Modeling the early stages of a user-centered process in architectural design through adaptation of the methodologies of New Product Design

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ABSTRACT. In order to reach a degree of quality in architectural buildings that is like/y to / ead to user safisfaction, architectura/ design relies on integrating user-re/ated information even before the generafion of building concepts. However, integrating such informafion may be seen as a hindrance to architectura/ creation.

It therefore seems necessary to propose a methodo/ogica/ approac h that al/o'AS integration of a user-centered point of view as v.e/l as generation of creafive architectura/ concepts. Our research proposes to app/y a co//aborafive process of New Product Design (NPD) in order to enrich the more tradifional process of architectural design.

We v.ill present some experirœntal oork carried out as part of an architectural project for the design of ercergency she/ters, as an alternafive to rrore usua/ habitats. We v.ill then discuss the possibi/ity of adapting NPD methodo/ogy to architectural design, and v.hat potential this offers to improve the integration of user-related information v.ithin architectural creativity.

KEYWORDS : architectura/ design, user centered design, NewProduct Design

1. Introduction

Architects formulate problems and search for solutions based on data provided by a Project Initiator (Prost, 1992). Spatial organization takes shape as a response to this project, based on complex co-evolutions of problems and solutions (Dorst & Cross, 2001). In the standard, traditional approach to architectural design, although taking the user into account is acknowledged as an essential parameter of solution-finding, this is often viewed as a constraining element, or even a hindrance to freedom in architectural creation (Pinson, 1993). Nonetheless, performance in any architectural project should be evaluated, not just based upon the architectural qualities of a formai abject, but also on the degree to which users appropriate this abject for themselves (Prost, 2002) In order for design results to be optimal with respect to users, architectural design needs to define a methodology allowing integration of user-related information from the early stages of the process, in order to achieve true improvements in the quality of the end architecture (Quanjel et al, 2006).

2. A method for human-centered architectural design

Before presenting the stance chosen for this research, we will start by briefly investigating is historical context, namely how the methodology of architectural design came to evolve in past years.

2.1 Pratiques architectura/es centrées uti/isate ur

In the early 20th century, the concept of "usefulness" constituted a central tapie of architectural design. Initially, users were considered in terms of their functional requirements. Users' expectations and their dreams were interpre ted through architectural practice. However, since architectural proposais proved ill-adapted to users, it became necessary to take users into account in a scientific and objective manner. New approaches were put forth to integrate relevant user-related information by making users participate directly to the design process.

In the 1960s, two kinds of user-centered architectural practices were prevalent. One was based on the direct participation of users to the design process, and another on the participation of human factors experts to architectural design. Following this evolution, user-related criteria were increasingly recognized as important design parameters (Lawrence, 1982).

From the second part of the twentieth century onwards, consciousness of taking users into account in architectural design has been driven forward by social demand regarding the design of workspaces. Research on the ergonomie perception of such projects, as well as on the process of ergonomie intervention, was applied to architectural design. However, user-centered recommendations proved to be formulated either "too early" or 'loo late" (Bouché, 2001). If the intervention takes place when the project is already given concrete expression, relevant suggestions cannaibe integrated. Conversely, even if rigorous and accurate user-related information are provided in the early stages of the project, these are often viewed as just another constraint limiting the architect's imagination.

In order to reduce the distance between concrete realization of the architectural abject and integration of needs and expectations expressed by users, architectural design relies on explicit and direct participation of users to the process.

As Godschalk (O. Godschalk, 1970) points out, one key factor of participatory design is interaction between users, who provide information regarding their own behavior, and designers, who provide information regarding potential solutions.

As Hill (J. Hill, 2004) also points oui, formulating the user's point of view in a creative fashion may help increase, not diminish, the architect's competence. Interactions between architects and users are still a major tapie of research on participatory architectural design. In verifying the creative potential brought on by participatory architectural design, Lawrence (R.J.

Lawrence, 1982) highlights the need for a more effective methodological representation to assis!communica tion between designers and users involved in a participatory design project. Wulz (F. Wulz, 1986) poses the question of how users might be more involved in the design process, and shows the need o democratize architectural design in order to alleviate the dominance of architects' influence over the project, since architects then reject user proposais.

2.2 ***Prog-amming user centered architectura/ design***

Since the 1960s, much research has been carried out into how one should manage and develop processes of architectural design (Baudon, 2004). One such example is the work of Alexander (Ch. Alexander, 1964) who analyzed the architect's as a problem solving activity. Indeed, architectural design may be viewed as the search for a program responding to the design problem, i.e. a description and prescription that are most adequate to the context of the project. To achieve this, Alexander stresses the needo include and involve future users. According to him, the raie of the architect is to allow spatial design to conform to users' persona! aspirations. According o this view, he proposed a rational method translating the unconscious process of architectural design into an conscious one (Martin, 2000 ; Baudon, 2004). But this idea, which supposes that the problem may be fully defined before elaborating the solution, led to much criticism. Alexander's proposed approach implies that the architectural abject is but the product of a hierarchical, functional logic, as might be a product design through engineering (Conan, 1990).

In the 1990s, based on the premise that architectural design had been rationalized according to the same principles as those guiding industria design, Michel Conan, a French architect, proposed a model of the main stages of architectural design. He viewed architectural design as a creative problem-solving activity, integrating research results from the social as well as technical sciences. He then proposed a method for architectural programming. The dominant idea in this method is that architectural intent is no!jus!the result of problem solving,but also involves the architect following a path allowing progressive adjus tment of use-related intentions with technical and architectural possibilities.

2.3 ***The current state of the user centered process of architectural design***

Zwemmer defined a process of user centered architectural design. He describes this process as an interaction between the architect and a group of users. Kernohan *(*cited by Zwemmer) views taking users into account as a factor of increased complexi ty in the process of architectural design. In order to contribute to improved integration of user-related information, our research proposes an analysis of the initial stages of the design process, i.e. those stages where design concepts are generated. High perrformance in this stage is essential o the quality of end products of design (Rickaby, 1979; Fruchter, 1996; Austin, 2001; Quanjel, 2006).

3. The NPD model : collaborative user centered design

In order to help designers integrate informa tion related to users, as well as generate creative architectural concepts in the early stages of desigrn, we put forth our main hypothesis, namely that a generic model of New Product Design (NPD) may be used in architectural design. The collaborative approach derived from NPD methodologies should make it easier to integrate user-related information in the early stages of architectural design.

3.1A mode/ of architectural design based on mode/s of NPD

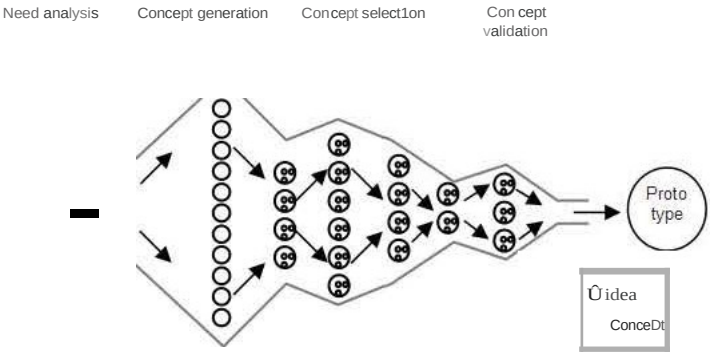

Figure 1. Initial stage of the NPD process nouveaux

For the pas! decade, research into the design of innovative products has focused on the concepts of novelty and utility. Scientists in the field have set the goal of elaborating and developing methodological tools to assist the onset of creative solutions in the process of concept generation.
According to Quarante and Ulrich (fig. 1), the initial stage of the NPD process is made up of four sub-stages, ail focused on end-users: 1/ user needs analysis, 2/ concept generation, 3/ concept selection and *41* concept validation. Designers are provided with a scope statement, which defines produc!specifications. Following this, a collective search for ideas is carried out to generate a list of items liable to give rise to product concepts. Concepts are drafted, elaborated upon, and selected through a series of cycles of divergence and convergence. At the end of this iterative process, a single concept is selected and then developed.

According b NPD models, the design process starting with idea generation up to concept selection may be structured as follows (fig. 2):

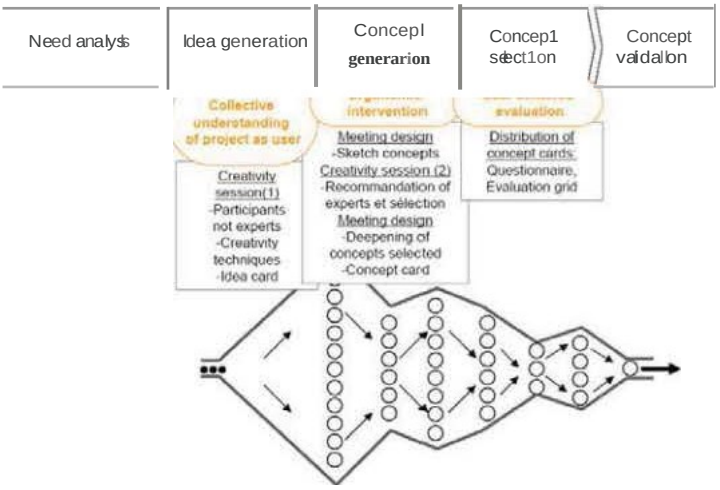

Figure 2. The initial stage of architectural design based on a NPD approach

x User needs analysis: based on the results of prior studies, participants sugges! ideas which are mas!suited to project goals, using group imagination;

x Idea generation: the goal of this stage is to carry out a creative activity during which participants, who are not experts in the field of architecture but are potential "end users", get to grips with project data, i.e. its context and goal. Participants to hese creativity sessions note their ideas in the form of cards describing and illustrating their principle in a synthetic fashion , as well as their main advantages and drawbacks;

x Concept generation : This stage, carrüed out by the architect and design team, involves linking, categorizing, combining, and synthesizing patchy ideas into concepts by providing hem with a common tille. Description of these concepts is then carried out in more depth within a second stage. This in-depth explora tion requires expert knowledge. Criticism regarding technical and economical feasibility of these concepts may also be addressed at this time.

x Concept selection: In order to evaluate basic concepts from a user-centered point of view, a document is handed out to project participants, generally a questionnaire followed by an evaluation grid. Usability inspection methods may be applied to these concepts in 1ater stages of detai1ed design.

3.2 *An experimental application of the NPD mode/ for architectura/ design*

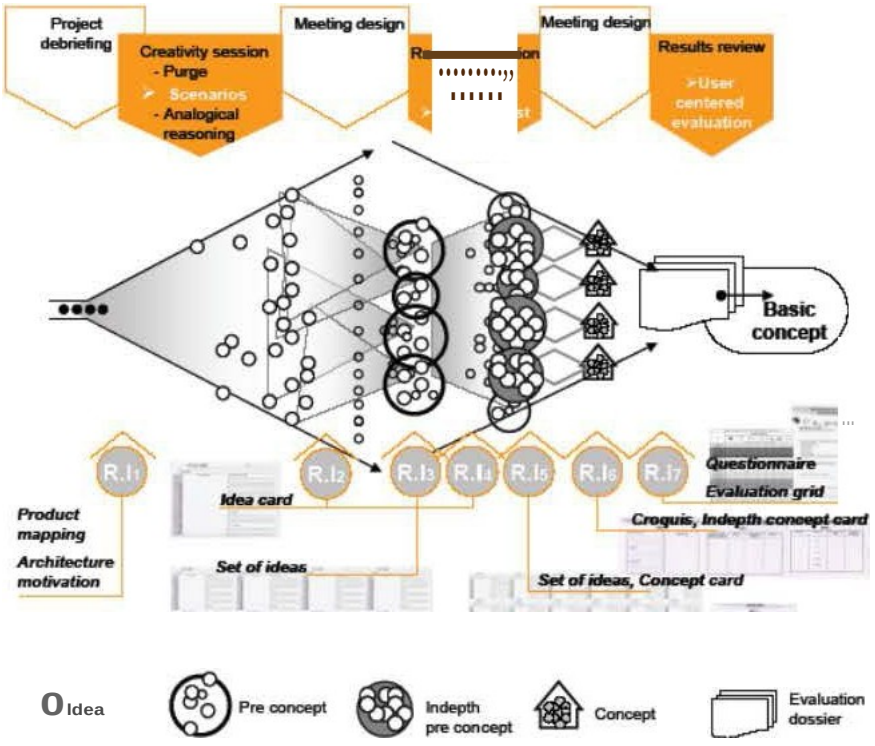

Figure 3. A model of the initial stages of user-centered architectural design

We have chosen to apply the NPD model to architectural design following the collaborative approach promoted by recent work on the design of innovaîive products. The area which we chose to explore as a field of application was the design of an emergency shelter. We have chosen a NPD methodology that highlighting collaboration between professionals from

various fields of design. These design actors are experts in the field of ergonomies. This process also provides means to analyze designer actions and results thereof, in the form of intermediate representations of an emergency shelter.

3.2.1 An architectura/ project : emergency shelter

The emergency shelter seemed an interesting tapie for us b test the pdential of adapting product design methodologies, which are collaborative by definition,b architectural design. Indeed, such housing serves as a replacement for existing habitat in the event of its destruction by natural or man-made disasters. In such projects, lis essential b account for several unavoidable constraints as well as funàamental needs, which may prove of vital importance in this very specific context. Designing an emergency shelter, even a small one, relies on a fund of knowledge from various fields, knowledge which must be combined and structured as part of a mehodology aiming to assis! collaborative creativily. Il therefore seems a particularly relevant application to validate a design approach wrth a strong focus on user needs, but also on the design teams ability o generate new and ingenious ideas given the various constraints included in the project. Therefore, this field of application is particularly suited to validating a design model inspired by NPD and applied in the field of architecture.

3.2.2 A description of the experimental process

We carried out a collaborative project in architectural design following a modified version of the generic model described in part 3.2 (fig. 3). In this part, we describe activities and behaviors of al1 project participants at each stage of the process.

3.2.2.1 The design project

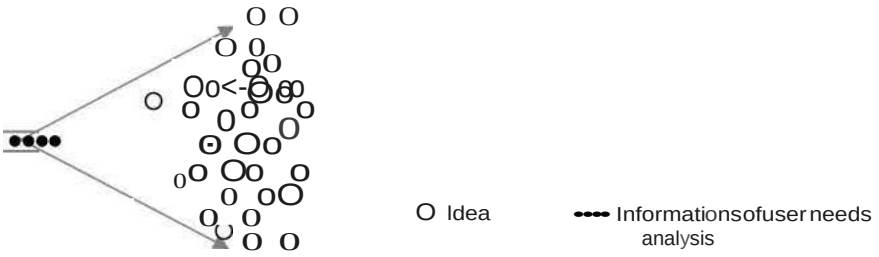

Figure 3. Génération des idées

Following a brief presentation of the results of user needs analysis, the design team participated in a creativily session in order to generate a number of creative ideas. Eghl participants were present, each wrth their own professional background (architects, engineering designers, ergonomists, and designers). As is frequently recommended in creativity sessions, critical reactions to the results, whether based on knowledge or persona! opinion, were forbidden. Following this strict rule, a number of techniques preserted below were chosen and applied to slimulate idea generation. Through these, collective understanding of the project arase based on free-minded and iterative communication between participants, giving much importance to the imagination. At the end of this session, participants were asked to produce a number of idea-cards, in which hand-drawn sketches complemented verbal descriptions of ideas, highlighting the principle, advantages and drawbacks of each. Session duration was 3 hours, during which about 30 cards were produced.

Creativity techniques used during the session were as follows:

- The purge: before anything, participants did away with all preconceived ideas regarding the product to be designed, by writing them down and presenting them orally. This initial exchange, based on spontaneously generated images and words, allows to start off creative interactions in a very natural way:

- Scenarios: the problem is contextualized, based on a series of ideal, or conversely, catastrophic situations, in order to let participants' attitudes to the problem emerge spontaneously, and let them imagine solutions with a concrete backing. Scenarios may be acted out using improvisational raie-play.

• Analogical reasoning: participants suggest ideas by seeking them out in fields remote from the initial problem domain. This allows them to open up a field of possibilities and let the imagination take over In order to circumvent the problem. In order to search for solution ideas, we relied on fields that had no connection with an architectural product such as the emergency shelter. Such fields included plants, animals, sport, etc.

Within this project for the design of an emergency shelter, designers had to account for the extreme conditions of temporary housing. Participants were divided into two groups. Each of them listed and described potential difficulties, imagining situations where they might occur and suggesting potential solutions. Scenario-based design allowed participants to project themselves as users in situations involving an emergency shelter.

3.2.2.2 Generation and implementation of concepts

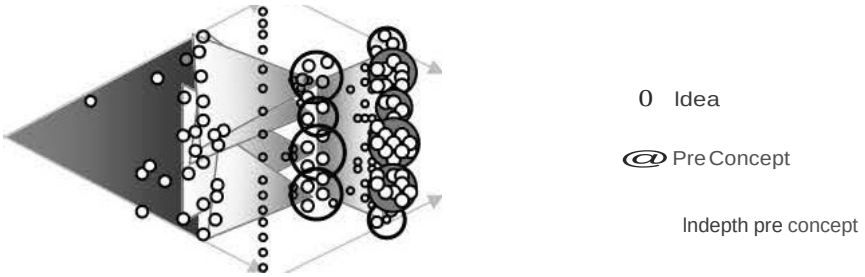

Figure 4. Génération des concepts

The concept definition stage starts off with the generation of preliminary concepts by small groups of 3-4 designers, each including an architect and other design professionals (designers, engineers or ergonomists). These smaller groups were put in charge of identifying tapies responding strongly to the project in order to group the ideas produced in consistent subgroups, illustrating more global concepts that might be used to design the end product. New ideas may be generated in this stage in order to connecl existing ideas, to strengthen an existing concept, to make a set of ideas more consistent or comprehensive to turn il into a concept. In order to better carry out this complex activi!y, ideas produced in the prior stage are categorized according to common wordings. They are then put together for examination of their mutual compatibility, to construct groups of ideas. In order to make these groups more apparent and to enrich them, complementary ideas are generated and added to them.

Participants from these small groups thus generated preliminary concepts, i.e. consistent sets of ideas, based on about 30 initial ideas. At that time, the architect, as session pilot, asked groups to look for product concepts in a more global and creative view, with the explicit goal to make each preliminary concept more consistent. This deep conceptual exploration, carried out in a dynamic and collaborative way, allowed participants not just to link ideas together, but also to initiate specific patterns of reasoning based on cognitive transformations. Indeed, the pilot architect stressed the importance of the need for complementarity between ideas in order to generate preliminary concepts.

Ideas generated in the initial stages tended to offer real-world solutions to local or partial problems, rather than global responses to project goals. The task of trying to establish connections and giving each group of loosely-knitted ideas a specific identity within a short timeframe turned out to be very difficult. Creativity based on preliminary concepts was an approach spontaneously chosen by participants, through which 8 preliminary concepts were quickly defined on the basis of ideas generated beforehand and of roughly ten new ideas.
This stage relied on idea search within more specific domains, and on deeper conceptual exploration. To achieve this, we invited more specialized participants: a construction engineer, a materials engineer, an aeronautics engineer, an ergonomist, two designers and two architects. More information was provided to them regarding the context of the project in order to focus creativity on more specific points.

The first part of this session consisted in finding new ideas regarding design choices and principles that had not been defined with sufficient precision beforehand. Participants then produced idea cards. The first batch of concepts was then presented to the participants, allowing generation of new ideas or concepts. Thus, the 8 concepts generated in the prior stage were completed with around 20 new ideas and 3 new concepts. The ideas focused on specific project elements were eventually integrated to the various existing groups through critical discussion confronting the points of view of the various design professionals involved. This discussion allowed crossfire of knowledge, opinions, and more importantly, types of expertise to give rise to inspiration for the generation of new concepts.

The usual view of this is that the raie of domain experts and specialists expresses itself in an analytical approach aiming to correct a real-world, physical artefact. What we have shown here is that communication between experts of various fields might bring forth some degree of creativity, as long as participants are involved in a leisurely, fictitious and convivial situation, which leads participants to show a great degree of tolerance despite obvious differences in their respective points of view. When participants were asked to link their ideas to an existing idea set, they had to analyze and interpret these various sources of information, all the while explicating the reasons for their choices. Data based on local and very specific knowledge turned out to be a major source of creative inspiration to the subgroups of participants.

Although the initial stages of the design project are concerned with free-minded involvement of domain novices in order to generate numerous concepts, the next stage requires examining the feasibility of these concepts in order to reach consensus between the points of view of the various experts involved.

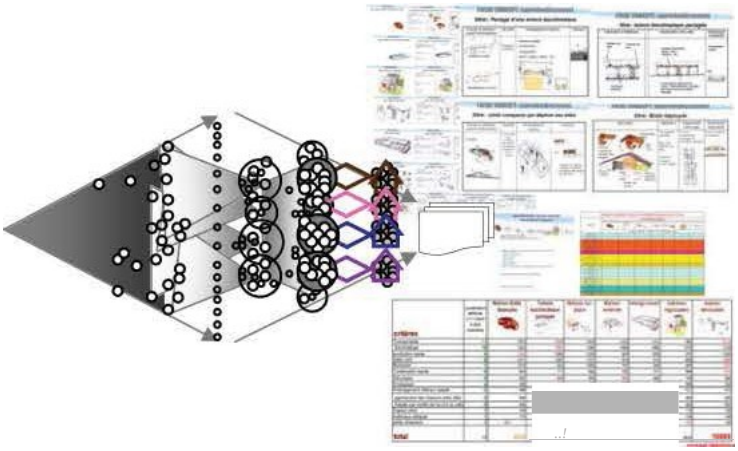

Figure 5. Evaluation des concepts

At this point, the design team will share concepts, ending up with merging some of them, and elaborating upon others. Concepts developed in his way are presented in the form of a concept card, formalized in equal detail, before these can be evaluated. Concept cards are based on sketches which allow the substance of a solution to be clarified in wriling.

Representations of concepts must include a simple, clear and global explanalion before going into any detail. Indeed, if the description is tao refined from the star!, this may prevent evaluators from interpreting the concept and analyzing il clearly. An easy-10-grasp presentation of concepts ranging from global to detailed levels, presenting each concept at various resolutions, will help designers gain a better understanding of each one. To combine results of the intermediate evaluation of concepts with project developments, the questionnaire seems an appropriate tool b allow decision making in design as we ll as providing a more concrete response b project demands.

Concepts were presented in the form of concept cards and submitted them to the judgement of members from the design team (10 persans in total), using a questionnaire and an evaluation grid as methodological tools for evaluattion. Based on this, participants were asked to hink spontaneously about the concept they preferred overall, as well as b classify evaluation criteria and complete the lislwith specific criteria. The goal of the evaluation grid was b allow designers to reflect in more depth about the various parameters involved, grading each concept according to the criteria described in the scope statement. Grading was then weighed based on the criteria participants viewed as most fundamental. This process allowed us to assign an average grade to each concept, hereby helping wi h concept selection. Two evaluation stages were carried out in a democratic fashion, allowing us b select those products that had received top grades in each criterion.

4. Discussion

One major stake of our research has been to analyze how b assis!the generation and developmen!of architectural concepts, integrating user-related data in the initial stages of the design process. In order to propose an application scheme for the generic collaborative methodology of **NPD** in the early stages of architectural design, we will discuss in this part the behaviour of the members of the design team, as well as the results obtained in the course of this architectural projecl.

4.1 Collaborative creativity in architectural design

In traditional architectural design, the architect initiates and shapes his project by prioritizing constraints and elements defined from the time of the initial project order. From this diagnosis, formulated from a personal point of view, he searches for and elaborates architectural concepts. In developing sketches to help ease simulation of future use and coordination of design choices, he verifies and contrasts his architectural reasoning. Our methodology, however, proposes an alternative based on collective work involving several disciplines.

From a creativity-based point of view, and compared with the architect's more traditional individual working practices, we can see a number of advantages. In the needs analysis and idea generation stages, crossing various the contributions of participants allows rapid generation of large quantities of ideas. The next stage of in-depth concept elaboration then allows enriching concepts with further ideas, based on the specific, expert knowledge of participants involved.

Although we have shown it is possible to gather a design team within a collective, creative activity in architectural design, the question remains as to how synthetic the ideas produced should be to be project-relevant. In order to enrich concepts generated through connecting existing ideas, expert participants suggested new ideas. Besides the architect, few project members seem interested in a synthetic view of things. They each proposed novel ideas, but these generally didn't complement each other.

4.2 Integrating user-related information in the initial stages of architectural design

Amongst the techniques used in our first creativity session, the "scenario" tool allowed us to construct a common understanding of the project by playing the part of users. Participants thus highlighted a large number of problems and generated large numbers of solutions spontaneously and in a collective way.

During the second creativity session, which involved experts, the ergonomist expressed his point of view regarding the user. This was a major contribution to enriching idea contents during concept elaboration. However, according to him, it was difficult to contribute relevant and concrete ideas at this relatively abstract stage of the process. Despite this, we posit that his involvement in the early and abstract stage of concept generation may be seen as a potential opportunity to integrate user related information in the design process.

4.3 Collective intermediate evaluation

Whereas architects generally make personal decisions when selecting a concept worth developing based on his professional experience, collective evaluation relies on the spontaneous opinions and perceptions of experts from various professions. This stage appears essential, not just for choosing a concept, but also to interpret results of an evaluation. Indeed, such evaluations rely on information concerning needs and expectations put forward by potential future users. This type of information should be integrated as early as possible in the design process in order to be applied to an architectural solution. Varying, or even opposite opinions between evaluators should be viewed as viable resources for user centered architectural design.

5. Conclusion

Contrary to the traditional view of architectural design, in which the architect carries out a personal inquiry, our research has attempted to instil a collaborative activity in the process,

characterized by creative communication between the architect and the remainder of the design team, including engineers, ergonomists and future users. We have elaborated and put forth a preliminary model of the collective process of architectural design, integrating the user's point of view, which is likely to bring relevant resources to the creative activities involved in the early stages of design.
Through simulation, we applied an alternative model of architectural design in order to validate il. We believe that both the tacit knowledge of users (Spinuui, 2005) and collective intelligence in the design team (Fischer et al, 2005) may influence the quality of results in architectural design.

7. References

C. Spinuzzi, "The methodology of participatory design", Technical Communication. 52, pp163-174

Ch. Martin, « Maîtrise d'ouvrage. Maîtrise d'œuvre, construire un vrai dialogue. La contribution de l'ergonome à la conduite de projet architectural», Octares Editions, 2000

D. Godschalk, « Negotiate: an experimental planning game », Proceedings of the 1st annual environmental design research association conference, pp345-349, 1970

D. Pinson, « Usage et architecture ». L'Harmattan, 1993

D. Quarante, "Eléments de design industriel", Paris, Polytechnica, 200 1

E. Quanjel .W. Zeiler, N. Borsboom , H. Spoorenberg , "Integral design methodology for collaborative design of sustainable roofs", 23th coference on passive and low energy architecture, Switzerland, 2006

F. Wulz, "The concept of participation", Design studies, 07. pp153-162, 1986

G. Fischer, E, Giaccardi, H. Eden, M. Sugimoto, Y. Ye,,, Beyond binary choices: integration individual and social creativity", Human-Computer Studies, 63, pp482-512

J.C. Lebahar, « La conception en design industriel et eni architecture : désir. pertinence, coopération et cognition », LAVOISIER, 2007

J. Redstrêim, "Toward user design ? On the shift from abject ta user as the subject of design", Design Studies, 27, pp123-139, 2006

J. Verbeke et M. Stellingwerff. « A Future Focus on Collaborative Design », Architectural Information Management - 04 Collaborative Design, pp98-103. W01

K. Dorst et N. Cross, "Crativity in the design process: co-evolution of problem-solution", Design Studies, 22. pp425-437. 2001

K.T. Ulrich, "Product design and development", Eppinger, 2000.

L. Wang, W. Shen, H. Xie, J. Neelamkavil, A Pardasani, "Collaborative conceptual design - state of the art and future trends", Computer-Aided Design. 34. pp981-996, 2002

M. Zwemmer et A.D; Otter, "Engaging Users in Briefing and Design: a Strategic Framework", Eindhoven University of Technology, Netherlands, pp405-416, 2008

M. Conan, « Concevoir un projet d'architecture », L'Harmattan, 1990

Ph. Baudon, « Conception », Edition de la Villette, Paris, 2004

R. Fruchter et al, "Interdisciplinary communication medium for collaborative conceptual building design", Advances in Engineering Software, 25, pp89-101, 1996

R.J. Lawrence, "Trends in architectural design methods - the liability of public participation", Design Studies, 03, pp97-103, 1982

R. Prost. "Conception architecturale", L'Harmattan. 1992

S. Austin et J. Steele, "Mapping the conceptual design activity of interdisciplinary teams", Design Studies, 22, pp211-232, 2001

G. Bouche, « Les enjeux de la programmation », Ergonomie et Conception architecturale, Colloque ADEO 2001

S. Macmillan et al. "Developpement and verification of a generic framework for conceptual design", Design Studies. 22, pp169-191, 2001