Characterization of Collaborative Design and Interaction Management Activities in a Distant Engineering Design Situation

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Abstract. This paper presents an empirical research to study synchronous and asynchronous collaborative design in a technology-mediated situation. In this experiment we wanted to create a design situation where four distant designers had to communicate using commercial software and standard hardware configurations. Our methodological approach gave us the opportunity to examine two main lines of research questions concerning: (1) the specificities of technology-mediated design meetings that contrast to those of face-to-face design meetings; (2) the differences between synchronous and asynchronous collaborative work in mediated design engineering situations. Our approach stresses on some important aspects related to the management of the synchronous activity in a distant mediated situation. The originality of the approach relies on the hybrid characterization of both solution and problem management on one hand, and activity management (e.g. speech turns, meeting agenda) on the other hand.

Keywords: distributed design, engineering design, protocol analysis.

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Understanding the fundamental nature of group activity in order to support it implies : «Extending our understanding of the dimensions by which the important aspects of the situation, the task, the technology and the group composition affect collaborative work » and « Constructing methodological tools to analyze and assess collaborative situations» [1].

Today, distributed design situations are becoming natural design situations for a great number of engineers. This is mainly due to the market globalisation that leads the companies to reorganise their design activities in global development teams often scattered over the world. Development cycles reduction also greatly influences the design practices and foster the development of technology-mediated design. Today information technologies enable easy distant communications and effective data transfer. Besides, synchronous communications using video conferencing facilities and application sharing are now both user friendly and robust enough for a wide professional use. However, few studies have addressed this question in the field of engineering design, and the need for specific results pointing out the specific requirements in terms of mediating tools remains important. However the study of such situations is tricky and raises many methodological issues that cannot be addressed in a single paper. Rather, our purpose is to study collaborative work in mediated design engineering situations and provide results characterising the specificities of such activities, including our methodological approach especially our analysis framework.

Collaborative work may be involved in various spatio-temporal situations. The temporal dimension may be synchronous or asynchronous. The space may be the same (co-location) or different (distant location). For each spatio-temporal situation, various tools may be involved as described in the typology of Johansen [2].

Our objective is to examine the collaborative design activities and the interaction management activities involved in a technology-mediated engineering design project. The design project studied here requires alternating between two mediated situations: synchronous distant meetings and asynchronous distant design work. Two lines of questions will be examined: (a) the specificities of technology-mediated design meetings that contrast to those of face-to-face design meetings (as reported in the literature); (b) the differences between synchronous and asynchronous collaborative work in technology-mediated engineering design situations.

1 Theoretical framework

1.1 Collaborative design activities

Previous studies on face-to-face design meetings have analyzed collaborative activities occurring during such meetings: for example, in the development of local area networks [3], of software [4] [5] [6] [7], of aerospace structures [8], of mechanical devices [9] or of a backpack-to-mountain-bike attachment [10]. In face-to-face design meetings, authors have identified various types of collaborative activities.

One type of activity, related to the object of the design task, concerns the evolution of the design problem and solution:

- design activities, i.e. elaboration , enhancements of solutions and of alternative solutions;
- evaluation activities , i.e. evaluation of solutions or alternative solutions, on the basis of criteria. These activities may be supported by argumentation;

Another type of activity, related to the object of the design task, concerns the construction of a common referential by the group of actors: cognitive synchronization (often referred to as "clarification") activities, i.e. construction of a shared representation of the current state of the solution [11].

Furthermore, group management activities, related to process issues, are also involved:

- project management activities, i.e. allocation and planning of tasks;
- meeting management activities, i.e. ordering, postponing of topics in the meeting;

Most of these studies tend to show the predominance of cognitive synchronization activities in such meetings. Stempfle and Badke-Schaub [9] found that some teams bypassed cognitive synchronisation (referred to as "analysis") and that this led them to premature evaluation of design ideas. Indeed, these collaborative activities do not occur only during formal meetings and a lot of work has illustrated the importance of informal communication in design teams [12].

1.2 Interaction management activities

The characteristics of grounding activities in communication media have been analyzed by Clark and Brennan [13]. These authors have identified several constraints, related to the spatio-temporal settings and the tools available to communicate, which affect interaction management activities and common grounding: e.g. co-presence, visibility, and simultaneity.

Collocation is assumed to facilitate these activities. Several key characteristics of collocated synchronous interactions have been identified by Olson and Olson [14]:

- rapid feedback: It allows for rapid corrections when there are misunderstanding or disagreements;
- multiple channels (visual, oral, etc.): it allows for several ways to convey complex message and provides redundancy;
- shared local context: a shared frame on the activities allows for mutual understanding about what is in other's mind;
- co-reference: gaze and gestures can easily identify the referent of deictic terms;
- impromptu interactions: opportunistic exchanges can take place;
- spatiality of reference: both people and ideas (work objects) can be referred to spatially.

A question is how far distance may affect the ease of interaction management activities.

1.3 Intermediary objects and actions on technical

This category relates to the activity of direct physical interaction with the design artefact. In that case the role played by the graphical representations of the design artefact is essential in collaborative design. Boujut and Laureillard [15] or Schmidt and Wagner [16] propose the concepts of cooperative features, coordinative artefacts or intermediary objects to characterize the particular role these representations play in the collaborative processes. These intermediate representations may support co-design, argumentation, explanation, simulation or be an external memory of design rationale. Sharing these representations between distributed groups via shared electronic and physical media may also support awareness in remote collaboration [17]. Schmidt & Wagner [16]) distinguish between different functions of the artefacts involved in a cooperative process: construction of a common ground about a design principle, a task, etc.; reminders of design principles, open problems, etc.; traces of activities; representation of design decisions. Boujut and Laureillard [15] propose to characterize specific artefacts called "cooperative features" which are involved during cooperative sessions as mediations between the designers. During cooperative sessions the designers create their own shared representation (mainly using sketched signs). Boujut and Blanco [18] observed co-located meetings and analyzed the roles of the objects involved in such situations. The issue raised by the involvement of such intermediate representations in a virtual environment remains important. This aspect has been explicitly addressed in Ruiz-Dominguez et al. [19] and the reader can refer to this publication for a detailed analysis. However, we stress here the importance of integrating this dimension within the analysis framework.

2 Research questions

Two main lines of research questions will be examined in this paper. The first line of questions relates to the specificities of technology-mediated design meetings that contrast to those of face-to-face design meetings. This question can be decomposed into two sub-questions distinguishing collaborative design activities from interaction management activities.

The first sub-question concerns the nature of the collaborative design activities involved in technology-mediated design meetings compared with face to face design meetings (as reported in the literature). Previous studies on face-to-face design meetings tend to show the predominance of cognitive synchronization activities in such meetings. We will examine whether or not the same trend can be found in technology-mediated design meetings.

The second sub-question concerns whether or not all the key characteristics of face-to-face design meetings are important to reproduce in technology-mediated design meetings. Several key characteristics of collocated synchronous interactions have been identified by Olson and Olson [14]. We will examine whether these characteristics are important in technology-mediated design meetings and, to what extent, specific interaction management activities appear in the new situation.

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The second line of questions concerns the differences between synchronous and asynchronous collaborative work in technology-mediated engineering design situations. We will examine whether or not the same collaborative design activities occur in these two work modes. We will also analyze whether or not the same uses of the technical devices (specifically shared graphical representations) occur in these two temporal modes: we will distinguish between several ways intermediary objects support collaborative work: supporting on-line co-production, guiding explanation, supporting argumentation, supporting tracing, and supporting simulation.

In order to address these questions, we have extended a methodological framework based on previous research in cognitive ergonomics and social psychology [20] [21].

3 Experimental setting

The experiment was carried out in four different French universities, namely Belfort, Grenoble, Nancy and Nantes. The four universities are involved in a research program which aims at setting up distributed design experiments in the field of engineering design. The experimental protocol we present here has been jointly developed by the four universities mentioned.

In this experiment we wanted to create a design situation where four distant designers had to communicate using commercial software and standard hardware configurations.

3.1 The design task

The designers had to develop a new model of a children's trailer (see Figure 1).

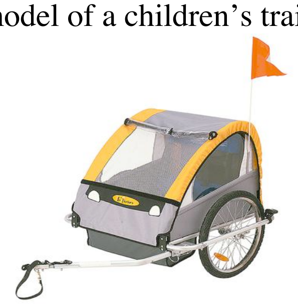

Figure 1: example of a children's trailer

The input to the design process was a report of a preliminary study. The designers were asked to develop a solution that could be industrialized, defining the manufacturing requirements, describing the technical solutions and providing suitable CAD models.

The study was carried out during the early detailed design phases. This allowed us to identify the difficulties of communication between different domains. Manufacturing constraints are traditionally difficult to introduce during design, and we wanted to focus on this aspect. Negotiations were necessary in order for the participants to agree on the solution. The other point we wanted to raise was the process of building CAD models, sharing the results or collectively modifying the models during synchronous communications. We wanted to observe the evolutions of the CAD models as a medium for design communication, and the way CAD software was involved in the process: the design task therefore centred on embodiment and early detailed design.

The designers were given a design brief including:

- general requirements on the product;
- a rough project description (organization, communication protocols, specialties involved, etc.);
- preliminary schedule setting the different design meetings;
- list of the preliminary documents;
- list of the deliverables.

The preliminary design report included a functional analysis of the product detailing the functional requirements, a proposition of a technical solution and some preliminary plans detailing the solution.

As a preliminary task, the designers had to produce the various CAD models of the preliminary solution. The deliverables were specific to each domain.

3.2 The designers and their roles

The designers were four master students in engineering design. Therefore they were quite familiar with CAD systems and specific design support tools (except the project manager). A preliminary interview showed that the designers were familiar with all the software but the collaborative environment (Netmeeting®). Besides, they were rewarded and were working under a precise contract defining the conditions of their involvement. We deliberately choose this option in order to create a situation as close as possible to a professional working condition. Figure 2 displays pictures of two designers in their design environments.

Four roles were prescribed:

- a project manager;
- an industrial designer;
- an engineering designer, 1;
- an engineering designer, 2.

The project manager was in charge of the overall consistency of the solution. He also had the responsibility of the digital mock up and the agenda. The industrial designer was in charge of the usability constraints, and the ergonomic aspects of the product. The engineering designers were in charge of the technical and industrial aspects; they were responsible for two different areas of the product.

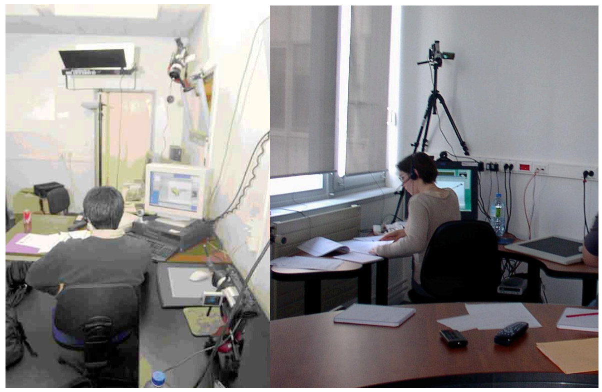

Figure 2: Two designers and their environment

3.3 Design work modes

Two work modes were distinguished during the product design process: synchronous and asynchronous modes (see Table 1).

- Synchronous mode or design meetings. Four meetings of two hours each were held in March 2002 (7, 14, 21 and 28 March), representing 8 hours of synchronous work (Table 1). The designers were in four cities : Nantes, Grenoble, Belfort and Nancy.
- Asynchronous mode or distributed design. The designers had to work at least 4 hours per week. This work was mainly individual. Communication was allowed with other designers via electronic mail.

A phase of familiarization with the communication and CAD tools was set up previous to the experiment to ensure that the participants would know the functionalities put at their disposal.

Date	**Modality**	**Time**
Meeting 1	synchronous	2 hours
1 week	asynchronous	4 hours
Meeting 2	synchronous	2 hours
1 week	asynchronous	4 hours
Meeting 3	synchronous	2 hours
1 week	asynchronous	4 hours
Meering 4	synchronous	2 hours
1 week	asynchronous	4 hours
Debriefing	Face to face meeting	4 hours

Table 1: Planning of synchronous/ asynchronous work

3.4 Technical aspects

3.4.1 Software aspects

The software available for communication were: Microsoft Netmeeting® for videoconference, Eudora® for e-mail and Ftp soft for file transfer. In addition we provided an FTP account for storing information and sharing the data. For carrying out the technical aspects the designers could use Solidworks® for 3D modeling and a local software for basic material strength analysis.

3.4.2 Hardware aspects

We used a French academic network providing speed transfer of 100 Mbytes/s. The four centers were connected to a server where Solidworks were running in order to save CPU resources on the users' workstations. Netmeeting was running on each computer and all the participants were connected to the server. Everyone was sharing the same CAD software located in the server.

3.5 Data Gathering

3.5.1 Video-recording of technology-mediated meetings

Two types of Video-recording were performed:

- Workstation view (Private space). The designers' face and local environment were video-recorded. This shows the designers movements in their private space and their use of the objets they had at hand.
- Screen view (Public and private space). A second video recorded the designers' screens. This is both private and public data because applications, programs, etc, could be open on a designer's screen, some of them in private space and the others in public space.

Finally, we obtained a 64-hour corpus: two views per four designers per four 2 hour meetings.

3.5.2 Pre and post-questionnaires

Two questionnaires were prepared to find out how the designers felt during synchronous /asynchronous work. The designers answered a questionnaire before and after each distant design meeting (pre and post design questionnaire). The questionnaires are divided into two parts: the first part deals with asynchronous work, whereas the second part deals with synchronous work. The main subjects dealt with in the pre and post questionnaire interviews are displayed in Table 2.

Pre questionnaire Interview	**Post questionnaire interview**
Asynchronous period ➘ Work planning ➘ Problems the group met ➘ Technical Functionality (use & problems)	**Asynchronous period** ➘ Work planning ➘ Designers goals
Synchronous period ➘ Work planning ➘ Problems to tackle ➘ Technical Functionality (use & problems) ➘ Suggestions to be made	**Synchronous period** ➘ Work planning ➘ Solutions adopted ➘ Technical Functionality (use & problems) ➘ Constraints and assessment of solutions

Table 2: Main Subjects dealt with in the pre and post questionnaire interviews

4 Data analysis methodology

4.1 Analysis of a technology-mediated design meeting

As a preliminary work on our 64-hour corpus, we focused on only one meeting in order to develop and apply our analysis methodology. We chose to analyze the third meeting, as it was the one in which the widest range of activities was observed and we also found that the learning process (especially regarding the tools) was quite stabilized at this stage of the design process. We then transcribed the whole corpus of this meeting.

We adopted and extended a coding scheme based on previous research in cognitive ergonomics and social psychology [20] [21] [22] [23]. The reliability of our coding scheme as been tested in D'Astous et al. [24] in which we hound that he degree of accordance between the two coders was quite good, as measured by two statistical tests: the kappa of Cohen and the index of fiability of Perrault and Leigh.

Our coding schema has two levels. At the first level, the coding is done to analyze the activities involved during the synchronous meeting. Three types of activity categories are distinguished: collaborative design activities (Table 3), interaction management activities (Table 4), and activities belonging to a relational register.

	Description
Meeting management	Organizing the actual meeting regarding the time available and the tasks to be done.
Project management	Planning the design: this involves organizing and distributing tasks according to the designers' skills.
Cognitive synchronization	Ensuring that team members share a common representation of a concept, projects goals, constraints, design strategy, solutions, etc.
Argumentation	Describing why a solution should or shouldn't be adopted.
Assessment of solution(s)	Evaluating positively or negatively a proposed solution.
Assessment of constraint(s)	Evaluating positively or negatively a constraint.
Proposing Solution(s)	Proposing, explaining a solution or an alternative solution.
Enhancing a solution	Enunciating supplementary and complementary ideas to develop a solution.

Table 3: Collaborative design activities categories

	Description
Technical resource management	Taking care that all the group shares the same technical resources, the same software in a private or shared space at a given time T. This ensures that a local context is shared.
Audio management	Ensuring that team members can hear the other members clearly.
Management of turn	Managing turn taking distribution.

taking	
Information resource Management	Ensuring that team members are aware of the information under discussion, and have the same document version (in their private or public spaces). This supports co-reference.
Regulator	Verbal utterances from the members who are listening, to indicate their continued presence and attention. For example: « Mmh », « Yes ».
Screen management	Ensuring that team members have a good visibility of the documents on the screen (like sketches). This supports both co-reference and ensures that a local context is shared.
Technical problem management	Help offered from one member to one or several members to give access to data that they can't open for some reason. These problems could be due to software, telecommunication failure, etc.

Table 4**:** Interaction management activities categories

Referring to Vacherand-Revel [21], we distinguish activities belonging to the relational register. We consider the relational register as an affective dimension. We only consider it for exchanges which are not directly about work. These kinds of exchanges allow the co-designers to share emotional affects (e.g. at the beginning of design meeting; "It's ok, we are all tired, there is no problem!").

At the second level, the coding focus is on the designers' *actions on technical devices*. Five categories were distinguished (Table 5).

	Description
Online co-producing	One or several team members use the technical device to produce together, develop a solution, a document.
Supporting argumentation	A member develops argumentation concerning a solution with an open file shared by the group (over the network).
Guiding explanation	A member uses the screen to focus on a field of the solution in order to support her/his explanation by moving the mouse to show a specific field of the solution on the screen.
Simulating	A member describes a procedure by simulating its execution. This may be for various reasons: technical failure, difficulties in finding a document, a resource, etc.
Tracing	A member keeps or seeks a trace of documents to remind the group of a decision, solution etc;

Table 5: Actions on technical devices

An excerpt of the coded corpus is shown in Annex 1.

4.2 Synchronous versus asynchronous work

The questionnaires revealed which activities were done and which tools were used during synchronous versus asynchronous work. Our analysis involved two phases. Firstly we systematically counted the tools reported to be used by each designer. Secondly a content analysis revealed which activities and which functionalities were associated to the tools used.

Then, the results obtained were interpreted for those tools which were used by at least three designers in order to gain a representative view of their use.

5 Results

5.1 Global distribution of activities

Figure 3 displays the global distribution of activities between our categories of the first level of analysis. It appears that collaborative design activities represent the most frequent exchanges (71%) occurring during the design meeting.

Interaction management activities represent 24% of the exchanges. This proportion is relatively important if we consider that no technical problems appeared during the design meeting.

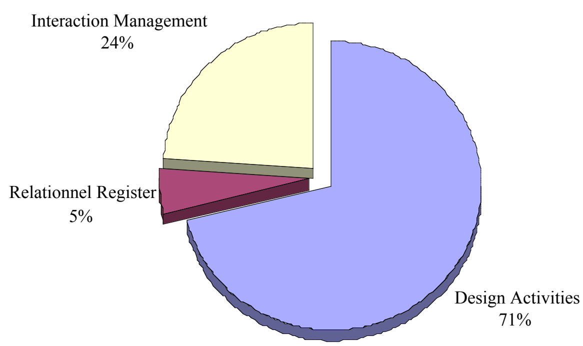

Figure 3: Global distribution of activities

Activities belonging to the relational register do not occur frequently (5%). These activities appeared mostly at the beginning, before and after break time and at the end of the meeting in order to initiate and close designers exchange.

5.2 Face-to face design meetings versus technology-mediated design meetings

Figure 4 displays the distribution of collaborative design activities in the technology-mediated design meeting. Cognitive synchronization (41%) was the most frequently occurring activity with respect to other collaborative design activities: assessment (23%); argumentation (18%); proposition/enhancement (12%); management (6%). So the mediated characteristic of the meeting does not seem to affect the nature of collaborative design activities involved in the meeting. So, with respect to the literature, we found the same predominance of cognitive synchronization in our technology-mediated design meeting as in face-to-face design meetings.

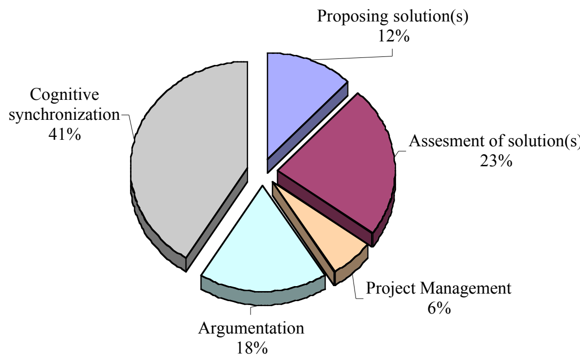

Figure 4: Collaborative design activities

We found that interaction management activities were relatively important in our technology-mediated meeting representing 24% of all activities. Figure 5 displays the distribution of interaction management activities in our meeting. The occurrence of these activities shows that co-reference is difficult. This is reflected by the importance of particular interaction management activities: information resource management (38% of interaction management activities) and screen management (17% of interaction management activities).

Management of turn taking (7% of interaction management activities) was principally made by the project leader in our technology-mediated meeting. In face-to-face design this is not usually the case, as turn taking is done on the basis of non verbal cues and does not require explicit management activities. Impromptu interactions or side discussions, which may reveal opportunistic data gathering, for further phases of the task, were not observed unlike in face-to-face meetings. These two results are similar to those found in computer-mediated communication [25].

Furthermore, the absence of visual modality was regretted by the co-designers (as reported in the questionnaires). However, other studies [26] [27] show that in a complex task, face visibility is disturbing whereas functional visibility is helpful. We can assume that, in our technology-mediated design situation, functional visibility would have allowed a local context to be shared and co-reference to be easier.

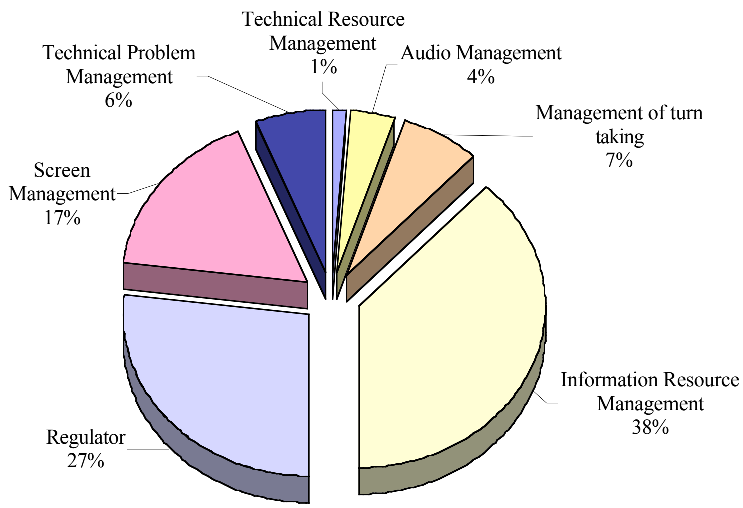

Figure 5: Interaction management activities

5.3 Synchronous versus asynchronous collaborative work in design

Based on the analysis of the questionnaires and of one design meeting, we found that both design activities and the use of tools varied according to the temporal mode, synchronous *versus* asynchronous, of the design work.

In the asynchronous mode, reported design activities (on the basis of the questionnaires) were mostly the implementation of solutions, i.e. 3D graphical realization of the design artefact. The CAD application and the common data repository were used respectively for graphical design and for storing and consulting design files. Electronic mail was mostly used to communicate about project management.

In the synchronous mode, reported design activities (on the basis of the questionnaires) and observed design activities (in the design meeting which we analyzed) were mostly proposition/enhancement of solutions and assessment of solutions. Co-elaboration of solutions was observed. Whiteboard and shared CAD applications were used to co-produce solutions, and to support argumentation and explanation (Figure 6). The role of graphical representations of the design artefact as entities of cooperation or intermediary objects [15] was central in the collaborative design activity.

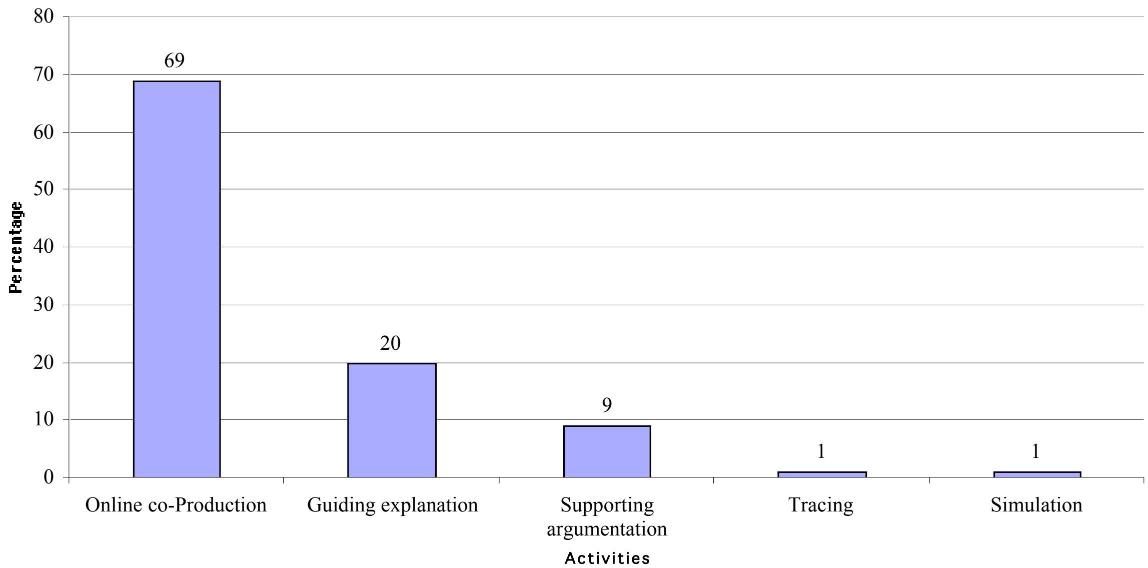

Figure 6 : Technical Devices Use (percent)

Supporting online co-production activity was the most frequently occurring use of technical devices (Figure 6). This activity was supported by computer graphics and sketches on the Netmeeting whiteboard (Table 6). Guiding explanations and supporting argumentation also had to be provided using graphics. These results show that the most widely used technical devices for mediated engineering design activities relate to graphical representations.

	Online co-production	Guiding explicatio	Supporting argumentation	Tracing	Simulating	**Total**
Whiteboard	**177**	**62**	19	5	0	**263**
Graphics	**228**	**69**	**39**	2	0	**338**
Excel Software	20	8	2	0	1	**31**
Explorer	0	0	0	0	3	**3**

Table 6: Supporting tools regarding technical devices (in occurrences).

6 Discussion and further work

Our methodological framework has allowed us to analyze synchronous and asynchronous collaborative work in technology-mediated distant design situations. We found the same predominance of cognitive synchronization in our technology-mediated design meeting as in face-to-face design meetings (as reported in the literature). We found that interaction management activities were relatively important in our technology-mediated meeting. The distribution of interaction management activities shows that co-reference was difficult. Based on the analysis of the questionnaires and of one design meeting, we found that both design activities and the use of tools varied according to the temporal mode, synchronous *versus* asynchronous, of the design work

Several limitations of our work should be highlighted. Firstly, several characteristics of our experiment limit the generality of our results: (1) the particularity of the meeting analyzed for characterizing synchronous work; (2) the designers profile; (3) the familiarity with the communication tools.

As concerns the particularity of our analyzed distant meeting, it is clear that further studies should be conducted to verify the generality of our preliminary results on synchronous distant design work.

The designers profile is also very important. In our experiment we hired students in engineering design. They were paid for their work and were working under a precise contract defining the conditions of their involvement. This question remains as to for us whether more experienced professionals would have performed differently. We plan to carry out experiments involving skilled designers and junior designers as a matter of comparison to evaluate the impact of design experience on the performance.

The skills and level of familiarity with the various communication tools is also important. We should be more careful in training the designers and/or carry out experiments with a trained team and a novice team in order to characterize a "familiarity" impact of the communication tools.

Secondly, the data recording and gathering could be improved. On the technical side videos should be more carefully synchronized in the various centres and the format should be standardized. Audio-recording is also a problem. Finally we had a 64-hour corpus that remains difficult to analyze without the help of video indexing systems. The amount of data is an issue in this kind of experiment.

Asynchronous work was analyzed on the basis of questionnaires. This analysis could be improved by a finer methodology based on gathering, other data e.g., email exchanges or computer interaction collected using specific "spy" software.

Thirdly, further development of our analysis methodology could be done. Our coding schema could be improved, in particular the categories concerning the "actions on technical devices". We felt that these categories could be refined to account for more subtle interactions through the technological tools.

Finally, the design task is a key point in the success of the experiment. A lot of experiments have been carried out in creative design phases or in early design phases [10] [28]. Exploring design solutions in a team involves 2D sketching, but when we consider embodiment design phases, the use of specific 3D modelling tools becomes necessary. Few experiments have been carried out at this stage. For us this remains an important challenge.

Acknowledgments

The design experiment mentioned in this paper has been carried out by the GRACC group, a French research group composed of four universities (Belfort, Grenoble, Nantes, Nancy). More information can be found at http://www.3s.hmg.inpg.fr/ci/gracc.

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ANNEX 1

CORPUS Designer identification	**CORPUS Time**	**CORPUS Behavior on tools**	**CORPUS Verbal**	**CODING Activities (design or interaction management)**	**CODING Actions on technical device**
NC	00 :54 :19	Whiteboard (lid on screen) (drawing)	You gotta… lower it, yeah OK like that,	Cognitive synchronization	Online co-producing
NC	…	Whiteboard (lid on screen) (drawing)	and some small rubber bands to fasten it at the bottom	Proposing Solution(s)	Online co-producing
NT	…	Whiteboard (lid on screen)	No, you take it away	Proposing Solution(s)	
G	…	Whiteboard (lid on screen) (delete drawing)	You definitely take it away	Cognitive synchronization	Online co-producing
B	…	Whiteboard (lid on screen) (pointing)	We can place some small rubber bands	Proposing Solution(s)	Guiding explanation
B	…	Whiteboard (lid on screen) (pointing)	And ahhh, peace of, here you are,	Technical resource management	Guiding explanation
B	…	Whiteboard (lid on screen) (pointing)	Some small rubbers here for rolling them up if one one fully opens the window… to fasten the plastic stuff	Proposing Solution(s)	Guiding explanation
NT	00 :54 :35	Whiteboard (lid on screen)	OK	Assessment of solution	
G	00 :54 :44	Whiteboard (lid on screen) (drawing)	And instead of using a zipper couldn't we use fasteners, like this ?	Proposing Solution(s)	Online co-producing

Annex 1: excerpt of synchronous meeting coding

G, NC, NT, B: Represents the four designer