

Innovative Learning for Collaborative Design in Ergonomics

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Abstract. *The proposed article deals with introducing collaborative architectural design into the training of ergonomists at the Master 2 level. The collaborative design workshop aims to confront ergonomists with the difficulties any design project involves, and which challenge architects, designers, engineers and so on: collaboration between people with different skills and different expertise; powerful time constraints; need for their work to converge; working together and/or at a distance; sharing documents; decision-making, etc. The article will present a short review of work carried out in the domains of architecture and design, and of the contribution of ergonomics within architectural projects. We shall then present the workshop's educational aims, and give details of the way it functioned. Finally, observation results will be presented and discussed.*

Keywords. *Collaborative design; architecture; ergonomics; training workshop.*

COLLABORATIVE DESIGN LEARNING IN AN ARCHITECTURAL PROJECT

Architecture and design

An architectural project generally depends on a context – temporal, geographical, political and economic. From the earliest design phases it includes different skills areas such as engineering, ecology, law, ergonomics and sociology (Hubers, 2009). It has to respond to a program taking account of a certain number of parameters – technical, social, environmental, industrial, legislative, political, etc. It develops in an increasingly restrictive regulatory framework, and since the 90s a variety of research has shown that it is rarely led by a single individual (Visser, 2002). Faced with competition, short deadlines and complicated quality and regulatory requirements, architecture firms have to innovate, using interdisciplinary design methods that combine the

different skills and tools needed to bring the project to completion (Farel, 1995; Bucciarelli, 2002).

Nowadays architects no longer work alone, but collaborate with engineers, landscapers, designers, economists and so on. So the project becomes collective, uniting a variety of skills and knowledge that are all involved from the earliest design phase.

These particularities lead to consider design in terms of skills and collectivity (Cross et al., 1995; Jeantet et al., 1998; Larsson, 2005; Bucciarelli 1988, 2002; Minneman, 1991). This means that the activity of design combines collective actions, as well as the individual actions of different experts (Pahl et al., 1999). It is not simply a matter of assembling points of view. It is the result of interaction between

the different components of the project, subjective in character (Pousin et al., 1986) and the consensus achieved between all the players who participate in designing the architectural project.

Such collective activity also obliges participants to use instruments of sharing, without which it would be impossible (Boujut, 2000). The aim of most of these instruments is to facilitate cooperation between those involved in a project, by making it easier for them to exchange information at different times and at a distance. They are only used, however, when the project is sufficiently advanced.

The sketch-phase, when important design choices are made, continues to make little use of such instruments of collaboration. Yet it is essential for the start of design activity in an architectural project that participants be able to meet despite distance, and communicate in real time. Sharing-instruments aim to facilitate exchange. Exchange is important in constructing what cognitive ergonomists call “cognitive synchronization”, “temporal-operational synchronization”, “mutual awareness” or “common operative references”. All these concepts have already been defined in the field of cognitive ergonomics and constitute “the backbone of the collective resolution of a design problem” (Darses, 2004).

Ergonomics and architecture

Various works in ergonomics has explored different positions for the ergonomist within architectural projects, wishing to reinforce the dialogue between project management and ownership (Martin, 2000). Diverse experiences of participating in design projects have made it possible to identify the positive contributions of each position as well as the main stumbling-blocks: weak ownership which delegates the whole project to its management; projects mainly oriented towards technical or financial possibilities; a residual place accorded to future and possible human activity.

The real question about the ergonomist’s contribution in the design process is that of his/her position. Is s/he a specialist, expert in the human factor, called on at precise moments? In this first case, s/he

remains outside the design process and the main players use what s/he gives them whenever they think it opportune. Is s/he a potential actor in the design process, able to provide clarification about future and possible activity and to give structure to the design collective? In this case s/he is included in the design process, *within* the collective of those involved, and takes full part in debate, orientations and the choices finally made (Beguin, 2004; Danielou, 2004). The latter is our point of view (Folcher, 2003) and the *raison d’être* of the workshop offered in the Master 2 professional training, whose main issues we will spell out below.

EDUCATIONAL AIMS AND HYPOTHESES

The training workshop in collaborative design’s first aim is to create a cross-disciplinary, collaborative design milieu with its own tools. The design approach adopted is that of design-for-use (Folcher, 2010), which relies on methodological tools from the field of ergonomics to achieve overall understanding of projects and a broader exploration of design possibilities.

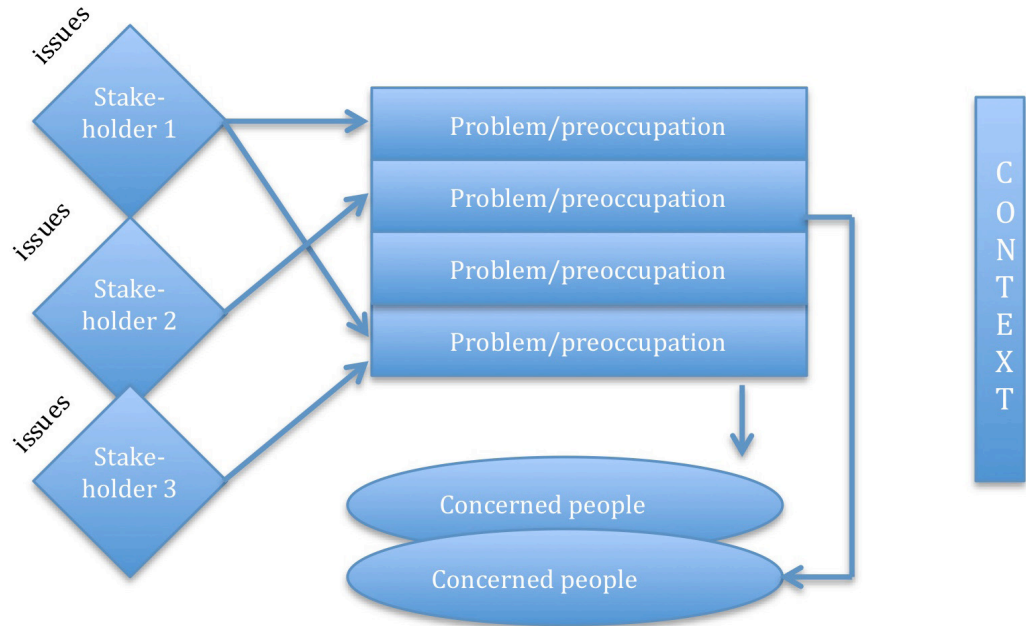
The second aim is to accompany students of ergonomics and design in the gradual construction of shared references for the possible forms of future activity. In another words, it means allowing and equipping the construction of common operative references (de Terssac and Chabaud, 1990).

The third aim is to accompany and structure rapid exchange between ownership and management of the project throughout its duration, all the way from the earliest schematic models to projections in physical space.

The design exercise proposed in the workshop, through a lived experience of collaborative design, is conceived with a didactic goal and has certain characteristics which ensure its ecology: a variety of actors express their potentially-contradictory points of view on the project; collaborative design activity unfolds in two different situations (physically present, and at a distance); the exercise is time-limited; a final result in the form of a sketch is required.

Two hypotheses underlie the workshop:

Figure 1
Social analysis of the project.



1. The first is that collaboration in design requires tools to enable designers to develop a broader vision (of the diversity of stakeholders and the plurality of issues involved) and construct shared references to the future, possible human activities when taking account of all the constraints that arise.
2. The second, more exploratory hypothesis seeks to document the way the design collective exists in two distinct situations: when physically present and when working at a distance.

PROPOSED METHODOLOGICAL TOOLS

The design-for-use approach to collaborative design articulates two methodological tools.

The first is a tool for social analysis of the project, used by practitioners of ergonomics to structure their interventions. It details the preoccupations and/or problems expressed by each stakeholder, and their issues; it presents the people likely to be concerned by the preoccupations and/or problems

expressed; and it makes explicit relevant elements of the context. Figure 1 provides a schematic illustration.

The second tool is an enlarged method for exploring the possibilities in design, which are structured according to three broad types of contribution:

1. The project management contribution: exploring questions about the will to change and create new things. They address the way the project is piloted and how it develops, considering all the elements deemed relevant: political, strategic, financial, temporal, human;
2. The ownership contribution: exploring questions about how the will behind the project is made concrete in the form of something viable. They guarantee the feasibility of achieving the project on various levels: technical, legal, security, ecological, human;
3. The end users point of view contribution: exploring questions from the point of view of future, possible activity at the heart of the

project. They address the way general human characteristics are taken into account, as well as the specific, multi-determined human activities in the precise situation.

This method takes the form of a table which students complete as their developing projects unfold. An extract from the method used in the projects will be presented in the results section.

COLLABORATIVE DESIGN WORKSHOP: PRESENTATION

Two groups of 5 students (ergonomists and designers) took part in the collaborative design workshop, accompanied by three student observers (ergonomists) for each group, so as to record the process and analyze it at the end of the experience.

Thus in this workshop students in ergonomics were either designers or observers, whereas design students exclusively played the role of designer. Each group within the collaborative workshop was asked to design a secondary school for 240 pupils. They had to comply with a set of constraints in the program they were given, and were invited to implement an innovative approach to design enabling them to imagine and design a school which would be “different” from the way schools are traditionally conceived (Figure 2).

Four stakeholders who originated the demand for the school design set out their points of view on the project, and the issues involved: the Mayor of the town where the school would be located; a member of the regional council with responsibility for questions of disability and accessibility; a representative of the building standards department; and the future head teacher of the school. Throughout the design procedure students were also helped and guided by two engineering-architecture trainers, who advised and helped them with the presentation of their ideas and thoughts.

1. The design procedure fell into four phases:
2. Forming and presenting the exercise, the working context, listening to the four stakeholders, and learning to use the SketSha software in the distance-working situation;

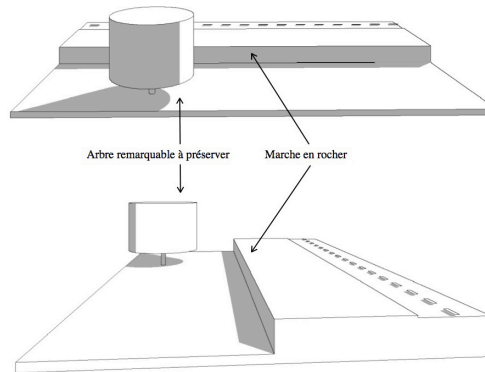


Figure 2
School design outline
(extract).

3. Collaborative design working physically together;
4. Collaborative design working at a distance using SketSha software;
5. Finalizing ideas and presenting the project.

In the distance-working situation, designers were able to work simultaneously with the help of an innovative technological tool, the *Studio Digital Collaboratif* developed by LUCID of Liège University. It enables virtual working meetings to take place, at which participants can share spoken exchanges as well as any sort of document they have brought – these documents can also be modified and annotated graphically in real time (Ben Rajeb and Leclercq, 2012).

RESULTS: PROJECTS PRODUCED AND DESIGN PROCESS

In the time allowed, the two groups produced projects that explained the main lines of orientation and justified the choices they had made, and delivered a final graphic sketch:

- Group 1 opted to design an “innovative school that makes culture more visible and the town more attractive”. They called their project ART’CADEMIE (Alexandre et al., 2012).
- Group 2 focused on “a school for everyone, a place where activities can meet”. They called their project ECHOLOGIA (Houidek et al., 2012). Analysis of the way the design process unfolded

shows the existence of 'moments' which gave structure and rhythm to the collaborative design activity in the groups (see Table 1):

- Moment 1 "*Brainstorming*": consisting in social analysis of the project on the basis of what the stakeholders said, and construction of an overall vision; initial structuring of the project's general orientation. Students were physically present, producing documents to illustrate and synthesize their ideas. During this period an overall vision of the project is constructed gradually: the stakeholders, the problems and preoccupations they express, and the people likely to be concerned by those problems, are at the heart of the project. This vision is the basis for preliminary sketches on paper, resulting from oral exchanges between the different designers, who have differing references and experience.
- Moment 2 "*Sketches taking shape*": consisting in further exchange on the project's orientations, and drawing up initial schemes. Students were still physically present and produced drawings and plans on paper. Students gradually make their sketches more concrete, adding measures and integrating the constraints of the plan given in the outline. Certain structure-giving choices appear in the paper sketches, such as arrows marked in red that indicate the intention to open up the school and facilitate people movement towards the interior of the building.
- Moment 3 "*Translating drawings and sketches into m² on the plan*": consisting in carrying out numerous calculations of space and levels, transforming drawings into concrete plans. Very detailed calculations (e.g. the height of a step) and difficulty in achieving them. Students were working at a distance, and produced unfinished plans within each level. Moment 3 makes it possible to pursue reflection around the project, using SketSha for the sketches and video-conferencing for oral exchanges. But the system, by offering a grill which allows the addition of a graphic scale to the sketches

produced, very rapidly led the group to focus on detailed feasibility calculations for certain spaces (measuring a stairwell for example) to the detriment of the place and function of these elements in the project. As a result of this distance, the tool and the type of project that they have not yet mastered, numerous conflicts came to light between the project stakeholders. They had to adapt quickly to the conflict situation that arose, and aim for a more global vision of the project. This moment then led to another period centered on the general dimensions which had to be respected in the plan (e.g. the situation and dimensions of classrooms relative to the library and dining-room) rather than precise calculations of isolated elements.

- Moment 4 "*Abolishing m²*": consisting in elaborating plans according to dimensional constraints, rather than strictly complying with criteria about m², with return to a more overall vision. Here, the students work at a distance and produce finalized plans for each level. This moment is when they return to the heart of the project, and takes the form of different sketches, more and more finalized according to level, and structured by the orientations defined during the design process.
- Moment 5 "*Reorganizing and finalizing project*": consisting in plans aligned with project orientations, space constraints examined, choices made in line with orientations. Students at a distance, produced presentation aids. At this point, groups retook possession of the project and were able to present it and make its guiding principles explicit, illustrating them with freehand drawings and SketSha sketches.

All through the construction of their projects, students practiced the method of enlarged design-possibility exploration, which they interpreted in their plans and sketches afterwards, introducing site and program constraints. Table 2 presents an extract of this exploration work.

The five moments that structured the collaborative design process bear witness to reorganizations

Table 2
Enlarged method for exploring
design possibilities for Echologia
school project (extract).

Objectives	Project Management contribution <=> End user contribution	Ownership Contribution <=> End user contribution	Solutions explored and selected
Accessibility	A school for everyone: -taking account of diversity -simplifying people-movement - respecting others	- For all disabled persons: wide corridors, large entrance, ease of access to all levels - Avoid multiplying means of access: long corridors, accessible toilets	Classrooms: arranged in blocks of 3 on 2 levels to create fluid people-movement - Room doors 1m wide for wheelchair access - Creating an identical, superposed access area on all floors Blocks: stairs/elevators, toilets and security post at an equal distance for everyone, everywhere, and close to each classroom. Ease of access: Facilitating people-movement towards the inside for everyone: all corridors in line for greater security and to avoid getting lost + accessibility for maintenance staff (disabled or not).

of collective activity, notably under the effect of teachers' interventions which guided or even reoriented the designers' work:

- Help with the initial definition of the school project: what school? For whom?
- Help with more detailed definition: a school for all; each future user's activity; accessibility;
- Reorientation: from detailed calculation of elements towards the overall meaning of the project: placing sketches in the plan, rather than precise calculations about the size of a staircase.

COLLABORATIVE DESIGN WHEN PHYSICALLY PRESENT, AND AT A DISTANCE

The work of the observers made it possible to follow the collaborative design process and identify the specific aspects of each situation and the role played by different artifacts (Belaitouche et al., 2012; Mateev et al., 2012).

Conflict. When physically present, confrontations relate to the main ideas of the school project and are expressed individually: everyone sets out

their arguments and opens them up for debate in the group. New ideas gradually emerge and a consensus forms. When distance working, confrontations still relate to the project's main ideas but are expressed by one pair towards the other situated at a distance.

Withdrawal. When physically present, withdrawal takes the form of a less active role for one of the participants, which has several functions: indicating disagreement, or the wish to start another activity, related to the activity going on (e.g. making a drawing while the group progresses with producing ideas). This type of withdrawal turned out to be productive, as it makes it possible to share the drawings which fuel the ideas produced.

When distance working, withdrawal took the form of disappearing from the camera angle. This was less comprehensible and thus less productive in terms of taking the collective work forward.

Speaking and decision-making. When physically present, the flow of speech enables a certain proliferation of ideas. People occasionally talking over one another can be dealt with in the situation.

Decision-making happens before action: consensus is developed orally and is then translated into action.

When distance working, for reasons of comprehension, the pairs have to alternate speaking to each other in the form of questions and answers. Decision-making seems to follow the opposite movement from that observed when physically present: action takes place before agreement is reached, which can generate disagreement and even conflict within the collective. Actions carried out before oral agreement can include erasing part of a drawing or alternative propositions. They can serve a function of collegial decision-making, or the imposition of an idea.

Diversity of activities. The work of design is as much a matter of exchange and debating ideas as it is of drawings, sketches, tables and plans. When physically present these diverse activities – exchanging, writing, drawing – coexist without difficulty and mutually enrich one another: a quick sketch can be produced to support an idea. At a distance, on the other hand, it seems necessary to sequence activities, and this takes the form of a different way of organizing activity: expressing an idea, then writing or drawing – or developing a drawing and then explaining it.

Using artifacts. When physically present, designers make use of a wide variety of artifacts – sheets of paper, notebooks, pens, pencils, felt-tip pens, erasers – which enables them both to express numerous ideas and to withdraw in order to further develop an idea or drawing. It would appear that these artifacts serve a function of collaborative work just as much as individual, withdrawn work in the service of the collective work.

At a distance, work done on paper has been scanned and designs and drawings are available in digital form. Pens, erasers and felt-tip pens take the form of the SketSha software pen. This pen has several functions: it can write like a pen or felt-tip pen, erase, place and displace items on the plan. In addition there is only one pen, so that whichever designer happens to be holding it has considerable power to transform the project. Here too a certain

sequentiality can be observed in activities, as they develop step by step with the progress of exchanges and as the designers pass the SketSha pen from one to another.

CONCLUSION

In the first part of the paper we pointed out characteristics of design situations and the importance of collaboration, given multiple players: the importance of communication, the nature of tasks and how to distribute them, individual skills, negotiation procedures, conflict management and synchronization (Darses and Falzon, 1994). The ergonomic collaborative design workshop enabled our students to encounter complexity of design activity and collaboration. This innovative learning approach involves not only questions related to process and the “how-to” of design, but also questions related to the different types of contribution which have been articulated throughout the project, namely project management contribution, the ownership contribution and the End users point of view contribution.

The objective of the design methodology we proposed is to create unity of design and to allow diverse constraints to be expressed in an equivalent manner: constraints related to feasibility, and the will of stakeholders, go alongside those which deal with the planned end users. The End user point of view contribution plays a mediating role as it fertilizes different points of view, and makes it possible to anchor propositions in human-scale reality. It structures the whole project, from the first proliferation of ideas and drawings up to its finalization in the form of a sketch and/or plan.

Through being involved in the design process, observing and analyzing it, our students were able to realize that this sort of architectural design situation has its advantages and its limits. They nonetheless expressed the view that it would have been better to include architecture students too, so that they could contribute different expertise and points of view; this would have enriched their ideas, reflections and questionings about both about the project itself and about the collaboration process.

REFERENCES

- Alexandre D., Ali Ahmad, Adam J., Quattrocioni A (2012) *Art'Cadémie, une école pour vous*, Project realized during the collaborative design workshop, Master 2 Ergonomie et conseil psychologique, University Paris 8. Unpublished document
- Beguín, P 2004, 'L'ergonome acteur de la conception', in *Ergonomie*, P Falzon (ed), Paris, PUF, pp. 376-390.
- Belaitouche M., Hammouchene R., Wagner C. (2012) *Observations*, Project realized during the collaborative design workshop, Master 2 Ergonomie et conseil psychologique, University Paris 8. Unpublished document.
- Ben Rajeb, S. and Leclercq, P 2012, 'Quelles collaborations distantes synchrones dans les pratiques de conception architecturale ? : Analyses comparées des pratiques de conception assistées par la visioconférence, le partage d'écran et le Studio Distant Collaboratif', in *Echelles, Espaces, Temps*, 01Design'8, Bruxelles.
- Boujut, JF 2000, 'Intégration produit-process en conception : organisation et outils', report, PROSPER program: Systèmes de Production, Stratégies, Conception, Gestion.
- Bucciarelli, LL 2002, 'Between thought and object in engineering design', in *Design Studies*, 23 3, pp. 219-231.
- Cross N, Clayburn Cross A 1995, 'Observations of teamwork and social processes in design', *Design Studies*, 16 (2), pp. 143-170.
- Daniellou, F 2004, 'L'ergonomie dans la conduite de projets de conception de systèmes de travail', in *Ergonomie*, P Falzon (ed), Paris: PUF, pp. 359-373.
- Darses, F 2004, 'Processus psychologiques de résolution collective des problèmes de conception: contribution de la psychologie ergonomique', *HDR Psychologie Ergonomique*, University Paris V- René Descartes.
- Darses F and Falzon P 1994, 'La conception collective : une approche de l'ergonomie cognitive', in *Coopération et Conception*, Toulouse, pp. 1-12.
- de Tessac G and Chabaud C 1990, 'Référentiel opératif commun et fiabilité', in Leplat J., de Tessac G. eds., *Les facteurs humains de la fiabilité dans les systèmes complexes*, Octarès, Toulouse, pp. 110-139.
- Folcher V 2003, 'Appropriating artifacts as instruments: when design-for-use meets design-in-use', *Interacting With Computers*, 15, pp. 647-663, Elsevier.
- Folcher V 2010, 'Développement des hommes et des techniques, perspectives de conception pour et dans l'usage', *HDR Ergonomie*, University Paris 8.
- Houidek L., Jarry A., Lantz M., Lambert A. (2012) *Echologia*, Project realized during the collaborative design workshop, Master 2 Ergonomie et conseil psychologique, University Paris 8. Unpublished document.
- Hubers JC 2009, 'Collaborative design in Protospace 3.0', in Wamelink H., Prins M., Geraedts R., 'Changing roles; new roles, new challenges', TU Delft Faculty of Architecture Real Estate & Housing, Delft, www.changing-roles09.nl.
- Jeantet A and Boujut JF 1998, 'Approche socio-technique', in Tollenaere M (ed), *Conception de produits mécaniques, Méthodes, modèles et outils*, Hermès.
- Larsson A 2005, 'Engineering Know-Who: Why social connectedness matters to global design teams', Ph.D thesis, University of Technology of Luleå.
- Martin C 2000, 'Maîtrise d'ouvrage, maîtrise d'œuvre, construire un vrai dialogue', Toulouse: Octarès Editions.
- Mateev C., Sangare L., Tichadou C. (2012) : *Art'Cadémie: observations from group 1*, Project realized during the collaborative design workshop, Master 2 Ergonomie et conseil psychologique, University Paris 8. Unpublished document
- Mineman S 1991, 'The Social Construction of a Technical Reality: empirical studies of group engineering design practice', Ph.D. Dissertation, Stanford University.
- Pahl G, Frankenberger E and Badke-Schaub P 1999, 'Historical background and aims of interdisciplinary research between Bamberg, Darmstadt and Munich', in *Design Studies*, 20 (5), pp. 401-406.
- Pousin F 1986, 'Concevoir et visualiser : la représentation en question. Les nouvelles images et la CAO', in *Le Carré Bleu*, 2/3.
- Visser W 2002, 'Conception individuelle et collective: Approche de l'ergonomie Cognitive', in M Borillo, JP Goulette (eds), *Cognition et création: Explorations cognitives des processus de conception*, pp. 311-327.

