et al eds (2011). Connecting brains shaping the world ⇒ Collaborative design spaces, Europia Productions, Paris, pp 97-110

Wondimu1 P., Hassan H., Rempling R. and **Roupe M.** (2011). Building Information Modelling: Major adaptation barriers in Swedish bridge sector. In: Carrara G. et al eds (2011). Connecting brains shaping the world ⇒ Collaborative design spaces, Europia Productions, Paris, pp 247-259

Wurzer G. (2012). Towards use cases in sparse architectural data exchange, International Journal of Design Sciences and Technology, 19:2, pp 83-90

Zignale1 D., Halin G. and **Kubicki S.** (2011). Modelling practices and usages to improve adaptation of groupware-tool services. In: Carrara G. et al eds (2011). Connecting brains shaping the world ⇒ Collaborative design spaces, Europia Productions, Paris, pp 53-66

Instructions for Authors

All papers are reviewed by at least two reviewers. All reviewed and accepted papers have to be resubmitted, implementing reviewers and editors comments or suggestions. Only accepted papers conforming to instructions will be considered for publication in the *International Journal of Design Sciences and Technology*.

The first page of the paper must contain the full title of the paper as well as the name, affiliation, address, telephone, fax and email of the main author and co-authors (if applicable). Also mention the name, postal address, telephone, fax and email of the author to whom all correspondence to be directed.

The second page should contain the full title of the paper, the sub-title (if any), an abstract of 100 to 150 words summarising the content of the paper and 3-5 keywords for the purpose of indexing (the use of references in the abstract is discouraged). Maximum length of a long paper is 7000 words (4000 words for short papers). Please note that the use of Footnotes and endnotes are discouraged. The layout of the journal allows the use of 'side notes' (see a sample issue of the journal). Where appropriate give information for the 'side notes' (maximum length 60 words) between double square brackets (such as full bibliographic reference, page numbers, remarks and notes). All side notes should be numbered consecutively. For instance: [[17 A 'side note' reflects additional information, a reference or the URL of a website]]

The paper will be written in (UK) English. It will be single-spaced with 30 mm margins on all sides (paper size A4). Use Times New Roman for the main body of text (size 10), figures (size 8) or tables (size 8). The use of **Bold**, *Italics*, ALL CAPS, SMALL CAPS, etc. is discouraged. All chapters should be numbered consecutively (more than one level sub-headings are discouraged). All Figures and Tables with their respective captions should be numbered consecutively. They should each, be placed on a separate page, at the end of the paper. All figures, tables and equations should be mentioned in the body of text. Give an approximate insertion point for figures and tables, between double square brackets. For instance: [[insert Figure 5]]. You will be asked to resubmit your drawings if necessary. **Do not layout your paper**. *Do not use any styles or any automatic layout system.* Please do not use 'Track Changes'.

All Tables should be referred to in the text as Table 1, Table 2, etc. All Figures should be referred to in the text as Figure 1, Figure 2, etc. Line drawings should be of good quality. Use light background if possible (white is preferred). Photographs and screen-shots should also be submitted separately as JPEG files (use high resolution for better results). Authors should prepare high quality figures and drawings. Avoid the use of colours in your illustrations, as the journal is not published in colour. Maximum width and height of a figure are respectively 115 (150 mm if absolutely necessary) mm and 190 mm. Maximum width and height of a table are respectively 115 mm (150 mm if absolutely necessary) and 170 mm. All Equations will be numbered consecutively and should be mentioned in the text.

Use 'Harvard System of Reference'. Bibliography (references) is collected at the end of the paper, arranged in alphabetical order by the first author's surname, followed by initials. All authors should be mentioned. Dates will appear between brackets after the authors' name(s). This is followed by the title of the book, name of the publisher, place of publication and page numbers (if applicable). To refer to a journal paper, add the full title of the journal followed by Volume:Issue Number and page(s). Examples of references to a book, a journal or a website are shown below:

Dixon, N.M. (2000). Common Knowledge: how companies thrive by sharing what they know, Harvard Business School Press, Boston, MA
Buxton, W. (1997). Living in Augmented Reality: Ubiquitous Media and Reflective Environments. In: Finne K., Sellen A. and Wilber S. eds, Video Mediated Communication, Erlbaum, Hillsdale N.J., pp. 363-384
Beckett K.L. and **Shaffer D.W.** (2004). Augmented by Reality: The Pedagogical Praxis of Urban Planning as a Pathway to Ecological Thinking, University of Wisconsin, Madison
Djenidi H., Ramdane-Cherif A., Tadj C. and **Levy N.** (2004). Generic Pipelined Multi-Agents Architecture for Multimedia Multimodal Software Environment, Journal of Object Technology, 3:8, pp. 147-169
Gorard, S. and **Selwynn, N.** (1999). Switching on to the learning society? Questioning the role of technology in widening participation in lifelong learning, Journal of Education Policy, 14:5, 523-534
Blackman, D.A. (2001). Does a Learning Organisation Facilitate Knowledge Acquisition and Transfer? Electronic Journal of Radical Organization Theory, 7:2 [www.mngt.waikato.ac.nz/Research/ ejrot/Vol7_1/Vol7_1articles/blackman.asp]
World Bank (2002). Social assessment as a method for social analysis, World Bank Group [www.worldbank.org/gender/resources/assessment/samethod.htm]

Papers in their definitive version will be submitted as a MS Word file for the PC (MS Word RTF format for Macintosh). In addition, a formatted version of the paper (including images and tables) will be submitted in PDF format and all figures must be submitted in high resolution jpg or tiff format. Submit your paper as an email attachment to the Editor-in-Chief [beheshti@ planet.nl]. You can also send your paper and images on a CD-ROM by an International Courier to:

Editor-in-Chief
International Journal of ***Design Sciences and Technology***
Europia Productions
15, avenue de Ségur
75007 Paris, France

Author(s) have to complete, sign and return a *Copyrights Transfer Form* to the publisher. This copyrights transfer assignment will ensure the widest possible dissemination of information. Papers published in the International Journal of *Design Sciences and Technology* cannot be published elsewhere, in any form (digital, paper-based or otherwise) without a prior written permission from the publisher.

The author(s) are responsible for obtaining permission to utilise any copyrighted material. For more details about this subject, please contact the publisher at an early stage.

The decision of the Editor-in-Chief on all matters related to the International Journal of Design Sciences and Technology including the review process, publication of papers, etc. is final and cannot be disputed.

The leading author of a paper published in the International Journal of *Design Sciences and Technology* will receive a digital copy of the author's paper free of charge. Printed copies of any individual paper (minimum 50), any issue (minimum order 10 copies) and the Journal Year Book (one or more copies) can be purchased from the publisher (ask for an invoice from the address above or IJDST@europia.org).

How to Order

International Journal of ***Design Sciences & Technology***

IJDST-online

You can view and download a digital version of individual papers free of charge from the journal's website.

IJDST Hardcopies

Hardcopies of any individual paper (minimum order 50 copies), any issue (minimum order 10 copies) and volumes (minimum order is one single copy of the book containing 2 issues) can be ordered directly from Europia Productions. You need to send your **Request for an Invoice** (preferably by email, Fax or letter) indicating details of your order and the quantities. Please provide your full name and initials, postal address, email and telephone number. An invoice will be sent to you indicating the total amount of your order, the cost of packing/postage and method of payment.

Individual Subscription IJDST Hardcopies

Individuals can subscribe to receive a hardcopy of the book containing 2 issues for € 150.00 (incl. 5.5 % VAT, packing and postage). You need to send your **Request for a Subscription Invoice** (preferably by email, Fax or letter) indicating the IJDST Volume. Please provide your full name and initials, postal address, email and telephone number. An invoice will be sent to you indicating the method of payment.

Institutional Subscription IJDST Hardcopies

Libraries and organisations can subscribe to receive a hardcopy of the book containing 2 issues for € 150.00 (incl. 5.5 % VAT, packing and postage). You need to send your **Request for a Subscription Invoice** (preferably by email, Fax or letter) indicating the IJDST Volume. Please provide details of the library or organisation, name contact person, postal address, email, telephone number and Fax number. An invoice will be sent to you indicating the method of payment.

Other Publications

Other Europia Productions publications can be ordered from the address below. You always need to send your **Request for an Invoice** (preferably by email, Fax or letter) indicating details of your order and the quantities. Please provide your full name and initials, postal address, email and telephone number. An invoice will be sent to you indicating the total amount of your order, the cost of packing/postage and method of payment.

Europia Productions
15, avenue de Ségur, 75007 Paris, France
Telephone +33 1 45512607
Fax +33 1 45512632
E-mail: dst@europia.fr
URL: Europia.fr/DST

International Journal of
Design Sciences and Technology

Editor-in-Chief: **Reza Beheshti** and **Khaldoun Zreik**

Volume 19 Number 2

Issue Editor: **Reza Beheshti**

Table of Contents

1630-7267