From concurrent engineering to collaborative learning of design

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ABSTRACT. In the hostile and competitive environment we live in, complexification of products and systems, as well as the necessity to innovate drive the companies to work together more and more. Literature dealing about themes of group work abounds ; terms are however defined in a blurred and even contradictory way depending on the authors. Our paper aims at contributing to this clarification. Therefore, having defined the terms of communication, coordination, cooperation and collaboration, we shall more particularly analyse the design activity in a group and shall characterize distributed design and collaborative design. By using this characterization, we shall show the link with the learning of design in network. We will conclude on two collaboration levels between partners in an innovation context, namely : design together and learn together how to design.

KEYWORDS : concurrent engineering, co-design, collaborative design, distributed design, learning, inter-companies

1. Introduction

In the competitive environment we live in, companies are required to innovate so as to design new products of good quality in less and less time and at a lower and lower cost in order to satisfy the increasing needs of their customers. As the required technologies come from different subjects at a high level of competence, companies cannot innovate on their own. Therefore, they have to work in networks and find partners covering the other activities necessary to the design, manufacturing and distribution of the new product or service (Voisin, Sihem et al. 2004). These networks allow to weave relations of sub-contracting, externalisation or even design in group. Thus, companies have a natural tendency to concentrate on the core of their own skills in order to be the best in that area. For instance, car-makers integrate the parts manufacturers and subcontractors in the engineering platform ; as they no longer possess all the technological knowledge, they expect their partners to help them to be more productive and even to find some innovative solutions.

This way of proceeding can be initiated, either between the different services of the same company, that is to say within the company (intra-companies) or thanks to relations woven between different companies (inter-companies) (Galasso, François et al. 2005). It can work on the product itself or on extended product. This concept, which goes beyond the product itself, takes into account all the additional services in relation with it : packaging, guarantee and its image (Lehu 2004; Hunt, Wall et al. 2005).

There are two ways of organizing design : the sequential engineering which consists in achieving the tasks one after the other, and concurrent engineering (Prasad 1996) that was first used in the USA in 1989. In the same way, we can compare sequential engineering to a relay race and concurrent engineering to the progress of the rugby forward line. Concurrent engineering brings about shorter delays and lower costs of design as the different tasks are done in parallel ; it enables to improve the quality of the product (Sohlenius 1992).

This paper aims at presenting a preliminary work concerning the concepts linked to concurrent engineering. Thus, we shall study the grouping of companies designing the same product together.

First, we shall tackle the concepts dealing with the common activity, that is to say : communication, coordination, cooperation, and collaboration. Then, we will particularly focus on the design activity in group and define the two kinds of concurrent engineering, that is to say distributed design and collaborative design. Once we have clarified these concepts in the second paragraph, we shall examine in the third paragraph how these clarifications will allow us to enrich our thought about the learning of design in network so as to present the collaborative learning of design.

2. Concurrent engineering

Those who work on the practice of the design activity in a group are soon confronted with an abundance of terms which are little or badly defined in literature. Indeed, it seems difficult to associate the words of communication, coordination, cooperation and collaboration to another set of words such as concurrent engineering, distributed design, collaborative design and co-design. Once we have clearly defined the first set of words, our aim in this paragraph will be to use them in order to characterize the words linked to concurrent engineering.

2.1. Communication, coordination, cooperation, collaboration

Communication, coordination, cooperation and collaboration terms are largely approached in the literature ; there is not however definition, nor of unanimous approval of these concepts (Soubie et al., 1996 ; Robin, 2005).

2.1.1. Communication

Any work in a group implies some interaction between people ; communication, first and foremost, makes interaction between participants possible. Thanks to communication, people can exchange ideas, enrich them and unite their points of view. In this way, communication not only brings about the acquisition of new competences but also the creation of new ones. This exchange also limits the uncertainty linked to the design project (Bouzon, 2003). Communication can assume different forms according to the situation : words, writings, designs, gestures, positions, which are combined to express what needs to be understood by the others without any ambiguity (Soubie et al., 1996 ; Eckert and Stacey, 2001).

Communication is unavoidable in any team work, including the activities of design. Nevertheless, this dimension will not allow us to characterize distributed design and collaborative design. Moreover, the act of communication can be performed even if the entities communicating do not have a common goal ; this is the main difference with the other terms (David, 2004).

2.1.2. Coordination

Coordination is a set of rules and procedures allowing a group to work efficiently and harmoniously. Therefore, coordination implies a real management of tasks. It defines an order, a static structure, which enables to maximize team work (Dameron, 2003).

We can already clearly see two dimensions in the concept of coordination :

- a dimension linked with the management of tasks, implying a strong logic of work organization (which we will later call organizational coordination), and,

- a dimension linked with the functioning of the group which more particularly requires management skills based on a sound knowledge of the competences available in the group and a capacity to associate them in order to reach the common goal (later called cognitive coordination).

2.1.3. Cooperation

Contrary to coordination, cooperation belongs to the field of action. We use the expression cooperative process.

Lets start from two obvious approaches. First of all, the etymological origin from which the word cooperation comes from derives from the association of the root operare with the prefix co-, which means working together (Dameron, 2000). Then Le Petit Robert Dictionary informs us that cooperation consists in « participating in a common work ». This allows us to elaborate a first definition of cooperation, which refers to a common work aiming at producing a common realization. This process of action enables people to go beyond the limits of individual work by acting together.

In a more general sense, cooperation is a « collective action through which individuals contribute to the same result » (De Terssac and Maggi, 1996). Cooperation can be characterized by the sharing, from two companies at least, (in an inter-companies context) of a fraction of their resources (sharing of material or immaterial products) in order to pursue common goals in a given space and to obtain reciprocal advantages. If it means being interdependent in a given field of action, the different partners remain autonomous out of this cooperation area (Huet, 2004). Companies willingly get involved in an action of cooperation (Froehlicher, 2000).

2.1.4. Collaboration

Here again, let us start from two simple approaches. The etymological roots of the word collaboration, col and laborare, means working with others. Moreover, The Petit Robert Dictionary defines collaboration as « working together ». These approaches focus on the process of working together in itself (Kvan, 2000 ; Rose, 2004). Therefore, collaboration requires a strong commitment to a team spirit as well as a maximum support to the common aims and results. Thus, this requires a greater confidence between partners (Kvan, 2000). In order to find the best solutions to the problem raised in the shortest time, partners have a common space to store and share information; this space gathers together competences and skills (formalized, structured, classified...) for them to be easily available for all the participants (Hadj-Hamou and Caillaud, 2004).

2.1.5. Conclusion

To conclude, we can say that each of these four terms : communication, coordination, cooperation, and collaboration contributes to the characterization of team work in its own way. Indeed,

- communication is an essential tool for the exchanges within the group ;
- coordination is a means to organize team work ;
- althrough cooperation and collaboration both apply to the process of team working :
    - cooperation focuses on the participation to a common work ;
    - collaboration focuses on the importance of working together.

In the following paragraphs, let us see how those terms enable us to characterize the activities of concurrent engineering.

2.2. Distributed design

As far as distributed design is concerned, the project leader identifies the task to be completed to meet the customers' special needs, then divides it into different independent secondary tasks and distributes them according to the competences and skills of the members of the project group, between the different designers who are located in different places. These tasks are organized to form a whole : the final product, which is also the common goal (Darses and Falzon, 1996). Then, the designers work « simultaneously, not jointly but in parallel on their task. Each one has his/her own secondary goals, while knowing the final common goal » (Visser, 2001). Each person or group is responsible of a part of the problem that is to be solved. The results which are gathered are then coordinated and assembled in order to form the final result (Dillenbourg et al., 1996). The main difficulty with this type of design lies in the abstract definition of the problem and the lack of knowledge about the design project at its beginning (Darses and Falzon, 1996). Each designer participates in a common work as he achieves the precise task that he has been given.

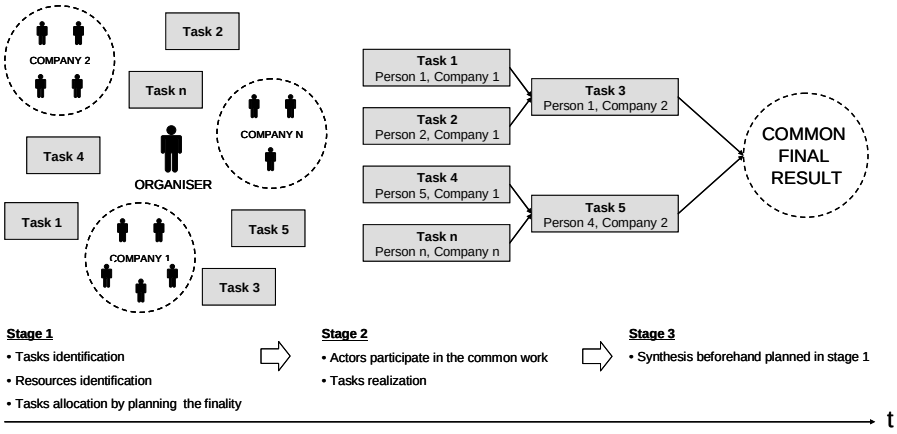

Figure 1. Schematization of distributed design.

Thus, thanks to the terms that we have defined earlier, we can come to the conclusion that two types of mechanism are used to characterize distributed design :

- coordination : which is performed beforehand by the project manager. In the first place, it consists in dividing design into several tasks, then in distributing the tasks between the different designers and finally in ensuring the global coherence of the project during the addition/amalgamation of the several works, as well as the coordination of the actions to be launched and the timing of the tasks. We have chosen to call this type of coordination : organizational coordination since it is mostly based on a strong organization of the project at its beginning

- cooperation : between the participants since they participate together in a common work.

2.3. Collaborative design or co-design

As far as collaborative design is concerned, the designers of the whole group work together in order to design the product according to the customers' special needs. The project leader, as well as the project group (a group of designers from different companies who have competences and skills in different fields) thus try to build and keep a common view of the problem and then solve it together (Dillenbourg et al., 1996). Each of them helps within the field of his/her competences (Kvan, 2000). Different milestones can be foreseen in order to put the works in common, get the approval of the hierarchy and define the tasks that are to be achieved next. However, the main goals as well as the secondary ones are not defined beforehand (Darses and Falzon, 1996). Designers from different fields get together so as to share information, assessments, ideas, and resources in order to solve the problem together. In this context, communication between members, in addition to coordination, is vital. (Sun et al., 2003). Collaborative activity is synchronized and coordinated all along the process of collaboration so as to build and keep a common view of a problem or of a situation between all the participants in order to solve the problem together (Dillenbourg et al., 1996). However, this is not enough, the organizational and social aspects necessary to collaborative design must not be neglected (Detienne, 2006).

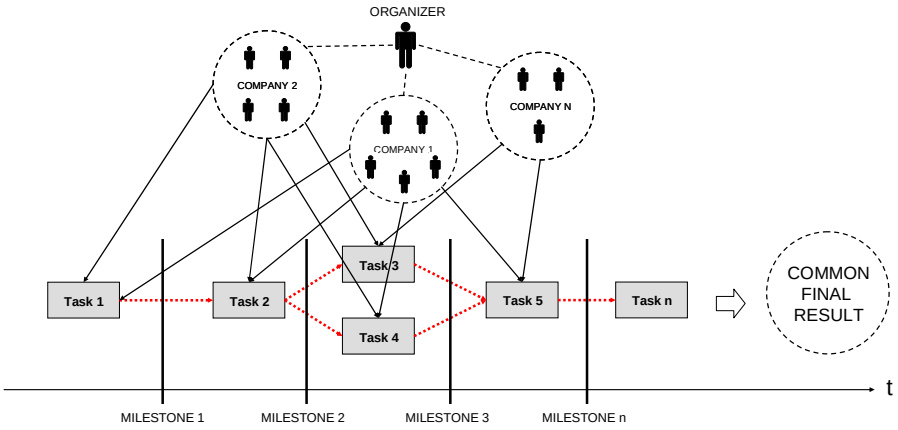

Figure 2. Schematization of collaborative design.

There again, thanks to the terms that we have defined earlier, we can come to the conclusion that two mechanisms are used to characterize collaborative design :

- the coordination of all the designers' competences, which shall enable the creation of a system of reference with all the mutual competences so as to combine them to solve the problem. Coordination is essential but it is different from the type of coordination used in distributed design because it is more based on the management of competences in order to

contribute to the common goal together. That is why we have chosen to name it cognitive coordination.

- collaboration between participants, that is to say working together to end up with a common work.

2.4. Conclusion on concurrent engineering

Concurrent engineering is an important concept nowadays : it allows performing a complex task thanks to a multidisciplinary design team (Li et al., 2004). However, the different designers do not take part in the design process in the same way. Indeed, Robin et al. refer to what they call the design environment which they define as « the context in which it is suitable to place the participants in the design activity so as to reach their goals » (Robin et al., 2004 ; Robin et al., 2007). In order to characterize these different approaches, we have chosen to link the different terms of concurrent engineering in the following way :

	Concurrent engineering	
	Distributed design	Collaborative design
Mode of organization of the groupwork	Organizational coordination	Cognitive coordination
Groupwork process	Cooperation	Collaboration

Table 1. Concurrent engineering, distributed design and collaborative design

Some individuals take part in activities of distributed design while others work in collaborative design. In both cases, they benefit from all their different skills so as to reach their common goal, and from a common environment in order to share and exchange the different competences produced during the designing process (Povada, 2001).

3. Implications of the characterization of concurrent engineering in the learning

What is at stake concerning the competitiveness of the companies is the capacity to create the required resources in order to innovate. One of the resources that can be used consists in « asking for new competences outside the company, so as to create complementarities thanks to alliances and invent multiple combinations in order to continually increase their intelligence » (Moreau, 2003). In order to master or at least to take part in activities of concurrent engineering, it is essential to master the methods of design. This third paragraph aims at examining how the characterization made in paragraph two can give us food for thought concerning the learning of design. We have therefore chosen to start from former works that present the actual state of our researches on the learning network for innovative design, so as to see how the characterization of distributed design and collaborative design will help us to enrich them. Consequently, we shall examine how the 19 criteria which we have established beforehand (Maranzana and Gartiser, 2006) can be more aptly applied to distributed design or collaborative design in order to conclude and present a collaborative approach of the learning of design.

3.1. From the learning network for innovative design…

Our preceding works (Maranzana and Gartiser, 2006) led us to characterize what we have called a learning network for innovative design. Indeed, we have woven links between three components, namely, innovative design, learning and network. It allowed us to define a way of working that makes innovation possible thanks to confrontation and the enriching of ideas : the learning network for innovative design.

We suggested that such a learning network brings individuals from different autonomous organizations together, so as to create a favourable context that would stimulate the learning processes, creativity, and therefore innovation. Such a network is « centred upon the act of learning [...] and considers the enriching of its members' competences as essential. This enriching is achieved thanks to the transmission of explicit or implicit competences, the exchange of experiences, the expansion of reflection » (Collignon, 2004). Thus, it makes it possible to learn through practice, that is to say thanks to the confrontation of ideas, of competences and experiences between the different partners. Therefore, this sharing of knowledge and the creation of new collective knowledge allows every member of the learning network to increase his/her efficiency in his/her own project and consequently increase the global performance of his/her company.

This learning network for innovative design thus seems to be a strategic instrument that can trigger processes of collective learning, thus making it possible for companies to be part of dynamics of innovation, which would be out of their reach, had they remained on their own. It is a place where the capacity to learn how to innovate can arise and develop from exchanges and the participation in different common activities.

3.2. Relations between the criteria that characterize the learning network for innovative design and the characterization of concurrent engineering

Our former works led us to characterize the learning network for innovative design according to 19 criteria (see (Maranzana, 2005) for a more detailed presentation of the criteria). To be more precise, these 19 criteria can have different modes ; we came to the conclusion that some of these modes were irrelevant for the creation of a learning network for innovative design.

We shall examine here how the criteria are coherent with the characterization of concurrent engineering (Table 2).

Therefore, we can notice that, in most cases, the dimensions used to characterize the learning network for innovative design are the same that we have used to characterize collaborative design. Consequently, we can improve our terminology and coin the expression « a collaborative learning of innovative design ».

3.3. …to the collaborative learning of innovative design

Companies already design together. They already have their own network. The idea contained in collaborative learning is to bring together different partners or even different types of partners (each of them with his/her knowledge, competences, assessments... and already involved in different networks) with the prospect of increasing their knowledge in the

			Distributed design		Collaborative design	
N°	Names	Possible values	Organizational coordination	Cooperation	Cognitive coordination	Collaboration
1	Structure	Formal				
		Informal				
2	Exchanges between partners (what ?)	All tacite or explicite knowledge				x
	Exchanges between partners (how ?)	Personnal exchanges		x		
		Using the learning network				x
		Reciprocity (sum different zero)				x
	Exchanges between partners (with which logic ?)	Accumulated				x
		Integrated		x		
3	Specificity of network's assets	Low				
		High				
4	Organization	Hierarchical				
		Non-hierarchical				x
5	Kind of partners	Individual partner		x		
		Every kind of partners				x
6	Business sectors of the partners	Different				
		The same				
		Complementary				
7	Proximity	Geographic				
		Electronic	x			
		The two			x	
8	Optimal number of partners	More of two				
9	How are the links between the partners build ?	Volontary			x	x
		Forced	x			
10	Communication	All means				
11	Intermediary actor (organizer)	Yes			x	
		No	x			
12	Autonomy of the partners	Independency	x	x		
		Inter-dependency			x	x
13	Agreements between partners	Yes				
		No				
14	Degree of confidence	Distrust	x			
		Confidence			x	
15	Management of opportunist behavior	Control	x			
		Using hostages			x	
16	Human relationships	Low		x		
		High				x
17	Culture	Specific		x		
		Common				x
18	Intensity of the exchanges	Low		x		
		High				x
19	Recognition system	Imposed	x			
		Based on the different approaches			x	

Non selected values

Criteria not allowing us to choose between distributed design and collaborative design

Table 2. Location of the 19 criteria with regard of distributed design and collaborative design

field of innovative design in the long term. It will mean sharing their goals and systems of reference (based on a common vocabulary for instance).

In collaborative learning, the different partners have a common goal (learning together and progressing together about the learning of a methodology in order to solve problems concerning design) on the one hand, and individual goals peculiar to their companies or universities (designing such and such a product in such and such a way for the companies, research for the universities, experiences for the consultants) on the other hand.

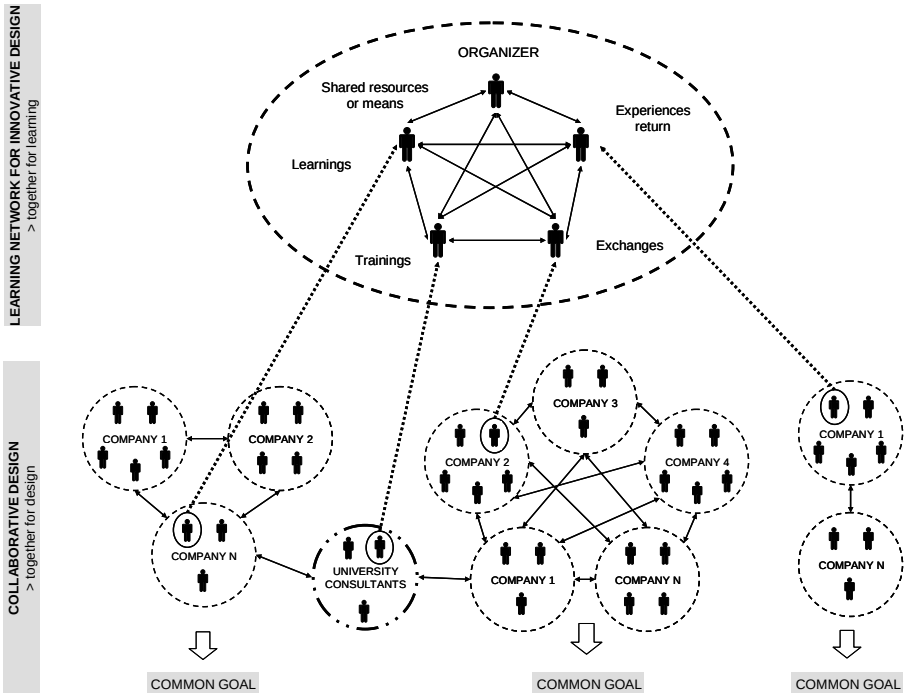

Figure 3. Collaborative design and collaborative learning

4. Conclusion

Collaborative design and collaborative learning of design are two important dimensions that contribute to efficient innovation in companies. In the first case, we design together whereas in the second case, we learn together how to design ; nevertheless, the same characteristics can be found in both cases: cognitive coordination and collaboration. The « place », the « participants » and « the aims » are not the same but each of them, in its own way, participates in a common aim. We are at two different levels in a single system : one is very operational (designing), the other aims at increasing knowledge, competences and skills

in the company. Both tend to bring it an unquestionable competitive advantage by giving it the capacity to innovate efficiently.

5. Acknowledgement

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