

# Quality of collaboration in design: articulating multiple dimensions and viewpoints

Michael Baker, Françoise Détienne

UMR 5141 LTCI, CNRS – Telecom ParisTech

{michael.baker, francoise.detienne}@telecom-paristech.fr

Jean-Marie Burkhardt

IFSTTAR

jean-marie.burkhardt@ifsttar.fr

## Abstract

The aim of this paper is to provide a research synthesis and a theoretical-methodological framework for the appraisal of the quality of collaboration in co-design situations. The paper presents a discussion of how good collaboration can be related to successful design, and discusses some existing approaches to evaluating the quality of collaboration. A broader perspective on collaboration and its qualities is then elaborated, in terms of nine propositions, comprising defining characteristics, specific processes, and theoretical-methodological standpoints with respect to collaboration processes. The concluding discussion aims to bring strands of research together with a view to outlining future research perspectives. It is argued that there is no privileged standpoint from which to evaluate the quality of collaboration: the qualities to which precedence will be given in this depend on the objects of co-design activities, what is at stake, and the viewpoints of social actors involved. Research approaches in this direction could take this into account by articulating alternative perspectives within a dialogical approach.

**Keywords:** Co-design, collaboration, quality evaluation, CSCW, CSCL

## 1. Introduction

Design is an activity consisting in specifying an artefact, given requirements that indicate one or more functions that it must fulfil and/or objectives that it must satisfy (Visser, 2004). The most common conception of design problems is to consider them as “ill-structured” (Eastman, 1969; Simon, 1973). The main characteristics of such problems are: many degrees of freedom in the problem’s initial state; instability of design requirements and co-evolution of problem-solutions; multiplicity of acceptable solutions and multiplicity of criteria; complexity and interdependency between design subtasks, which leads, in collaborative design, to tightly coupled work and close interdependencies (Olson & Olson, 2000). In terms of the cooperative work arrangements distinguished by Schmidt (1994), design typically serves a generic function, which is the confrontation and combination of perspectives. It is a cooperative work arrangement that facilitates the application of multiple perspectives (conceptualisation of the field of work) on a given problem, so as to match the multifarious nature of the field of work.

---

\* This paper is a substantially revised and extended version of:  
Détienne, F., Baker, M. & Burkhardt, J.-M. (2012). Quality of collaboration in design meetings: methodological reflexions. *CoDesign: International Journal of CoCreation in Design*, 8(4), 247-261.

There is an important distinction to be made between two types of design situations, according to the nature of shared goals: *distributed design* and *co-design* (Falzon, 1994; Détienne, 2006) involving respectively the predominance of either *cooperation* or *collaboration* processes.

In distributed design (a notion to be distinguished from distributed work and distributed cooperation), each actor or team has his/her own subtask to perform. Participants pursue goals (or at least sub-goals) that are specific to them, and yet they do more than sharing resources: they need to *cooperate* through *coordination*, in order to pursue their own subtasks, because of interdependences between subtasks of the design project. Components of the design work are highly interdependent; thus managing coordination is one of the major challenges of computer-supported cooperative work.

In co-design, involving collaboration, actors or teams share a goal that is mutually assumed to be identical, and contribute in order to reach it by applying their multiple perspectives. They do so within the very strong constraints of direct collaboration so as to guarantee a joint solution to the problem. In this paper, our focus will be on *co-design situations, involving collaboration*, where design meetings are seen as one paradigmatic form of co-design often analysed in the literature (e.g. McDonnell & Lloyd, 2009). If cooperation involves shared goals and distribution of responsibilities for achieving subtasks amongst participants, collaboration involves this, but goes further, in terms of the mostly synchronous joint attempt to co-elaborate a shared understanding of the problem to be solved (Roschelle & Teasley, 1995). In many concrete situations, there is a continuum between cooperation and collaboration, the former requiring the latter, at least to negotiate subtask assignments, in situations where strict norms and social hierarchies do not prescribe this.

More generally, when people collaborate, they can be concerned not only with so doing, but also, reflexively, with understanding why it proceeded the way it did, produced the outcomes that it did, and even in trying to ensure that it works as effectively as possible. In other terms, this is concern with the *quality of collaboration* (cf. Détienne, Baker & Burkhardt, 2010, 2012): what it is that makes for a rewarding experience of collaborating with others? What processes of collaboration lead to outcomes that are viewed in a positive or negative way? These questions can be seen from the points of view of different social actors involved in the collaborative endeavour, as well as by researchers who may be more or less implicated. Individual participants may find collaborating with others more or less easy or difficult, pleasant or unpleasant, rewarding or detrimental to their self-esteem, and more or less productive. Some of these aspects may be shared amongst sub-groups within the collaborating group, by the sharing of experiences after the event. Collaborating on some task can be an everyday experience (such as trying to build a piece of furniture with others); but it often takes place — and this is our concern here — in an institutional setting, at work, or in education. In that case, the quality of a particular collaborative episode is also of concern to other people in the institution (colleagues, managers, teachers), whose role is to ensure that its overall objectives are met, as well as to people outside it (clients, parents).

Co-design situations are of course specific cases of task-oriented collaboration (some of whose specificities are mentioned above). Whilst taking these specificities into account, in order to give substance to the notion of “quality of collaboration” we shall draw on a broader base of research on collaborative processes, from both work and educational situations. In fact, in the twenty-first century, as reflected in research in cognitive ergonomics, HCI, CSCW and the related field of CSCL (Computer-Supported Collaborative Learning), the worlds of work and education are witnessing a new *rapprochement*: learning comes closer to work, and work to learning. Thus, work increasingly emphasises the need for training for innovation and flexibility (e.g. “lifelong learning”); and education increasingly emphasises the need for coming closer to demands of work (e.g. project-oriented pedagogy, where students’ try to satisfy the demands of an external client; Hakkarainen, et al., 2004). One approach to evaluating the quality of collaboration in design situations that we discuss below (§3) was inspired by similar work in CSCL (Spada, Meier, Rummel, & Hauser, 2005), where the aim was to understand the relationships between the quality of collaboration and learning effects. Finally, much research on co-design processes has in fact been carried out in situations where designers are being trained (e.g. Safin, Verschuere, Burkhardt, Détienne & Hébert, 2010; Engeström & Toiviainen, 2011).

Our aim here is thus to explore descriptive and normative approaches to the quality and qualities of collaboration, its processes and products, from different perspectives and across different timescales.

In what follows, we begin with a discussion of how good collaboration can be related to successful design (§2); we then discuss some existing approaches to evaluating the quality of collaboration (§3). In order to further advance approaches to evaluating quality of collaboration, we then (§4) elaborate a broader vision and perspective on collaboration and its qualities, in terms of nine fundamental propositions (in the sense of *proposals*, to be validated). The concluding discussion aims to bring strands of research together with a view to outlining future research perspectives. Whilst describing the main dimensions and processes of collaboration on which appraisals of its qualities can be based, we argue that there is no privileged standpoint from which to evaluate the quality of collaboration: the qualities to which precedence will be given in this depend on the objects of co-design activities, what is at stake, and the viewpoints of social actors involved. Research approaches in this direction could take this into account by articulating alternative perspectives within a dialogical approach to understanding the quality of collaboration.

## 2. Collaboration and co-design

Empirical studies on the process of collaboration in design teams (see for example, Olson, Olson, Carter & Storrosten, 1992; Stempfle & Badke-Schaub, 2002; Burkhardt, Détienne, Moutsingua-Mpaga, Perron, Leclercq & Safin, 2008; Détienne, Burkhardt, Hébert & Perron, 2008; Détienne, 2006; MacDonnell & Lloyd, 2009) in various application domains (e.g., software design, architectural design), have highlighted distinctive collaborative processes that are important for successful design. These processes can be taken as a benchmark for good collaboration with respect to design. They can be grouped along several dimensions concerning communication processes such as grounding, task-related processes (e.g. exchanges of knowledge relevant for the task at hand; argumentation processes), and coordination processes.

Communication processes are most important to ensure the construction of a common referential within a group of collaborators. The establishment of common ground is a collaborative process (Clark & Schaefer, 1989; Clark & Brennan, 1991) in which the co-designers jointly establish what they mutually understand so that design activities can proceed. Grounding is linked to sharing of information through the representation of the environment and the artefact, the dialogue, and the supposed “pre-existing” shared knowledge (relating to shared culture, institutional membership, experience). This activity ensures inter-comprehension and construction of shared (or at least compatible) representations of the current state of the problem, solutions, plans, design rules and more general design knowledge.

Empirical studies of collaborative design (e.g. D'Astous, Détienne, Visser & Robillard, 2004; Olson et al. 1992, Stempfle & Badke-Schaub, 2002) found that grounding, although time-consuming, was highly important in ensuring good design. Stempfle and Badke-Schaub (2002) showed that when teams bypassed grounding (referred to as “analysis”), this led them to premature evaluation of design ideas. These authors also argue that lack of a common frame of reference, as in the case of heterogeneous design teams, may encourage building of a mental model through questioning. Even if the questions are not meant to challenge an idea for a solution, but simply aim at establishing facts, thinking in detail about the problem may still cause previously unseen things to come up during the discussion. They argue that this mechanism could be one of the reasons why heterogeneous teams have repeatedly been found to outperform homogenous teams in complex problem-solving tasks (e. g. Thomas, 1999).

Task-related processes concern the evolution of the design problem and solution: (a) design activities, i.e., elaboration, enhancements of solutions and of alternative solutions; (b) evaluation activities, i.e., evaluation of solutions or alternative solutions, on the basis of criteria. These activities are supported by argumentation and negotiation mechanisms. These content-oriented mechanisms reveal how the group resolves the task at hand by sharing and co-elaborating knowledge concerning the design artefact, by confronting their various perspectives, and by converging toward negotiated solutions.

Whereas studies show evidence that these mechanisms are important for the quality of design products (e.g. Pahl, Badke-Schaub, & Frankenberger, 1999), other empirical studies show that important drawbacks of observed design teams (e.g. Stempfle & Badke-Schaub, 2002; Darses, Détienne & Visser, 2004) may be as follows: limitation in solution search; early choice of a solution without exploration of all alternatives; rapid solution evaluation on the basis of just a few criteria; and difficulties in taking into account all criteria and their inter-dependencies (constraint management). In design creativity studies

(Paulus & Nijstad, 2003), similar drawbacks are highlighted as well as disregard of too divergent ideas: they are interpreted by social phenomenon such as conformity biases and controlled by specific methods such as brainstorming. Overall, whereas openness and absence of judgement is promoted in encouraging idea generation, Stempfle and Badke-Schaub (2002) also observed that disagreement and the challenging of ideas can lead to careful re-analysis of the solution-idea, often with evolution of new and important insights. This refers to the notion of 'constructive conflict' that will be briefly developed in the next section of this paper.

Collaboration also concerns group management activities such as: (a) project management and coordination activities, e.g., allocation and planning of tasks; (b) meeting/interaction management activities, e.g., ordering, postponing of topics in the meeting. These process-oriented mechanisms ensure the management of tasks interdependencies, which is highly important in a tightly-coupled task such as design. These coordination mechanisms tend to become more central with technology mediation in distributed design (e.g. Herbsleb & Mockus, 2003).

### 3. Some methodological issues relating to collaboration appraisal

The question of how to evaluate collaboration is a topic of interest in several fields of human and organisational sciences, as well as in CSCW. On the basis of this large body of literature, we discuss some methodological issues and difficulties encountered in appraising<sup>1</sup> collaboration.

#### 3.1 Difficulties in "quantifying" collaboration

A large body of methodology developed to assess collaboration processes and collaborative tools has been focused on quantifying a restricted subset of fine-grained interactions. An example, given in a recent review by Hornbæk (2006), concerns the measure of "communication effort": number of speakers' turns; number of words spoken; number of interruptions; amount of grounding questions. Expert-based approaches to assessing the ergonomic quality of computer-supported collaborative tools have also been based on particular actions or behaviours that are specific to group activities (as opposed to usability features related to the task-world). For example, Pinelle & Gutwin (2008), in their heuristics-based method, proposed more than 40 typical actions that should be supported by tabletop groupware to support teamwork, such as "point to object during conversation to discuss content" or "rotate and move objects' to another person".

A first difficulty with these quantitative approaches based on behaviour coding is that explicit categories of analysis often remain *ad hoc* with respect to the considered situation, i.e. they are difficult to apply in all situations, and need to be adapted to specific situations.

An even more critical difficulty is that quantitative variations of most of these indicators are non-univocal: any increase or decrease of them could signify either an interactive-intensive collaboration or evidence of huge difficulties in establishing or maintaining the collaboration. As noted by Crook et al. (2010) "*Quality may not always be picked up in our observations of spoken and written communication. High quality collaboration can often arise because of participants realising they DON'T need to communicate.*" Indeed, the amount of collaborative behaviours may be strongly affected by factors related to the group as well as to the task and situation. For example, "team familiarity" (i.e. individuals' prior shared work experience) has been shown to improve the ability of learning to occur within the team, as the team is better able to identify, transfer and apply knowledge to solve the problem at hand (Staats, Gino & Pisano, 2010). Team familiarity can in turn leads to a significantly lower amount of observable interactions and collaborative behaviours, as noticed by Burkhardt et al. (2008).

---

<sup>1</sup> In this paper we mostly use the cognate terms "evaluate", "assess" and "appraise" indifferently. Although each term involves the core meaning of "ascribing value" to something or someone, there are nevertheless nuances of meanings in certain cases. For example, the etymology of "appraise" is that of "giving praise to" something or someone, which orients the ascribed value towards the positive aspects.

### **3.2 Towards qualitative multi-dimensional approaches**

More qualitative approaches, based on multiple-dimensional views of collaboration, have been recently adopted in several disciplinary fields, including cognitive ergonomics of design (Burkhardt, Détienne, Hebert, Perron, Safin, & Leclercq, 2009), crisis management (Gaudin, Philibert & Bonnardel, 2011), computer-supported collaborative learning (Spada et al. 2005) and organisational studies of team learning and management (Savelsbergh, van der Heijden & Poell, 2009).

In questionnaire and rating-based assessments, sets of items are to be responded to using various n-point rating scales. For example, the rating approach of Savelsbergh, van der Heijden & Poell (2009) is based on questionnaire and rating-based assessment of team collaborative learning and performance. These authors distinguish five main distinctive categories of behaviour, namely, *exploring and co-construction of knowledge, collective reflection, error management, feedback behaviour and collectively experimenting*. Participants are asked to assess how frequent these behaviours occurred within the team, based on 28 items with a 5-point rating scale ranging from (1) never, to (5) always. An example of an item relating to *Co-construction of knowledge* was "Information from team members is completed with information of other team members".

There are obvious advantages of multidimensional approaches to understanding collaborative processes (Savelsbergh, van der Heijden, & Poell, 2009). Firstly, they provide a more elaborated or nuanced view of collaboration than the previously reported approaches. Secondly, it is useful to identify potential relationships between distinctive dimensions of collaboration and aspects of team performance aspects, in order identify processes that could be improved.

However, these methods raise issues related to the temporal scale under evaluation. Concerning relationships between quality assessment and performance or efficiency aspects, some aspects of quality may positively or negatively correlate with performance, depending on the timescale adopted. For example, Bunderson and Sutcliffe's study (2003) suggests that teams' collaborative learning orientation is related both positively (in the long run) and negatively (in the short term) to team performance. In the short term, an extreme focus on learning and competence development would impair performance. Thus quality may need to be measured in a way that goes beyond the temporal and spatial limitations of studying particular collaborative episodes.

### **3.3 An approach to evaluating the quality of collaboration in co-design**

We now discuss in some detail one recent approach to evaluating the quality of collaboration in design. Burkhardt et al. (2009) have proposed a multi-dimensional rating scheme for evaluating the quality of collaboration in technology-mediated design. This method, initially (and partly) based on the method of Spada, Meier, Rummel & Hauser (2005) in CSCL research, distinguishes seven dimensions, along five aspects, identified as central for collaboration in design: communication (1, 2), task processes (3, 4), group processes (5), as well as symmetry in interaction (6), and individual task orientation (7). This approach has been modified so as to take into account characteristics of activity in collaborative design situations and to improve the assessment procedure; it has also been tested for inter-coder reliability. A summary of dimensions and indicators of this method is shown in Table 1.

This method has been used to analyse the quality of collaboration of two student teams in a longitudinal study of a collaborative distant architectural studio (Safin et al. 2010). The method is applied by the research to video data, in response to subjective perceptions of quality, for the whole interaction, along the different dimensions. Intersubjective agreement between analysts (who received prior training on use of the method, as defined by a manual) is checked statistically (Cohen's kappa test). This is thus a 'global' method, applied by an external observer (the researcher), designed for coping with large quantities of complex data.

TABLE 1. DIMENSIONS AND INDICATORS TO ASSESS THE QUALITY OF COLLABORATION (FROM BURKHARDT, DÉTIENNE, HEBERT, & PERRON, 2009)

| <i>Dimensions</i>                            | <i>Definition</i>   | <i>Indicators</i>   |
|--|---|---|
| 1. Fluidity of collaboration                 | Assesses the management of verbal communication (verbal turns), of actions (tool use) and of attention orientation                                  | <ul style="list-style-type: none"> <li>- Fluidity of verbal turns</li> <li>- Fluidity of tools use (style, menu)</li> <li>- Coherency of attention orientation</li> </ul>   |
| 2. Sustaining mutual understanding           | Assesses the grounding processes concerning the design artefact (problem, solutions), the designers' actions and the state of involved tools.       | <ul style="list-style-type: none"> <li>- Mutual understanding of the state of design problem/solutions</li> <li>- Mutual understanding of the actions in progress and next actions</li> <li>- Mutual understanding of the state of the system (active functions, open documents)</li> </ul> |
| 3. Information exchanges for problem solving | Assesses design ideas pooling, refinement of design ideas and coherency of ideas.   | <ul style="list-style-type: none"> <li>- Generation of design ideas (problem, solutions, past cases, constraints)</li> <li>- Refinement of design ideas</li> <li>- Coherency and follow up of ideas</li> </ul>  |
| 4. Argumentation and reaching consensus      | Assesses whether or not there is argumentation and decision taken on common consensus.  | <ul style="list-style-type: none"> <li>- Criticisms and argumentation</li> <li>- Checking solutions adequacy with design constraints</li> <li>- Common decision taking</li> </ul>   |
| 5. Task and time management                  | Assesses the planning (e.g. task allocation) and time management.   | <ul style="list-style-type: none"> <li>- Work planning</li> <li>- Task division</li> <li>- Distribution and management of tasks interdependencies</li> <li>- Time management</li> </ul>   |
| 6. Cooperative orientation                   | Assesses the balance of contribution of the actors in design, planning, and in verbal and graphical actions.  | <ul style="list-style-type: none"> <li>- Symmetry of verbal contributions</li> <li>- Symmetry of use of graphical tools</li> <li>- Symmetry in task management</li> <li>- Symmetry in design choices</li> </ul>   |
| 7. Individual task orientation               | Assesses, for each contributor, motivation (marks of interest in the collaboration), implication (actions) and involvement (attention orientation). | <ul style="list-style-type: none"> <li>- Showing motivation and encouraging others' motivation</li> <li>- Constancy of effort put in the task</li> <li>- Attention orientation in relation with the design task</li> </ul>  |

Results of analysis in this case highlighted that the quality of collaboration is a multidimensional property that changes over time and that also depends on the task and the phase of joint activity. More generally, the quality of collaboration and the design process appear to have a bilateral relationship: a good collaboration allows the design process to progress, and the progression of the design process provides the conditions for a good collaboration. We believe this to be an important result, with wide ramifications for collaborative design, as well as for other collaborative task-oriented activities.

#### 4. Salient characteristics of collaboration: nine propositions

Any approach to determining the quality of collaboration depends on how collaboration is conceived or defined, and on what are considered to be its most salient and relevant characteristics in particular situations, from the points of view of different social actors (including researchers).

In the previous section, we described some existing research approaches to analysing collaboration, with the characteristics on which they focus. Our aim here is to situate these methods within a somewhat broader vision of collaboration and its quality, which we summarise in the form of *nine propositions* (see Table 2). This will enable us, in turn, to propose a more general vision of approaches to the study of the quality of collaboration. It is important for us to be clear about *the status of these propositions*. These “propositions” are to be understood in the sense of “proposals”, for additional aspects of collaboration to be incorporated into methods for analysing quality of collaboration. *Given their status as propositions (i.e. proposals), their capacity for identifying aspects of collaboration that relate to quality of design products has yet to be evaluated.*

Taken in their entirety, the propositions represent a particular vision of collaboration in design, with a view to examining its quality. A somewhat classical recourse to etymology of the word “collaboration” may be of interest here, since we claim that our vision of collaboration concords with this. “Collaboration” means “co-e-labore”: “co” (together), “e” (prefix, as in “ex”, “out”, or “to bring out”, and “labore”, work. A contemporary gloss might be “working to bring out ideas together”, which seems to us to well represent the spirit of creative design.

We divide our propositions concerning collaboration into three groups: defining characteristics of collaboration<sup>2</sup>, specific processes involved in collaborative interactions, and epistemological standpoints (Table 2).

TABLE 2. NINE PROPOSITIONS ON COLLABORATION.

| <i>Type</i>                     | <i>N°</i> | <i>Proposition</i>  | <i>Description</i>  |
|---------------------------------|-----------|---|---|
| <i>Defining characteristics</i> |           |   |   |
|                                 | 1         | Collaboration implies a shared task focus                                   | Collaboration involves striving to elaborate a shared understanding of a shared task focus, involving particularly intense grounding (Clark & Schaefer, 1989; Baker, Hansen, Joiner & Traum, 1999). In that respect, it is distinguished from cooperation, which is compatible with distribution of responsibilities for achieving subtasks amongst participants (Roschelle & Teasley, 1995; Baker, 2002). This corresponds to the distinction between distributed design, implying cooperation, and co-design, involving collaboration (see §1 above). |
|                                 | 2         | Collaboration tends towards symmetry of participation                       | Collaboration tends towards symmetrical rights to participate in varied ways to the shared task, as well as tending towards symmetry and exchange of emerging roles (Baker, 2002). (“Symmetry” is not to be understood as “identity”, or ‘sameness’, since of course collaboration participants always differ in important respects): this is <i>symmetry of rights to participate</i> .  |
|                                 | 3         | Collaboration is multidimensional   | Collaboration operates on dimensions of the task, communication and the regulation of both (cf. §2 above).  |
|                                 | 4         | Collaboration is mediated   | All human activity is mediated by psychological-semiotic, and often physical tools (Vygotsky, 1934/1978). Co-design involves the interplay between varied semiotic registers, such as texts, diagrams, pictures (van Someren et al., 1998).   |
|                                 | 5         | Collaboration requires coordination and organisation                        | Coordination is required by collaboration on the level of individual actions and utterances, as well as on the levels of task progression (“task scripts” and procedures) and of successive collaborative activities themselves (“collaboration scripts”, e.g. successively, idea generation, organisation, selection, synthesis, ...).   |
| <i>Specific processes</i>       |           |   |   |
|                                 | 6         | Collaboration involves discursive, socio-relational and affective processes | Task-oriented collaboration, within specific meetings, involves the interplay between knowledge co-elaboration processes, interpersonal relations and the interactive circulation of affect (cf. “team building”).  |

<sup>2</sup> It is of course not possible to legislate with respect to definitions of important concepts in human and social sciences. We therefore claim that these characteristics of collaboration correspond to what is generally accepted in the research literature, and that they correspond to a useful distinction between phenomena of cooperation and collaboration (see §1 of this paper).

|                                    |   |  |   |
|------------------------------------|---|--|---|
|                                    | 7 | Collaboration is a more or less constructive, productive, creative and reflexive process | Collaboration can be constructive of new understanding in the group, without necessarily being productive in terms of the quality of the output and the efficiency of the process. Regulation of collaboration requires reflecting on collaboration itself. |
| <i>Epistemological standpoints</i> | 8 | Collaboration is a culturally-historically situated activity                             | Understanding how collaboration unfolds requires situating it in dominant cultural patterns, and relating particular meetings to others, situational stakes and the objects of the activity.  |
|                                    | 9 | Collaboration must be understood from multiple perspectives                              | The specific characteristics of collaboration that are judged to be relevant to evaluating its quality depend on what is at stake in the situation, from the points of view of social actors involved and concerned.  |

Since propositions 1 to 5 are largely definitional, below, we focus below on elaborating on specific processes of collaboration and our epistemological standpoints on evaluation of the quality of collaboration (propositions 6 to 9).

#### **4.1 Collaboration involves discursive, socio-relational and affective processes (Prop. 6)**

Although designers' knowledge heuristics are essential for design, designing is "more than a cognitive process": it is also social (in the sense of interpersonal) process in which solutions are negotiated (Bucciarelli, 1988; Schön, 1983). Such a social process of negotiation in co-design goes beyond cognitive design processes in terms of three main other types of processes: discursive, socio-relational and affective.

Discursive processes, are the means by which participants in a collaboration use language to 'do work on' representations, for example, by elaborating each other's proposals/ideas, drawing inferences from them, giving them argumentative or explanatory foundations. This is "more than" the pooling of individual designers' knowledge in that collaborative design solutions *emerge* from designers' interactions in a way that goes beyond the sum of individual contributions. Partly inspired by work on rhetorical relations (Mann & Thompson, 1988) and on discursive operations (Vignaux, 1990), it is possible to define a set of operations working on a linguistic-cognitive plane, that characterise knowledge co-elaboration, either within a specific participant's contributions or, more importantly, between participants' contributions (Baker, 1994). These include operations that provide 'foundations' for proposals (justification, explanation, argumentation), those that elaborate or extend proposals, that restrict them and reformulate them.

However, such discursive operations produced in social interaction always carry with them an aspect of face preservation or threat (Brown & Levinson, 1987), i.e. any transformation of another's ideas, in collaborative dialogue, constitutes also a certain *evaluation* of those ideas and of the person who proposed them, with all the affective aspects which will necessarily be associated. This is particularly apparent in the case of verbal conflict and argumentation dialogue. Any argumentative critique or "attack" (Barth & Krabbe, 1982) on a statement proposed by a participant, will also be experienced by that person as, to some extent, an attack on herself or himself, in terms of perceptions of competence that are projected. It is well established that the degree of aggressiveness of a critique is a determining aspect of how argumentation dialogue unfolds: the more the critique is perceived as aggressive (e.g. claim of irrelevance) the more it is likely that proposers of solutions will defend their views, and thereby themselves (Muntig & Turnbull, 1998).

More generally, it has been argued (Andriessen, Baker & van der Puil, 2011; Baker, Andriessen & Järvelä, 2013) that within particular organisational settings, continued collaboration across several meetings requires establishing and maintaining a "collaborative working relation". This is a specific relationship relating to the context of work, which may draw on, reaffirm or pose a threat to out-of-work relationships. A crucial aspect of this is the way in which "tensions" arising in the collaborative encounter are regulated and "relaxed" (Bales, 1950). Indeed, each collaborating group will have its own



specific tension/relaxation regulation 'signature', some collaborative working relations being able to support large leaps between tension and relaxation, others not (e.g. people who have a strong interpersonal relation can bear to have major disagreements; if not, the interaction may proceed in a more 'flat' tension/relaxation pattern). An important question concerns how such regulation interacts with collaboration on a discursive level.

In co-design situations, argumentative dialogues may proceed by a subtle interplay between arguments drawing on different types of knowledge and the images of their respective competencies that design participants project in the interaction (Fréard et al. 2010). When more than one participant has the same competence (e.g. interior designer), this can lead to competition and (relational) conflict, just as much to mutual understanding and co-construction: being on the same epistemic 'ground' leads to a particular kind of close collaboration, that is different from the case where there is a group of participants each of whom has unique specialities. Thus, the way collaboration functions may go beyond knowledge-based discussion and argumentation, to involve negotiation of competencies of stakeholders. On a social level, important aspects relate indeed to mutual respect, trust, as well as to responsibilities and accountability, within situational rules and norms. More generally, "ethical consideration" for others (Allwood, Traum & Jokinen, 2000) involving mutual trust and respect can be seen as not an 'optional extra' to collaboration, but as a very condition for its continuation.

In sum, collaboration in design, seen as the joint cognitive elaboration of ideas in language-based communication (including gestural and para-linguistic aspects), is inseparable from the interplay of personalities, persons, images of self and other, with all the affects that are involved.

#### ***4.2 Collaboration is a more or less constructive, productive, creative and reflexive process (Prop. 7)***

Although cooperation can proceed by dividing up sub-task responsibilities then combining solutions in a joint product, collaboration itself implies co-construction of the meaning of the problem to be resolved and its solutions, implying 'along the way', the elaboration of new knowledge, (mutual) understanding and social awareness (understanding of the group itself, how it works and what it is about). The distinction between "productive" and "constructive" collaborative interactions (e.g. Miyake, 1986; Baker, 1999) relates closely to two possible foci for the quality of collaboration. A "productive" interaction is one that is seen, from group-internal or external points of view (see Proposition 9), as having led to a 'good' *product*, irrespective of how that was achieved (e.g. it could have been the result of an interaction that was highly directed by one participant 'manager', with little collaboration). To speak of a *constructive* interaction is to focus on the *process* of collaboration itself, and its quality in terms of the extent to which mutual understanding is achieved, whether participants value others' contributions, the quality of the general affective atmosphere, the extent to which participants build on and elaborate others' contributions rather than their own (juxtaposition of monologues) and more generally, the knowledge that emerges from the interaction (whether or not this is reflected in the quality of the final product). A crucial question here is thus the relations between the collaboration process (constructive interaction) and product (productive interaction). In the ideal case, a constructive interaction is also a productive one; but this is not necessarily the case (an interaction can be constructive without being productive, and vice-versa). In this context, it is important to bear in mind the *temporal* dimension, since a given collaborative encounter may be constructive with respect to the group, but its productivity — once the group has learned to work together well — may only be made manifest in subsequent collaborations, occurring at a much later date.

Specific forms of socio-cognitive conflict may relate to constructive argumentation (Baker, 1999), involving reflection on the degree of acceptability of proposed solutions. In fact, engaging in argumentation with a view to cooperatively resolving a conflict ideas can be one of the most intense and constructive forms of collaboration, given that participants are often obliged to more precisely define key concepts during a debate (Walton, 1992). The study of the degree of constructivity of a collaborative

interaction is one way of approaching its creativity<sup>3</sup>, seen as the co-elaboration of new ideas that are feasible and socially valued (Bonnardel, 2006 ; Kristensson et al. 2004).

Reflexive activity, in the sense of reflecting not on the content of a problem or solution, but on one's collaboration and problem-solving strategies, may lead teams to consciously realise that they are stuck or not efficient and therefore change and improve their practices. This refers to the distinction in cognitive ergonomics between functional and meta-functional activity (Falzon, 1994). Schön (1983) stated that self-reflection is the key to successful designing for both individuals and teams. The beneficial effects of self-reflection in design teams have been emphasised by many authors (e.g. Badke-Schaub 1999; Valkenburg 2000) and have been described as powerful in dealing with complexity. However, Badke-Schaub (1999) also noted that self-reflection remains rare and, when criticisms of the team approach occurred, the reactions of the team were mostly unfavourable.

#### **4.3 Collaboration is culturally-historically situated (prop. 8)**

So far, our characterisation of collaboration has focussed on aspects that are *internal* to specific co-design meetings — the processes of elaboration of mutual understanding and knowledge that they involve, as well as emergence of roles, mutual regulation of affect, and so on. But of course, situational factors greatly influence the way that collaboration proceeds: it is necessary to establish close links between processes that are internal to collaborative encounters, as well as what is 'outside' or around them, in the past (the history of the company, and previous collaborations of a group) and elsewhere in physical and social space (e.g. the project manager, client, etc.).

Engeström and Toivainen (2011) thus criticise approaches to collaboration that narrow them down to "the analysis to the here- and- now, in other words, to very short slices of interaction with no history and no future." (p. 35). They argue that, whilst "such fine- grained analyses of discourse may be instructive, due to their isolation from more encompassing processes and historical changes, they have little to offer for researchers interested in problem- solving and learning embedded in complex transformations and design efforts typical to workplaces and professional networks." (ibid., p. 35).

What is required, in order to situated collaborative encounters in their cultural, historical and socio-institutional settings, is to consider "what are the dominant patterns of organising collaboration in this activity at present, what were they in its preceding historical forms, and what might they become in the future?" (ibid., p. 35). There is a link here with particular 'cultures' of collaboration, in particular institutions and *milieux* as well as, indeed, Cultures (with a capital "C", e.g. French or francophone Culture *versus* Japanese culture). Collaboration is thus seen as a *social practice*, which has a developmental past, present and future<sup>4</sup>; as an activity inscribed in particular social rules, a community of practice and division of labour. A challenge for future research is to understand how such cultures of collaboration develop over long periods of time — and a precise understanding of quality of collaboration along shorter timescales can contribute to achieving such a goal.

As with any activity, collaborations have an *object* and a  *motive*; and these will influence both the way that collaboration proceeds as well as social actors' perceptions of its quality or qualities. If, for example, in a particular institution at a particular point in time, what is primary is to increase the profit of the company in which design activity takes place, to position it in the marketplace with a particular 'image', to innovate, to enable a new team to learn to work together, to induce new members, or any combination of these motives, then it is clear that these stakes will weigh upon the collaboration, and will constitute primary criteria for the evaluation of its quality.

#### **4.4 Collaboration and its quality must be understood from multiple perspectives (prop. 9)**

The very idea of "quality of collaboration" might appear, at first sight, as reduced to that of researchers' normative perspectives on what constitutes good or effective collaboration, as a process, with respect to

---

<sup>3</sup> The question of emergence from interaction is relevant here, once collaboration is seen as a complex and non-linear process, from which unpredictable ideas can be produced (e.g. Arrow, McGrath & Berdahl, 2000).

<sup>4</sup> For example, since the Second World War, in work organisations, teams have gone through important historical transformations, where, for example, stable teams are typically being replaced by rapidly fluctuating forms of group activity, that are more and more loose and globally distributed (Engeström, 2006).

outcomes, and the relation between the two. Such a perspective exists and is, we would claim, legitimate (cf. Spada et al. 2005; Détienne, Burkhardt, Hébert, & Perron, 2008). But it is only one perspective amongst many. Such a perspective is often part of a research paradigm whereby qualities of the collaboration process are considered as intermediary variables, to be correlated with its outcomes (learning, quality of product).

Whilst speaking of quality of collaboration is in itself inherently a judgement, this can and must be nevertheless considered from multiple perspectives, of participants and other social actors involved in co-design, in relation to multiple stakes and objects of activity (cf. Proposition 8), in order to ensure social, practical relevance of the appraisal.

Participants in co-design have of course their own experiences and perspectives of collaboration. In relation to, yet also relatively independent from outcomes, collaboration can be a specific socio-relational personal *experience* that may be more or less personally rewarding (Crook, 1994). In multi-expertise situations, participants may feel that their own point of view has been more or less taken into account.

Whilst participants will be personally concerned with the quality of the collaboration process, as well as its products, it is probable that managers and clients will be more concerned with the quality of its outcomes, perhaps irrespectively of how these are achieved. An exception is the case where a co-design meeting has also an orientation towards learning to collaborate together, or 'team building'.

This highlights three points. Firstly, the evaluation of the quality of collaboration must be seen from the points of view of different engaged social actors; secondly, depending on these perspectives, different aspects of collaboration (as described in the above propositions) will be emphasised; thirdly, emphasis on process or product, constructive or productive interaction, and the relations between, the two, will be situated in the articulation between, perspectives of participants present or absent in the co-design meeting. Participants will most likely of course care just as much about the quality of products of co-design as external persons (such as owners, managers, clients), and it is of course possible that managers may care about the quality of collaboration processes, to the extent that they consider broader perspectives and temporal scales, relating to general development of collaborative teams, of individuals' skills in co-design, and the future of the company. If managers are able to take a longer term view of the degree of social cohesion in their enterprises, they may well realise that quality of products is not necessarily the only factor, especially if it requires a collaboration process that is de-motivating for participants (e.g. the cost in new personnel recruitment, absenteeism, lack of implication in the company's shared narrative, etc. may therefore be higher).

There is thus no 'neutral' or 'God's eye' view of the quality or qualities of collaboration, in the case of co-design, or in general: normative-descriptive methods for its analysis are necessarily from a particular perspective, relating to specific goals, stakes and objects of activity.

## 5. Discussion and perspectives

In this paper, salient aspects of collaboration have been articulated in the form of nine propositions, whose statuses are twofold. Firstly, they constitute a synthesis of aspects of collaboration that have been described in the literature, and in particular with respect to co-design situations, e.g. degree of grounding, effectiveness of coordination, symmetry of participation or roles. Secondly, they aim at providing an heuristic framework for advancing in reflexion on quality or qualities of collaboration in co-design. In this respect, we have highlighted four of these propositions — specific processes and epistemological standpoints — with the objective of broadening our view on quality, or rather qualities, of collaboration, from a communicational perspective to a more socio-cognitive, culturally-historically situated perspective. The very notion of quality depends on what is at stake for participants, as well as other social actors, and can be distinguished from a monolithic normative or simply descriptive approach.

Taking the situated nature of collaboration seriously, its quality depends intrinsically on what is at stake in the situation. Collaboration in task-oriented situations has indeed an object and a motive. As referred to above, combining and constructively confronting multiple perspectives on the situation, in particular those of the social actors present (co-designer) or possibly absent (e.g. manager), is then essential for

understanding what is at stake in the situation. As developed in activity theory, the hierarchically embedded levels of collective motive-driven actions, as well as individual goal-driven actions, should be taken into account, thus incorporating both the culture(s) of collaboration in a more historical perspective as well as their more local and situated contingencies. This highlights the importance of context, the social structure in which quality of collaboration is examined (e.g. power, collaboration cultures) as well as the various temporal scales along which it can be analysed.

Study of the perspective(s) on what is at stake in a particular situation can in turn inform the set of qualities of collaboration to which precedence should be given, as well as on the time-scale along which to examine them. Whereas there are generic processes involved in collaborating — from discursive to affective, and from productive to constructive and reflexive —, these processes might be hierarchised differently depending on the situation: e.g. productivity (team productivity and outcome improvement) could be viewed as more or less important than reflexivity (team efficiency and task mastery), or processes of interactive regulation of affect (team building and trust) could be more or less important than cognitive-discursive (argumentation and design rationale) processes. Accordingly, certain qualities could be seen as more or less essential depending on what is at stake in a situation, and could also turn out to be incompatible and even opposed. To take up again the example of outcome improvement *versus* task mastery, it has been well illustrated in the literature that team learning can be counterproductive (Edmondson, Dillon, & Roloff, 2007). It should be noted that this framework on the qualities of collaboration, although necessarily sensitive to each collaborative situation, is not *ad hoc* to the situation. Indeed the objects and motives in a situation can be seen as exemplars of more generic situations, as well as the generic process which are involved.

To return to co-design situations, and to the question of their potential specificity with respect to the issue of quality of collaboration, this will also depend profoundly on particular *design cultures* as well as on more local motives and objects of design. However, the strong focus put on creativity, at least in upstream design, emphasises creative and constructive processes in quality of collaboration. Affective regulation could also be most important as emotional tensions may occur, linked with the personal involvement and more or less strong ownership of designers with respect to their proposals of design ideas.

Finally, an important issue for further work on quality of collaboration concerns how to articulate viewpoints (etic and emic), in particular, the first-person perspectives of the participants with the third-party perspective of the researcher. Depending on the objective of research, be it transformative and/or evaluative, this question opens clear directions for future research.

Within a transformative objective, the researcher may be involved in the design situation itself, in a participatory design approach. The articulation of the various participants' perspectives on collaboration and its quality may then be oriented toward detection of incompatible perspectives and guidance for developing a common culture of collaboration. The researcher may also be involved in a reflexive transformation of the situation, perhaps within a dialogical approach. Auto-confrontation techniques, with methodological support for eliciting views on qualities of collaboration from multiple perspectives, those of the actors of in the situation, could then be used to encourage collective reflexion on the task, team and individual processes.

## Acknowledgements

This article has benefited from critical discussion on the theme of quality of collaboration with Kjeld Schmidt (of Copenhagen Business School), as well as from discussions having taken place during the COOP conference workshop on Quality of Collaboration (<http://www.iisi.de/international-reports-on-socio-informatics-irsi/>), organised by the authors of this paper in 2010 at Aix-en-Provence. This paper also draws upon work carried out with Stéphane Safin and Pierre Leclercq (University of Liège). Finally, this paper is based on existing published work (see footnote "\*" on page 1).

## References

- Allwood, J., Traum, D. & Jokinen, K. (2000). Cooperation, dialogue and ethics. *International Journal of Human-Computer Studies*, 53(6), 871-914
- Andriessen, J., Baker, M. & van der Puil., C. (2011). Socio-cognitive tension in collaborative working relations. In S. Ludvigsen, A. Lund, I. Rasmussen & R. Saljo (Eds.), *Learning across sites: new tools, infrastructures and practices*, pp. 222-242. London: Routledge.
- Arrow, H., McGrath, J.E. & Berdahl, J.L. (2000). *Small groups as complex systems: Formation, Coordination, Development, and Adaptation*. London: Sage.
- Badke-Schaub, P. (1999). Group effectiveness in design practice: Analysis and training by a critical-situation-approach. *Psychologische Beiträge*, 1 (41), 338–355
- Baker, M. (2002). Forms of cooperation in dyadic problem-solving. *Revue d'Intelligence Artificielle*, 16(4-5), 587-620.
- Baker, M. (1994). A Model for Negotiation in Teaching-Learning Dialogues. *Journal of Artificial Intelligence in Education*, 5 (2), 199-254.
- Baker, M., Hansen, T., Joiner, R., & Traum, D. (1999). The role of grounding in collaborative learning tasks. In Dillenbourg, P. (Ed.) *Collaborative learning: Cognitive and computational approaches*, Oxford: Pergamon. 31-63.
- Baker, M.J. (1999). Argumentation and Constructive Interaction. In G. Rijlaarsdam & E. Espéret (Series Eds.) & Pierre Coirier and Jerry Andriessen (Vol. Eds.) *Studies in Writing: Vol. 5. Foundations of Argumentative Text Processing*, 179 – 202. Amsterdam : University of Amsterdam Press.
- Baker, M.J., Andriessen, J. & Järvelä, S. (Eds.) (2013). *Affective Learning Together: social and emotional dimensions of collaborative learning*. London: Routledge.
- Bales, R.F. (1950). A set of categories for the analysis of small group interaction. *American Sociological Review*, 15, pp. 257-263
- Barth, E.M. & Krabbe, E.C.W. (1982). *From Axiom to Dialogue: A philosophical study of logics and argumentation*. Berlin: Walter de Gruyter.
- Bonnardel, N. (2006). *Créativité et conception. Approches cognitives et ergonomiques*. Marseille: Solal.
- Brown, P. & Levinson, S. (1987). *Politeness: Some Universals in Language Usage*. Cambridge: Cambridge University Press.
- Bucciarelli, L. L. (1988). An ethnographic perspective on engineering design. *Design Studies*, 9(3), 159-168
- Bunderson, J. S., & Sutcliffe, K. M. (2003). Management team learning orientation and business unit performance. *Journal of Applied Psychology*, 88, 552-560.
- Burkhardt, J.-M., Détienne, F., Hebert, A.-M., Perron, L., Safin, S., & Leclercq, P. (2009). An approach to assess the quality of collaboration in technology-mediated design situations. *Proceedings of the European Conference on Cognitive Ergonomics ECCE 2009*, 30 September - 2 October 2009 in Otaniemi, Helsinki
- Burkhardt, J.-M., Détienne, F., Moutsingua-Mpaga, L., Perron, L., Leclercq, P., & Safin, S. (2008). Multimodal collaborative activity among architectural designers using an augmented desktop at distance or in collocation. In J. Abascal, I. Fajardo & I. Oakley (Eds.), *ECCE '08: Proceedings of the 15th European conference on Cognitive ergonomics* (pp. 1-4). Funchal, Portugal: ACM.
- Clark, H. H., & Brennan, S. E. (1991). Grounding in communication. In L. Resnick, J.-M. Levine & S. D. Teasley (Eds.), *Perspectives on socially shared cognition* (pp. 127-149). Washington DC: APA.
- Clark, H.H. & Schaefer, E.F. (1989). Contributing to Discourse. *Cognitive Science* 13, 259-294.
- Crook, C. (1994). *Computers and the Collaborative Experience of Learning*. London: Routledge.
- Crook, C., Détienne, F., Dessus, P., Gentil, C., & van de Sande, C. (2010). Report on Discussion Group 3. In *Workshop « Analysing the quality of collaboration in task-oriented computer-mediated interactions », COOP 2010*. International Reports on Socio-Informatics, 7(1), 119-120.
- D'Astous, P., Détienne, F., Visser, W., and Robillard, P.N. (2004). Changing our view on design evaluation meetings methodology: a study of software technical review meetings. *Design Studies*, 25, 625-655.
- Darses, F., Détienne, F., & Visser, W. (2004) Les activités de conception et leur assistance. In P. Falzon, (Ed) : *Ergonomie*, PUF.
- Détienne, F. (2006). Collaborative design: managing task interdependencies and multiple perspectives. *Interacting With Computers*, 18(1), 1–20.
- Détienne, F., Burkhardt, J.-M., Hébert, A.-M., Perron, L. (2008) Assessing the quality of collaboration in design : bridging cognitive ergonomics and CSCW approaches. In *Workshop « CSCW and Human Factors », CSCW'2008*, November 9, San Diego, USA.
- Détienne, F., Baker, M.J. & Burkhardt, J.-M. (Eds.) (2010). Proceedings of the International Workshop on Quality of Collaboration. COOP 2010 Conference (Aix-en-Provence, 18 May 2010). *International Reports on Socio-informatics*, vol. 7, issue 1. Bonn: International Institute for Socio-informatics Publishers (ISSN 1861-4280). <http://www.iisi.de/102.0.html>

- Détienne, F., Baker, M. & Burkhardt, J.-M. (2012). Quality of collaboration in design meetings: methodological reflexions. *CoDesign: International Journal of CoCreation in Design* (Special Issue: Perspectives on quality of collaboration in design), 8(4), 247-261.
- Eastman, C. M. (1969). Cognitive processes and ill-defined problems: a case study from design. In *Proceedings of the first Joint International Conference on Artificial Intelligence*, Washington D. C.
- Edmondson, A.C., J.R. Dillon, and K.S. Roloff (2007). Three perspectives on team learning: Outcome improvement, task mastery and group process. *The Academy of Management Annals. Volume 1, Issue 1*, p 269-314.
- Engeström, Y. (2006). Development, Movement and Agency: breaking away into mychorizae activities. In K. Yamazumi (ed.), *Building Activity Theory in Practice: Toward the next generation* (pp. 1-43). Osaka, Center for Human Activity Theory, Kansai University.
- Engeström, Y. & Toiviainen, H. (2011). Co-configurational design of learning instrumentalities: an activity-theoretical perspective. In S. Ludvigsen, A. Lund, I. Rasmussen & R. Säljö (Eds.) *Learning Across Sites: New tools, infrastructures and practices*, pp. 33-52. London: Routledge.
- Falzon, P. (1994). Dialogues fonctionnels et activité collective. *Le Travail Humain*, 57, 297-312.
- Fréard, D., Denis, A., Détienne, F., Baker, M., Quignard, M., & Barcellini, F. (2010). The role of argumentation in online epistemic communities: the anatomy of a conflict in Wikipedia. In *proceedings of the European conference on cognitive ergonomics ECCE 2010*, 25 – 27 August 2010, Delft, The Netherlands.
- Gaudin, C., Philibert, B., & Bonnardel, N. (2011). Effet de la qualité de la collaboration sur la performance lors de la résolution de problèmes en équipe. In *Actes des Journées de Psychologie Ergonomique EPIQUE 2011*, Metz, 5-7 septembre.
- Hakkaraïnen, K., Palonen, T., Paavola, S. & Lehtinen, E. (2004). *Communities of networked experience: Professional and educational perspectives*. Amsterdam: Elsevier.
- Herbsleb, J.D. & Mockus, A. (2003). An empirical study of speed and communication in globally-distributed software development. *IEEE Transactions on Software Engineering*, 29(6), 481-494.
- Hornbæk, K. (2006). Current practice in measuring usability: Challenges to usability studies and research. *International Journal of Human Computer Studies*, 64 (2), 79-102.
- Kristensson, P. Gustafsson, A. & Archer, T. (2004). Harnessing the Creative Potential among Users. *The Journal of product innovation management* 21(1), 4–14.
- Mann, W. C., & Thompson, S. A. (1988). Rhetorical Structure Theory: Toward a functional theory of text organisation. *Text* 8(3), 243-281.
- McDonnell, J. & Lloyd, P. (2009) *About- Designing – Analysing design meetings*. CRC Press: Taylor & Francis.
- Miyake, N. (1986) Constructive Interaction and the Iterative Process of Understanding. *Cognitive Science*, 10, 151-177.
- Muntigl, P. & Turnbull, W. (1998). Conversational structure and facework in arguing. *Journal of Pragmatics* 29, pp. 225-256.
- Olson, G. M., & Olson, J. S. (2000). Distance Matters. *Human-Computer Interaction*, 15, 139-178.
- Olson, G.M., Olson, J.S., Carter, M. R., and Storosten, M. (1992). Small Group Design Meetings: An Analysis of Collaboration. *Human-Computer Interaction*, 7, 347-374.
- Pahl, G., Badke-Schaub, P., and Frankenberger, E. (1999). Resume of 12 years interdisciplinary empirical studies of engineering design in Germany. *Design Studies*, 20(5), 481.
- Paulus, P. B., & Nijstad, B. A. (2003). *Group Creativity: Oxford Scholarship Online Monographs*.
- Pinelle, D., & Gutwin, C. (2008). Evaluating teamwork support in tabletop groupware applications using collaboration us ability analysis. *Personal and Ubiquitous Computing*, 12, 237-254.
- Roschelle, J. & Teasley S.D. (1995) The construction of shared knowledge in collaborative problem solving. In C.E. O'Malley (Ed), *Computer-Supported Collaborative Learning*. (pp. 69-197). Berlin: Springer-Verlag
- Safin, S., Verschuere, A., Burkhardt, J.-M., Détienne, F., Hébert, A-M (2010) Quality of collaboration in a distant collaborative architectural educational setting. *Workshop « Analysing the quality of collaboration in task-oriented computer-mediated interactions »*, COOP 2010, Online version « International Reports on Socio-Informatics » (IRSI).
- Savelsbergh, C. M. J. H., van der Heijden, B. I. J. M., & Poell, R. F. (2009). The Development and Empirical Validation of a Multidimensional Measurement Instrument for Team Learning Behaviors. *Small Group Research*, 40(5), 578-607.
- Schaub, H (1997). Decision making in complex situations Cognitive and motivational limitations. In R. Flin, E. Salas, M. E. Strub & L. Martin (eds). *Decision making under stress. Emerging themes and applications*, Ashgate, Aldershot (1997) pp 291– 300
- Schmidt, K. (1994). Cooperative work and its articulation: requirements for computer support. *Le Travail Humain*, 57(4), 345–366.
- Schön, D. A. (1983). *The reflective practitioner: How professionals think in action*. New York: Basic Books.
- Simon, H. A. (1973). The structure of ill structured problems. *Artificial Intelligence*, 4, 181-201.
- Spada, H., Meier, A., Rummel, N. & Hauser, S. 2005. A new method to assess the quality of collaborative process in CSCL. In *Proceedings of Computer Supported Collaborative Learning 2005: The Next 10 Years!*, T. Koschmann, D. Suthers and T. W. Chan, Eds., Mahwah, NJ: Lawrence Erlbaum Associates. 622-631.
- Staats, B. R., Gino, F., & Pisano, G. P. (2010). Varied Experience, Team Familiarity, and Learning: The Mediating Role of Psychological Safety (Working paper): Harvard Business School.

- Stempfle, J., & Badke-Schaub, P. (2002). Thinking in design teams - an analysis of team communication. *Design Studies*, 23, 473-496.
- Thomas, A (1999). Group effectiveness. A balance between heterogeneity and homogeneity. *Psychologische Beiträge*, 40, 226-236.
- Valkenburg, R C (2000). *The reflective practice in product design teams Industrial Engineering Design*, Delft University of Technology.
- van Someren, M., Boshuizen, H. P. A., de Jong, T. & Reimann, P. (1998). *Learning with multiple representations*. Oxford: Elsevier Science.
- Vignaux, G. (1990). A Cognitive Model of Argumentation. F.H. van Eemeren, R. Grootendorst, J.A. Blair & C.A. Willard (eds.), *Proceedings of the Second International Conference on Argumentation*, Vol.1 (June 19-22), chapter 40, pp. 303-310.
- Visser, W. (2004). *Dynamic aspects of design cognition: elements for a cognitive aspect of design* (Research Report No. 5144). Rocquencourt: INRIA.
- Vygotsky, L. S. (1934/1978). *Mind in society*. Cambridge, MA: Harvard University Press.
- Walton, D.N. (1992). *Plausible argument in everyday conversation*. New York: State University of New York Press.

■