COLLABORATIVE PRACTICES ANALYSIS IN DESIGN TEAMS

Merlo Christophe [1], Pol Guillaume [1, 2], Jared Graham [2], Legardeur Jérémy [1]

(1) : ESTIA/LIPSI, Technopole Izarbel, 64210 Bidart, France
33-5.59.43.84.33/33-5.59.43.84.01
E-mail : {g.pol|c.merlo|j.legardeur }@estia.fr

(2) : SIMS, Cranfield University, Cranfield, Bedfordshire, MK43 OAL, UK
Phone/Fax
E-mail : {g.jared}@cranfield.ac.ukr

Abstract: The subject of this paper is the collaborative practices used in the product development process in SME's. The background and industrial case study and the theoretical basis are described. A new tool named CoCa is proposed to analyse collaborative practices in situ in order to track all the collaborative events and the project context. Finally, from first experimentation results, some indication is given of its potential use in gaining understanding of complex collaborative processes.

Key words: Coordination, Collaboration, Human factors, Project and process management, Software tools.

1- Introduction

In the worldwide competition between companies, the development of new products has become a challenge where innovation and coordination of design process are two main keys for success. Today design projects depend on the ability to co-ordinate and to control the collaboration between the numerous actors participating in such projects: e.g. designers, experts from different disciplines and with different experiences, external partners. Coordination and control of engineering design are part of a global approach of the development of new products which implies the need to identify the different situations occurring during the design process and adequate resources to satisfy design objectives.

Many studies have tried to identify the best practices and strategies developed by enterprises [BY1] in order to improve the development of new products taking into account environmental challenges, market and customer characteristics, marketing process, product characteristics, new product development process, organizational characteristics and corporate culture, learning practices, and performance.

A project manager now has a wide range of criteria to take into account in order to control all aspects of a project such as the product development steps, objectives and results, tasks and scheduling, resources, expert skills, actors' network, levels of interest, collaborative guidelines, and heterogeneous collective and individual objectives.

On the one hand [CW1] suggest that task management, scheduling, planning, and resource management are the most important issues when it comes to operational coordination.

Clearly, a project manager intends to apply these aspects to control the design process.

On the other hand, collaboration between designers [MF1] [GM1] offers the possibility of sharing specialist knowledge and capabilities. For the project manager, anticipating collaboration is difficult to take into account in the every day life of a project. The main problem is that of proposing to design actors the best context as possible (e.g. objectives, information, resources, tools, methods) in order to foster collaboration that will facilitate reaching project objectives.

In this paper our goal is to go deeper in the understanding and in the characterisation of such complex processes in order to help the project manager to improve the way he coordinates.

In this paper coordination and collaboration are first studied as complementary aspects. Then a model for analysing collaboration is proposed and we describe a tool for capturing collaborative events that occur during a design project in order to allow its users to identify best practices thanks to their knowledge, experience and skills. The following section, an industrial case study in a SME, focuses on some examples of traced events and corresponding analyses for project managers to understand how actors collaborate before trying to improve project coordination.

2- From design coordination to collaboration analysis

In design project management, the progress control of the design process can be defined as the understanding of existing design situations (in the real world) in order to evaluate them and take decisions that will modify and improve the future process, according to design objectives given by customer specifications or issued from the company strategy. The control problem here is a problem of decision-making to support designers in their activities [GD1] in order for them to achieve an objective in a specific context (figure 1). Each design activity has "input" and "output" information. Actors use the "input" in order to produce the "output", to achieve their activity and have "supports" namely: human and material resources and knowledge to

help them in their work.

For decision-making, project managers need to identify effective action levers which will influence collaboration thus increasing design performance. Moreover the situation in SMEs is very different to that in a large company, because in an SME each project is different and requires a specific study for each customer's specifications. Most of the time, the small structure of the SME does not ensure project management in a routine way and leads to combine various responsibilities. Indeed there are not enough actors to fulfil each design role, so most of the actors have various design roles in a project.

Figure 1: Control of design activities.
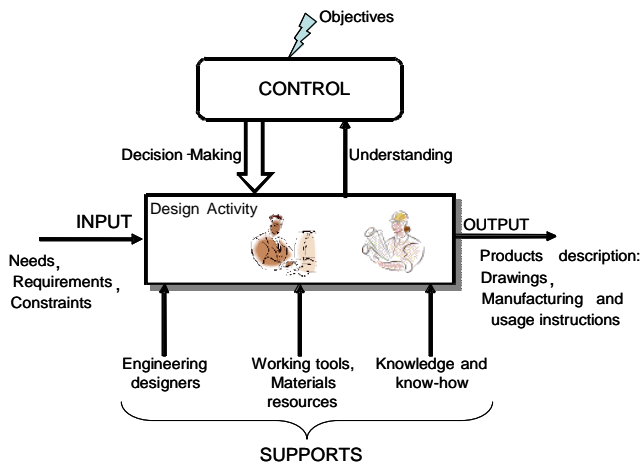
Consequently the role of informal relationships is very important in an SME in order that actors may help each other without rigid formalities. Thus, the combination of various responsibilities and the informal relationships lead to a high level of workload because informal tasks are added to the official ones. Accordingly SMEs have to manage deadlines by setting an order of priorities on design tasks according to the objectives. Another point specific to SMEs is their project structures with a rigid formalisation of their processes at a macro level and a very flexible non-formalisation of the detailed processes which allows informal relationships into the project.

In this context, the project manager coordinates (figure 2) by analysing the requirements from the customer, after which he defines the project team with its internal organisation [M1]. He then defines the sub-phase of the project plan and activities in each sub-phase, next he defines a plan to control the project progress and finally he applies this control plan. Periodically he controls project progress and makes the adequate modifications in accordance with the results and the design objectives.
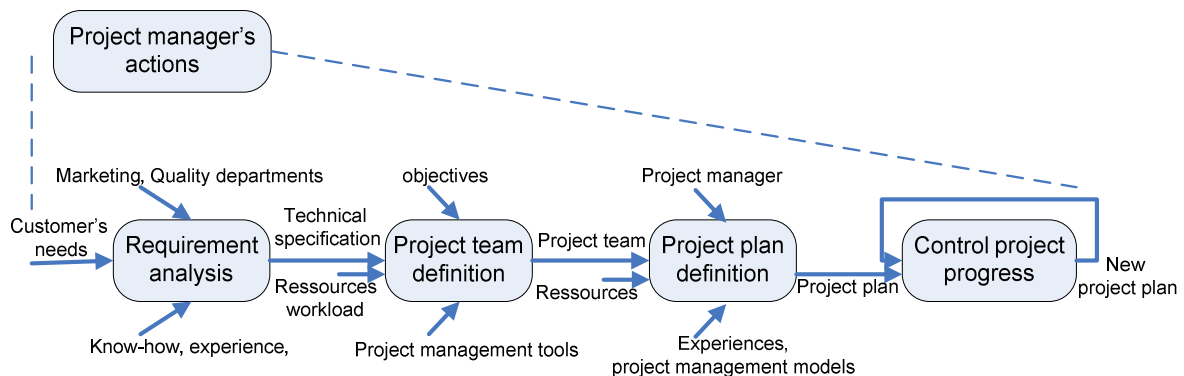

Figure 2: Synthesis of the project manager's actions.

One of the difficulties for the project manager is to take into account the collaboration into his project plan. In spite of various works on design collaboration, no generic rules and operational principles have been defined to help project managers in their daily work. As each company and each project is different, the assistance for the project manager must take into account the specificities of the local context of the project and the company. However it is essential to clearly understand what collaboration is, before defining devices to assist project managers. The study and the characterisation of the types of collaboration used in companies is an important issue for project managers in anticipating design situations during projects and defining the best form of collaboration in accordance with the specific design context. However there is a lack of devices to help the project manager to analyse the collaborative practices.

2- A model for analysing collaboration

We address collaborative aspects in a pragmatic way based on empirical studies of industrial situations. We have adopted a constructivist point of view based on the actor-network theory (ANT) in line with the works of [C1]. Therefore we consider that collaboration is a socio-technical process that entails the development of alliances among groups of actors, the evolution of practices and knowledge, the creation of specific mediating artefacts and finally organizational shifts.

We propose a model inspired by our literature review and industrial case study. It deals with the identification of the main relevant elements for the characterisation of the collaborative situations in design. Collaborative situations could be defined from a co-ordination point of view, with scheduling, planning, formalisation, with the definition of milestones and activities. Alternatively, it could be defined from a human relationship point of view with the persons who are involved in the collaborative event, with their skills, their motivation, and their form of communication. In fact both these two points of view must be taken into account in several collaborative factors to define collaborative events such as: do actors work in the same place or not? in synchronous or asynchronous mode? do they use predefined tasks? and so on. All these factors must be included in a tool which helps managers to analyse collaborative situations that occur in projects. The theoretical concepts are shown in the following class diagram (see figure 3).

The model of collaboration is built to characterise collaborative situations which occur during design projects in small companies. This theoretical approach is based on the capture of information describing collaboration between designers. This information may be used by the project manager to improve the way he coordinates design processes and actors.
This characterisation is based on the definition of collaborative events of the project. All these events should be associated with contexts in order to understand and analyse the collaboration: both the global context of the project and the local context of a collaborative situation. Moreover, the model should integrate different kind of parameters by capturing quantitative data such as time, activity type or problem solve as well as qualitative data such as quality of communication or interests of actors. These different categories of information characterise the collaborative events of a design project:
- The 'event' class that identifies any collaborative tasks and situations occurring in the project. This class allows the capture of each collaborative event - whether formal or informal. The first level of description of an event is its activity type (such as report, scheduling, validation, milestone, co-design…) and its achievement form (such as meeting, discussion, videoconference, conflict resolution…) through the 'activitySubject' and 'subject' classes.
- The 'context of the project' class, with the main information to situate the actor's tasks in the global project work of the company. This class is associated to 'customer' class and 'project' class.
- The 'context event' class which represents the local context and allows storing the basic definition of the event such as date, actor, expectations of the event, outcomes or taken decision.
- The characterization of the nature of the collaboration through several classes: 'Collaborative criteria' class which details the different types of collaboration used by actors in the event e.g. location, time, schedule, methods...
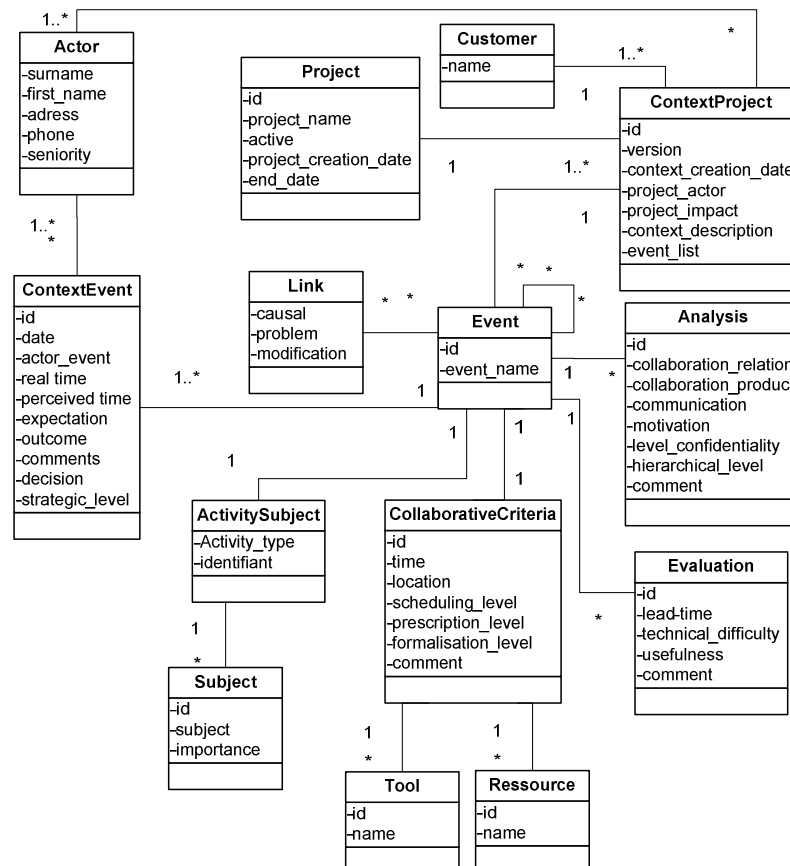

Figure 3: Class diagram of the collaboration model.

Events may not only be 'linked' in a temporal mode, but also   with causal links or problem links. For example, non-

formalised data could lead to losing time: in order to collect this information we can link two events to show that one event will have a problem which comes from the other event, this function is named "Link Problem" in our tool. We can also make links between events in order to show that an event is the cause of the creation of another one. Events stored may be scheduled tasks as well as un-scheduled events in order to identify formalised procedures but also real and flexible tasks sequences at a more detailed level. This information is generally useful to identify shortcuts or alternatives in the traditional process, then to analyse the parameters leading to these situations.

Previous classes are dedicated to the storage and characterisation of all collaborative events. Then the project manager needs to evaluate the situation and to introduce some analysis parameters and comments to prepare future analysis through the 'evaluation' and 'analyse' classes.

3- CoCa: a tool for analysing collaborative practices

CoCa tool has been developed to allow analysts of design process to apply the collaboration model. Analysts, either researchers or project manager or experts, are able to store information about collaborative events. Generally they begin with the definition of the project and its global context. This context ensures the capture of the global view of the project in order to facilitate the interpretation of the various collaborative practices occurring. Information about actors, the customer, and any other data like the impact of the project in the strategy of the company, or any text field to refine the description of the context of the project are included (figure 4). This context shows the list of the events occurring in a project together with the links between them.

Figure 4: Project context form with the list of events.

After the context of the project stored, CoCa ensures the capture of detailed information about the context of collaborative events included in the project. Events are so contextualised for a specific project context.

For example in our case study, a specific collaborative situation has been studied. The situation occurs at the beginning of the design process, when a financial estimate has to be defined to the customer before the real start of the project. This situation is representative of the various forms of collaboration achieved for the same activity defined initially in detail. In this situation we have found four different practices of collaboration. In order to differentiate these collaborative practices we have introduced collaborative criteria [MP1]. These criteria are used in the tool to describe the form of collaboration used in the event, so we can know if actors work in the same time or not, in the same place or not, if the event is planed, prescribed or formalised, if actors used specific tools, or information resources to do their work (figure 2).

Three other tabs record extra data on the collaborative event of the project like the type of activities done during the event, or like evaluation of the form of collaboration used or to make an ad-hoc analysis of the collaboration.
The evaluation of collaborative events by the analyst depends on the context of the project. For this reason, this tool manages the versions of the project context in order to have a history of the modifications done on the project context and on the event list during the project. For each version of the project context a comment field is filled to give to the user the opportunity to explain why modifications have been made.
Different pictures of the tool are shown in section 5.

For the analyst the main issue is to find a good set of information in order to analyse the collaborative practices used in the company and to improve his forecasts. The aim is to take into account the character of collaboration between actors in order to foster flexibility within the design process [VF1] and to bring the company closer to a dynamic model.
In the next section we introduce the industrial case study, before detailing some examples of the use of CoCa tool and the analyses that can be done with it.

4- Industrial case study

The industrial case study has been achieved in a SME which, some years ago, developed a new means of manufacturing structures using honeycomb sub-assemblies. This innovation confers lightness and significant vibration absorption on products whilst maintaining similar rigidity to steel. The company has captured several markets with products manufactured using its technology and consequently the number of employees grew from 4 to 40 over 10 years. Over this period the organisational structure and internal processes have not been formally revised. The objective of the study was to help the company to reorganise and to introduce the role of "design project manager" in order to manage further growth.
Our method of experimentation was based on a socio-

technical approach [BT1]. Our role was to participate in a company workgroup and thus introduce an external point of view.

In this context, problems of organisation, project management and relationships with suppliers, customers, and subcontractors come into play. We have first studied and analysed the company's design and industrialisation department. Then we have formalised:

- a new organisational structure
- the processes of development of new products
- and the management of technical information and of product data.

After this first phase we have focused our work on the study of collaboration and relationships between actors and on the design project co-ordination [DA1] [PJ1]. This phase is the way to test and validate CoCa tool to help with the analysis of collaboration.

Some results of the analysed projects are now presented.

5- Illustration: some examples of collaboration analysis

After four months, four different projects have been deeply analysed and more than one hundred collaborative events have been stored.

5.1 – Example 1: Evaluation and analysis tabs only

In this project, named ROTEM, the two materials proposed by designers for manufacturing are a new combination never experimented before: aluminium with stainless. No tests have been already done to test the assembly with glue and the resistance to the tire. These tests take a long time and the lead time is very short.

A significant event is the general review meeting of the technical department (RHPT). This meeting is the first collaborative event of a project where all members exchange to define the different steps and the technical work to do to answer to customer needs.

During the process a problem has been identified because of the lack of tests of the two materials. The possible traps are about the specific norms of fire and smoke for the materials used to manufacture the product. And the designers are worried about the resistance of the future product against tire. As these materials were indicated in the constraints of the customer, the RHPT meeting should have identified some tasks for evaluating the impact of the new combination of such materials.

As a consequence the analyst has been able to introduce directly the following information in the 'evaluation' tab of the RHPT event (figure 5): the participants do not detect any difficulty but this lack for anticipating test tasks must be capitalised to improve the list of verifications for next projects.

Figure 5 Evaluation in the event RHPT of the project "Rotem".

In this case the information in the 'evaluation' or 'analysis' tabs of an event are enough to understand the problem and identify a solution for the coordination.

Here he proposed to modify design methods by integrating new steps into existing procedures to avoid such traps, and integrate others tests on fire/smoke and on tire of the product. The new steps integrate tests on the assembly and on the tire early in the design process and store the results for a future use of these materials.

The input points of an analysis are often the 'analysis' and 'evaluation' tabs.

5.2 – Example 2: Analysis and links in AGV7 project

In this project the 'analysis' tab shows that in the event "need definition" of the AGV7 project the actors are fully involved (figure 6). This is indicated by a good evaluation of parameters 'consensus collaboration', 'high motivation' and 'constructive communication'. But the parameter 'unproductive collaboration' is set. Comments indicate that actors no have enough free time, so they are not really concerned during this event: they seem to be involved but no detailed job is done.

When looking at other events, the analyst defines a 'problem' link that allows characterising a better description with more details on the problem. The main problem incoming in this event is a lack of time for the actors to carry out the task. Previous tasks for analysing the customer specifications had a too short deadline and that is the real cause of the problem, as mentioned in the 'links' tab of the event (figure 7).

A possible solution can be to negotiate more time with the customer. But it can be difficult and another kind of solution is to manager differently the skills and the experience of the designers to choose for example skilled designers when delay is short.

Figure 6: Analysis of the event "Need definition" of the project AGV7.

Figure 7: Links of the event "need definition" in the AGV7 project.

5.3 – Example 3: Project process analysis

In the AGV7 project, a problem is identified during a meeting with the customer, at the end of the design phase of the project. The analyst must identify the origin of the problem by searching links between the events of the process: comparing the first tabs 'context', 'type/subject' and 'criteria'. All these links show the design process and allow rebuilding the sequence of the events of the project (figure 8).

Figure 8: Context project of the AGV7 project.

In this process the collaborative criteria give complementary information on the occurring events. Here for example the tool design has not been planned: on the 'criteria' tab the event is defined as "emergent" and "free". And the first event is the "need definition" already presented.

Figure 9: Collaborative criteria of the project AGV7.

The analyst concludes again that both project manager and technical team did not define some technical tasks, and the predefined design process must be improved.

A first solution is to add tasks into the process. Even if these tasks are not always needed in design projects, people will consider them and decide if they are useful or not. But they will never be forgotten.

A second solution is to define specific parameters that the project manager and the design team should evaluate at the beginning and during the project, in order to help them choosing the right tasks to do.

These short examples show that a lot of information about the collaboration occurring during design projects can be stored. Combining different information can lead to detailed analysis of problems or good practices in order to define guidelines to project managers.

6- Discussion

On the methodological aspect:

When a problem of collaboration between actors appears in a design event, the project manager is interested in analysing this event in order to understand what was wrong and what could be improved. This will orient the decision to take, improve or reject a collaborative practice that has occurred in projects.

The combination of different types of information allows identifying different kind of results by:
- establishing links between several events
- establishing correlation between several parameters of different types between several events.

The resulting analyses have a great impact on the project manager coordination tasks, here are some examples:
- guidelines can be defines to help him when selecting designers with an approach based on skills, defining required tasks, scheduling tasks, etc
- role of the project manager or of the company managers can be enforced or decreased depending on the context of a project to enhance prescriptive tasks or collaboration
- formalization of design process can be improved and detailed more by adding extra steps, for example through the quality documents of the company
- flexibility can be added in the process by introducing nodes for choosing best sequences of tasks.

The level of granularity of the events is also a methodological problem that we had to solve. We decided to trace events at their more detailed level, i.e. basic events. But when analysing it can be more difficult to navigate between events and to have a global view of the different phases. The possibility of indicating the level of granularity and to group sequences of events in a higher level event should help the analyst.

On the use of CoCa tool:

For the moment, this tool is in an alpha version and it is being tested during a new study in our SME partner. The main difficulty is the acceptance of the analyst by designers. Here the fact that we know people in the company well as a consequence of earlier interventions is a key to success. Nevertheless designers have generally a large amount of work and their motivation depends strongly on the position of their hierarchy: sometimes we had to explain again and convince

people because some messages from heads of departments were misunderstood.

Of course the work of the analyst is not easy: well-defined events such as meetings are much easier to trace than emerging events during a coffee break. But this challenge brings the richest results.

The main limit of such a tool is the subjectivity of the observer. The actual architecture of the tool does not allow us to have a multiple points of view of the same event. Indeed two persons cannot collect information on the same event in the same database. However, the capture of different interpretations and analyses would be interesting for a future version of the CoCa tool.

These tests allow evaluating the level of assistance of CoCa tool in the analysis of the collaborative practice of the company and what kind of impact it can have on the decisions of project managers.

On the evolution of CoCa tool:

CoCa is dedicated to collaborative events, but for analysing problem origins or good practices, non collaborative events can bring interesting information. So capturing all events of a project is a way to improve the methodology of analysing collaboration for coordination.

A graphical tool for analysing sequences of events and exploring links should be useful for the analyst. So the tool needs to provide a search by keywords and attributes to find main text data. And a graphical visualisation of information will be implemented to represent and compare various forms of collaboration with common criteria.

7- Conclusion

Coordination in design is a great challenge in companies. Focusing on SMEs, coordination must take into account flexibility factors and consequently anticipate on emerging phenomena and collaboration between actors. Collaboration between actors is important to federate actors and make coordination effective. Choosing a good form of collaboration between actors is necessary and requires analysing the collaborative practices inside the company. In this paper we propose a model to help the analysis of the collaboration. Thus, we are implementing such an analysis tool, CoCa. It does not help with coordination (decision taking) but helps to understand design activities and collaborative practices of the company. CoCa allows the capture of events of design projects from the point of view of collaboration and might be used to identify best practices, analyse encountered problems and improve managers' decisions. The presented examples show the complexity of the analysis tasks and the richness of the kind of results for improving design coordination. More experiments are planned to demonstrate the added-value of an analysis with or without CoCa tool.

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