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Combining Ergonomics, Culture and Scenario for the Design of a Cooperation Platform

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Abstract
Analyzing the way computer technologies are used is crucial to their development. Such analyses make it possible to evaluate these technologies and to enhance their evolution. The present article presents some ideas drawn from the development of a cooperation platform for elementary school children (10-11 years old). On the basis of an obvious ergonomic requirement, we worked on two other dimensions: cultural aspects and the teaching scenario. The goal was to set up observation situations and analyze the conversations produced during those situations, in order to understand what using the platform meant to both the pupils and their teachers.

Keywords
Cooperation, Usability, Ergonomics, Teaching Scenario, Culture, Analysis of Interactions.

1. Introduction

There is a large body of research on the development of computer technologies for schools. The idea is to teach children with computers, but also to enable them to learn remotely or to work on joint projects. This last case was our focus here. The objective is twofold. First, to teach children to cooperate with each other, mainly in an asynchronous way, and second, to teach them how to cooperate by means of an internet technology.

So, we are interested by a collective and distant production, and this production is mediatized by a computer device However, the implementation of such cooperative activities mediated by computer environments does not rest solely on the technical and ergonomic properties of those environments. A key element is the educational devices themselves. It is hypothesized here that three factors have an impact on the usability and acceptability of computer tools. Of course, the first is the ergonomic factor, which is the facet most often brought to bear. The second is the cultural factor. The third is the teaching scenario. We contend that these three factors must be simultaneously taken into account in order to analysis a computer tool from the standpoint of its use. Indeed, it is useless and hazardous to concentrate solely on ergonomic aspects, because one runs the risk of producing a perfectly efficient but useless tool. These three factors must also be considered early in the design process, because they have a strong impact on the definition of the observation protocol.

This is the point of view defended in this paper, based on the design of a platform for

cooperating via the internet called Coopera[1]. The platform allows pupils (5th graders age 10 or 11) from several elementary schools to carry out joint projects. The originality of the platform is that users are able to run their own cooperative activities by means of the file sharing and viewing capabilities of the model underlying the design. The viewing feature allows the pupils to know at any time who created or modified a file and what modification was made. This allowed us to study the role of the educational device along with the appropriation of the platform.

So, a cooperation platform is not only a technical support for the management of the activity and the exchange of information. It is obviously an instrument to be mastered by the users, but also a resource for collective action. We defend then that we better talk about an "instrumental device" but not only about a "technical device". This instrumental device is composed of three devices: the teaching scenario device, the computer device and the animation device. This results from our dialogical approach for use analysis. Since we are interested with the appropriation of the platform by the children, then we have set up some work sessions during which the children have produced some actions and some speech acts. And since they have to master the techniques proposed (the cooperation platform), then we have elaborated two animations during which the children have physically handled the concepts of the platform.

To defend our point of view, we will start by presenting our approach to use analysis. Our aim was to observe natural situations in which the tool is used. In other words, we do not rely on an experimental psychology framework or an ergonomic testing method, but rather work as would an ethnographer. This approach to use analysis is important because it guides us in capturing and defining the three factors we discuss here. We will describe these factors in the third part of this paper using an excerpt of a conversation between a pair of children working on the platform. Before that, we will describe the platform technically (second part). We will finish with a discussion that points out the merits of our approach.

[1] Coopera is a RIAM project (Network for Multimedia and Audiovisual Innovation) financed by the Centre National du Cinema (French National Center for Cinema), 2002-2004.

2. Theoretical frame for usage analysis

This section presents our theoretical background. We include our works in the situated-action paradigm, which allowed us to observe natural work situations and to examine the role of users in the development of the cooperation platform. We also present the participants of the three projects that occurred during this two-year program.

2.1. Two Reasons for Working like Ethnographers

The method we use to analyze cooperative work is an ethnomethodologically-informed ethnography (Crabtree, 1998), for two main reasons. The first is epistemological. Any human activity is instrumentalized by objects on one hand, and by language on the other. With objects and words (Vygotsky, 1978), we control and transform the environment and our own behaviors, and hence our relationships with other. It is therefore important that our analysis take into account the weight of the environment and the social relations in the activity under study. Inquiries about technology-mediated activity (Kaptelinin and Nardi, 1993, Kuuti & Bannon, 1993) is useful because it describes an action as a chain of operations carried out by individuals who are not thinking about it. The oberver's objective is to clarify this chain of operations.

The second reason is practical. The situations studied in the Coopera project are ones with strong social interactions in which the context deeply influences the activity. Therefore, the variables are multiple, and complex and we do not attempt to control them. On the contrary, our aim is to grasp this complexity. Moreover, our objective is not to compare groups of pupils under contrasted experimental conditions, which is why an ethnomethodological approach is more suitable than an experimental one (Nardi *et al.*, 1993).

In addition to taking into account the context, we look at the role of the users themselves. Educational devices involve at least two types of users, each with having different things at: pupils and teachers. In a certain way, a participative design process is taking place, because our observations are centered on the users' actual behavior in a situation that allows them to express their understanding of the cooperative situation and their needs. Finally, behind our ethnographical approach, we are promoting a way of building and analyzing situations of technology-mediated cooperation.

2.2. Setting Up of Natural Situations

Human activity is complex. It transforms the environment at the same time as it is transformed by it, in a kind of action-environment coupling (Hutchins, 1995; Suchman, 1987). To observe and study such a complex activity, it is illusory to try to characterize it using experimental parameters. On the contrary, it is necessary to set up situations in which natural practices can be carried out. Vygotsky (1978) proposed an experimental-genetic method which meets this requirement. In line with this method, we set up pairs of pupils working in their own classrooms on projects designed by their teachers. This has two main advantages. Firstly, it reflects the true use of technologies in France. Secondly, the discussions generated between pairs of pupils can be analyzed. Of course, we adapted the Vygotskian method to current visual audio technologies, which allowed us to obtain linguistic and material recordings of the activity. Moreover, we were physically present during the work sessions, as observers.

2.3. Analysis of Conversational Interactions

The social interactions recorded consisted of language use and the handling of objects (mainly handling of the mouse and keyboard, and events displayed on the screen). To analyze the linguistic part of the data, we relied on speech act theory (Searle & Vanderveken, 1985; Vanderveken, 1990), even if, theoretically, the principles of conversational analysis based on ethnomethodology do not go hand in hand with those of discourse analysis (Levinson, 1983). However, we can use these two opposing theories and tools because the speech act category is dialogized (Trognon & Brassac, 1995; Brassac & Grégori, 2001). The basic premise is that it is possible to "grasp" human cognitive processes by analyzing the speech produced by subjects in an interlocutionary situation. Better yet, a fine-grained description of the chain of conversation, for modelling purposes, is a reliable way of gaining insight into the mechanisms of human cognition. We are acting here as theorists of social interaction, viewed at the "micro" level.

The concept of speech act, in its original definition, will serve as our starting point. When a subject in a conversational context performs an utterance, he/she is accomplishing what is called a speech act. Each speech act is an elementary link in the conversational chain. Speech act theory was first axiomatized in the form of illocutionary logic (Searle & Vanderveken, 1985), and was then expanded into a formal general semantics (Vanderveken, 1990). Granted, this theory has been and still is the subject of heated debate from all sides; firstly, because it bears the mark of a radically monologuist attitude; secondly, because the role it grants to the speech act as the analysis unit of verbal interaction is often considered totally inadequate. We shall not dwell on this debate here, but it is clear that one of the major criticisms of this formal system – which meticulously models the expression and comprehension of language by human subjects through the in-depth study of their speech acts – completely fails to account for language usage in a dialogue situation. There are two main reasons for this: its omission of the non-literal dimension of conversation, despite how fundamental it is to intersubjectivity, and the static nature of any analysis that does not even address the processes at play in the dynamic progression of a conversation. The crux of this issue indeed lies here for anyone who hopes to use this theory to model interactions as they unfold, i.e., for anyone who wants to account for interaction as a process. The key

is to take this general formal semantics and transform it by what one might call "dialogization", where the goal is to delineate and handle the non-literal and dynamic facets of the interlocutionary exchange.

Dialogization basic idea is that, contrary to the classical theory, the initial utterance has no illocutionary status apart from that afforded by its processing by the actors as the conversation proceeds. Its status is not the product of the emitting speaker alone, nor can it be accredited solely to the listener. It is built by means of a meaning-negotiation process carried out jointly by the two interlocutors. A given utterance, in a given conversation, does not have just *one* meaning, the meaning its speaker attributed to it once and for all (whether literal or otherwise). It only acquires meaning within the subtle interplay of a process of negotiation between two conversers; even then, its significance is only temporarily stabilized, and it belongs to neither of them.

Being co-responsible for stabilizing the interlocutionary significance of each utterance in the sequence, the actors in the exchange participate in the co-construction of the meaning of the linguistic forms that weave the fabric of the conversation. Because it hinges on the key idea that meaning is co-constructed in a process-based and radically dialogical fashion, this way of modeling conversation takes a constructivist approach. It is not necessary to postulate the existence of a predefined meaning that precedes the expression or comprehension of the linguistic form produced in context. All that is needed is the simple idea that the conversers jointly mould the still-negotiable meaning in a process-driven way. This is the view of conversational exchange that will be used in our analyses.

Speech act category is therefore an interesting unit of analysis because it goes back to both to cognitive and social dimensions of conversations. It makes it possible to simultaneously take into account the meanings built by the subjects, and the social relations that emerge during the activity.

But we are not interested only in the language produced. We also observe the objects handled (Vinck & Jeantet, 1995), because they are means for coordinating actions and producting shared knowledge. Bringing such "intermediary objects" to bear in our analyses of the actors' schemes and actions is the outcome of much more recent, and much less polished, theorizing efforts on our part. The importance of such objects to exchanges between actors in a cooperative situation has become very obvious to us, and has forced us to recognize the merits of including object manipulation in our theoretical account.

2.4. Role of the Actor-User in the Design Process

The above points (setting up natural situations and analyzing situated social interactions) lead us to reflect upon the role of users (pupils and teachers) in the design of the cooperation platform. If we agree that meaning is produced in context (and more specifically in a natural context), then we must also agree that users who produce that meaning play an active role in the design process. They are not testers or evaluators, but prescribers. That is why the the situations are designed to promote our understanding of how users go about cooperating in a context that requires complex synchronizations, at the operative (concerning the platform itself), cognitive (concerning the knowledge produced), or social (concerning group awareness for example) level. This goal is very important because the concerned users are 10-11 year-old children, who are not accustomed to working this way, and teachers who are not used to to working in such a context either, even though they voluntareed to participate.

2.5. Ergonomics, Scenario and Culture

The development of such a cooperation platform for pupils must meet ergonomic requirements. Of course, the platform must be efficient and usable. The study of its contextual use must make it possible to work on this dimension. But it must also meet the requirements of a teaching scenario. It is the teaching scenario that situates the action and therefore allows us to construct a natural observation setting, for at least three reasons.

Firstly, the teaching scenario does or does not support cooperation; secondly, it does or does not motivate the children; and thirdly, because it involves the teachers in the project. Thus, generating good work situations means paying attention to this requirement. Moreover, the act of cooperating is not a meaningless act. It is based on social relations between individuals, by means of particular procedures. It is thus inscribed in a cultural environment that is complex. The development of the cooperation platform is therefore necessarily tied to this third requirement.

The analyses produced must make it possible to characterize the platform according to these three essential dimensions: ergonomics, teaching scenario, and culture. This is why we defend an approach centered on social interactions.

2.6. Participants

As stated above, the study involved two types of participants: pupils (5th grade) and teachers. The pupils were the direct users of the platform. They worked in cooperation across schools. The teachers could be considered as the administrators of the platform rather than direct users. They were important actors too, since they had to define the teaching scenarios. The computers were located in dedicated rooms that can be found in most French elementary schools today. Most of the time, two children shared a computer. Three projects were carried out during three school years using three successive versions of the platform.

Two schools were involved in the first project, entitled Poems. In an asynchronous way, the pupils exchanged their activities in order to write, illustrate, and format poems (May-June 2002). The cooperation gave rise to a final product that gathered all poems. The second project (Operette: school year 2002-2003) involved a third school. The task was to create a web site about the opera house in Nancy. In addition to creating the documents (computer files and web pages), the objective for the pupils was to learn how to share skills, share knowledge, and articulate ideas in order to achieve a common result. The third project, an online magazine, took place during the 2003-2004 school year. A fourth school joined the first three. Note that each year we worked with the same schools but new groups of children.

3. Coopera: Technical aspects

In any computer technology, the technical aspects are important. It is because the tool should function and because it should offer new possibilities that it becomes useful.

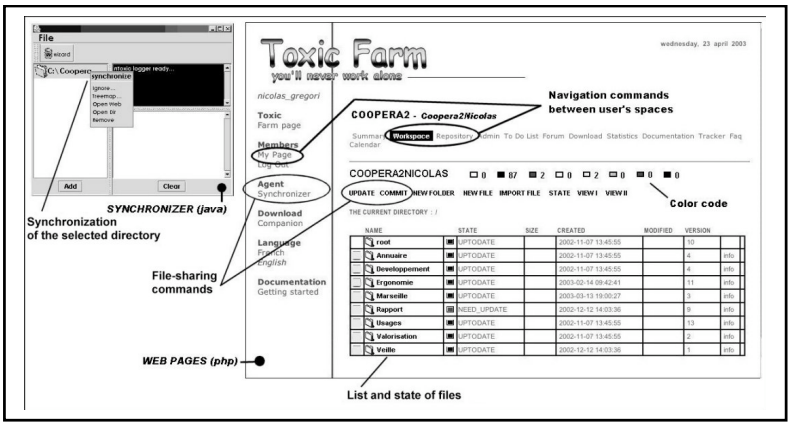

Figure 1. ToxicFarm. Each web page contains a lot of information. Most of the commands for space navigation, coordination, communication, etc. can be launched from nearly anywhere. This is disruptive for children who still have difficulty viewing the organization of spaces and need a clear structure for features and commands.

In this paper, we consider only a specific part of cooperation, that occurring between a group of persons working together to produce a set of documents in an asynchronous way, i.e. distributed in space and time. We relied on the cooperation model of a platform developed locally, the *ToxicFarm* (Godart *et al.*, 2004) (Figure 1). One of the goals of the project was to produce a version of this platform adapted to users who are not familiar with cooperative work.

3.1. Cooperation Model

The cooperation model implemented in *ToxicFarm* is widely used in cooperative work, in a large variety of applications (co-authoring, co-designing, co-engineering, etc.). It is rooted in the nature of cooperation itself, but has been equipped with tools and popularized in the software engineering domain through the copy/modify/merge paradigm[2], and in the groupware domain, typically in the diverge/ merge model of *Prospero* (Dourish, 1995).

This approach emphasizes multi-synchronous work where "Working activities proceed in parallel (multiple streams of activities), during which the participants are disconnected (divergence occurs) and periodically their individual efforts are integrated, by means of a synchronization, in order to achieve a consistent state and advance the activity of the group". Here, cooperation consists in creating alternative contributing versions of a base object, merging them back into the base object, creating alternative versions, and so on.

Privacy between partners is generally achieved by maintaining a multi-space: a central directory contains the up-to-date versions of shared objects and each partner is associated to a private workspace where he/she can check out objects to modify them. Before committing his/her own changes to the common directory, the user must merge those changes with other changes committed to the directory since his/her last check. This can lead to conflicts if two people have modified the same file in their own private space: in such a case, conflicts must be resolved before the file can be committed to the common directory (this can be done automatically or may require some communication between the two people.

[2] www.cvshome.org/docs/manual/

3.2. Initial System: *ToxicFarm*

Object sharing in *ToxicFarm* is based first on a workspace management system that implements a long-transaction model (Feiler & Downey, 1990). For each project, there is a shared object space (called the central directory) where all objects in the projects including their versions are stored. Each user in the project can create a private workspace. Initially, a private workspace contains a copy of the last version of all files from the shared space, i.e. a copy of the whole project. Users can update their private workspace with new versions from the central directory or publish new versions from their private workspace to the central directory. This system is similar to the widely-systems like CVS found in software engineering, except that this version of the management system has been simplified and generalized (updated version of directories). In addition, the long-transaction model requires the complete set of changes done in the directory to be published each time a 'commit' is performed. In order to avoid lost updates, a user can only 'commit' if no changes have been made in the directory since his/her last update.

Classically, the central directory is stored on a server, and private spaces are directly supported by the user's computer. But in ToxicFarm, the users' private workspaces are also kept on the central server, and an additional space level, called the local workspace, has been added. A local workspace is a copy of a private workspace located on the user's own machine (Figure 2). This allows for advanced functionalities like awareness and mobility support (Dourish & Bellotti, 1990; Gutwin *et al.*, 1996). To maintain consistency between the local workspace and its corresponding private workspace, the user can periodically synchronize them. All interactions between private and local spaces are managed by a tool called the Synchronizer.

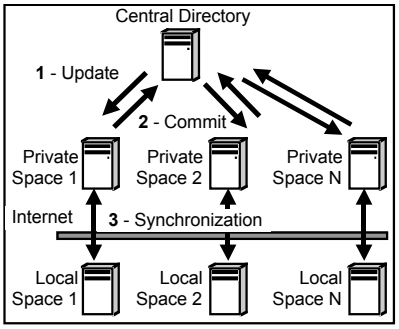

Figure 2. Space management in ToxicFarm.

A typical usage scenario for this platform can be described as follows: a new user wants to participate in a project, so he starts by creating a private workspace for the project. To be able to read and modify the project objects, he synchronizes this private workspace on his computer, which creates a local workspace for the private one. Then he works with his usual tools, modifying files in his local workspace (possibly disconnected from the network). He can periodically synchronize his work, which transfers his changes to his private workspace.

While this user is working, someone else may publish some changes in the common directory. To see changes in his local workspace, the user must, on his own initiative, update his private workspace and then synchronize. This may create conflicts that will have to be resolved. When he stops working, the user can synchronize and then publish his work. And when he reconnects after a break, he can update his private workspace and synchronize it in order to have knowledge of any work done by his partners during his absence.

The availability of the central directory and private workspaces on the central server provides users with state awareness capabilities. Users are notified of changes made on files in other users' private workspaces before they are published. States are seen from the point of view of the user. A file can:

– be up-to-date (no one has changed it),
– be locally modified (changed in the current user's private workspace),
– be modified (a new version has been published in the central directory),
– be remotely modified (a user has changed it in his private workspace but has not published it yet),
– cause a potential conflict (it has been locally and remotely modified),
– be in conflict (it has been locally modified and there is a new version in the central directory)
– be in version conflict (there are two copies of the same file in the private directory, the locally modified one and the updated one from the shared directory).

In classical systems, conflicts are detected only when they occur, whereas in our system, thanks to state awareness, they can be detected earlier and even avoided because users are aware of modifications that have not yet been published. Our assumption is that providing this kind of awareness will help project participants improve coordination. We use colors associated with files to represent file states and we provide a synthetic view of the states of files.

4. Three factors for Use Analysis: Ergonomics, culture, and teaching scenario

Once again, we were working at the same time on the evaluation and development of the platform, so psychologists and developers were always closely working together. In this section, we present the evolution of the cooperation platform. Then we describe the three usage factors we defend. This is done by analyzing an excerpt of a conversational interaction that occurred during the use of the second version of the platform (Coopera 1).

4.1. Evolution of the Coopera Interface

The Coopera interface has evolved during the two years of the project. In both its initial state (ToxicFarm) and as Coopera 1, it was composed of two very different elements: a set of web pages developed in php and a Java synchronizer (Figures 1-3). The final development combined all of the functionalities into a java tool (Figure 4).

As shown in Figures 1, 3 and 4, the evolution of the platform between versions

Coopera 1 and Coopera 2 is the clearest. The functionalities remain the same, but the tool is very different. Indeed, Coopera 1 ended up being just a graphic evolution of ToxicFarm. Coopera 2 represents a major evolution of the platform because it takes the cultural dimension into account.

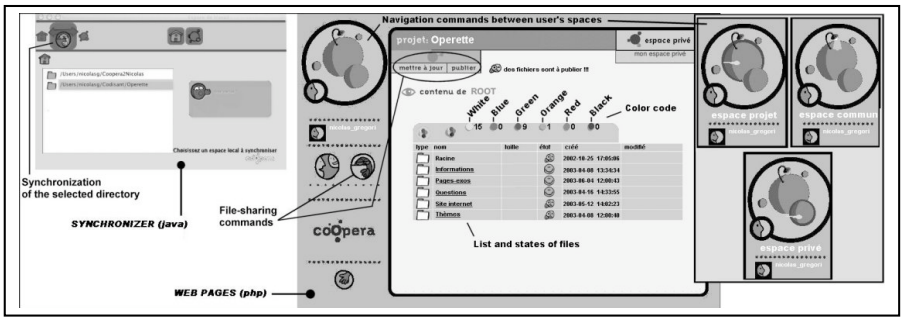

Figure 3. Coopera 1. Navigation can be done from feature to feature and colors are used to denote change. Only the subset of commands useful in the current context is displayed. Only one private and local space is allowed per user. The planet/satellite metaphor was introduced in order to enhance ther visual presentation of spaces. But this metaphor did not suffice. The particularization of the synchronizer remained a problem. Also, refreshing web pages in order to view modifications was difficult to manage for children.

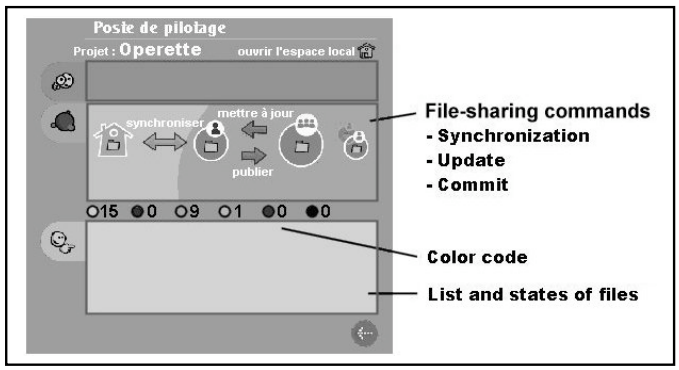

Figure 4. Coopera 2. On the same page, the cockpit (a Java rich client) shows the different levels of workspaces, handles a visual transfer of files between spaces, and provides real time awareness of space changes.

Thus, the evolution was not just ergonomic, an aspect which was also studied of course. But the redesign of the two environments (web pages and synchronizer) into only one was the fundamental step for Coopera 2. The concept of cooperation is now salient in the interface. It is expressed via the appearance of the principle of cooperation. Indeed, the file-sharing model is present and is used as a support for action, in two ways. First, its state changes according to the actions to be carried out. For example, if I must update my private space, the "update" arrow ("mettre à jour" on Figure 4) is active, informing me of the need to perform this action. Secondly, this representation makes it possible to carry out actions. If I want to update my private space, I click on the "update" arrow.

Now we will discuss the three factors in greater detail using a conversational sequence. In addition to the ergonomic and cultural aspects just mentioned, we will present some preliminary ideas on the teaching scenario, which does not appear directly in the interface.

4.2. A Sequence Analysis: Color Code Interpretation Difficulties

We now present a work sequence carried out by pupils. This will allow us to point out important parts of the cooperation dynamic, including how the state of the cooperative activity was perceived and how a situation was understood[3].

The excerpt studied here is part of the third work session out of seven on the Coopera 1 version. During this step, two girls were working together to answer a question sent by another pair from another school. Eleven minutes after starting to use the platform, the pair (J and S), supported by a teacher (T), opened a page showing their private space. J said (01) "You always have to look at the color circles there". The children started reading the color code. The main events are related to two errors they made at this time.

Figure 5 shows that the excerpt can be divided into two main times, that is two errors made by the children: a misidentification of the spaces and an action erroneously anticipated. From these two sequences, we will see that the children have a correct understanding of the file-sharing model (the names of the spaces, how files move from space to space, operations to move files). They also understood the principles of the color code (circles are related to a space, the number refers to the number of files in the space and provides an overall view of the project).

Misidentification of a space — After T's question about *"what are the color circles saying"*, S (03) answered interpretating the meaning of the blue circle : *"We have nine in blue"*. In other words, there was nine things in the corresponding space, named the common space (J 05a). Here really started the misidentification of the spaces since J, pointing to orange circle with mouse (07), said *"One in our space"*.

A process of stabilization is now going ahead, following T's intervention about the meaning of the green circle (13). This question breaks with the representations expressed by the children about the meaning of the circles. Knowing that the green circle is associated with the private space of J and S, the children now deduce that the orange circle represents the private space of their partners. That's what is done in J 20a. So T's initial question (T 2) is now satisfied, i.e. the children are now able to say *"what are the color circles saying"*. We have represented this question/answer pair with E1 (Figure 5).

An action erroneously anticipated — What does the green circle mean is now stabilized. But the two girls are now going to make a second error answering to T who questions the meaning of the number associated to the green circle (23b). The action associated to this circle is to commit but not to synchronize as J said (24). Our hypothesis is that J's error is not really due to a misunderstanding of the action to be realized but is due to a misunderstanding of the situation itself. More precisely, J's error is that she believes that the files in her private space are coming from her partners. When J evokes the case in which she would get a document from others (30b), she confirms our hypothesis because this highlights the fact that she has well understood the file-sharing model. This utterance is important because between T 26 and J 30a, J has just answered to T's questions. But in 30b, she has really expressed that she well understood how the cooperation platform is functioning.

For the first time, the situation expressed by the green circle and the number associated to it has been explicitly argued. And it is because this situation was implicit till now that the two girls and T misunderstood each other.

Viewing the file-sharing model in order to facilitate the cooperation — The children have made two main errors in this sequence. The anlaysis of the sequence made it possible to state that the file-sharing model did not pose difficulty for young children but that they misunderstood the situation in which they were and, consequently, that they were unable to anticipate what to do.

The children's first error regarding the state of the cooperative activity was not the result of a lack of knowledge, but of difficulty

3. For reasons of language comprehension, we have chosen to translate the sequence in English, even if this process poses some problems.

relating that knowledge to the properties of the color code. This difficulty expresses an ergonomic deficiency in the way the cooperative dynamic could be visualized, which was too abstract. The cognitive work required was too great for 5th grade children. A better view of the file-sharing model, one combining spaces and states, would certainly facilitate this understanding.

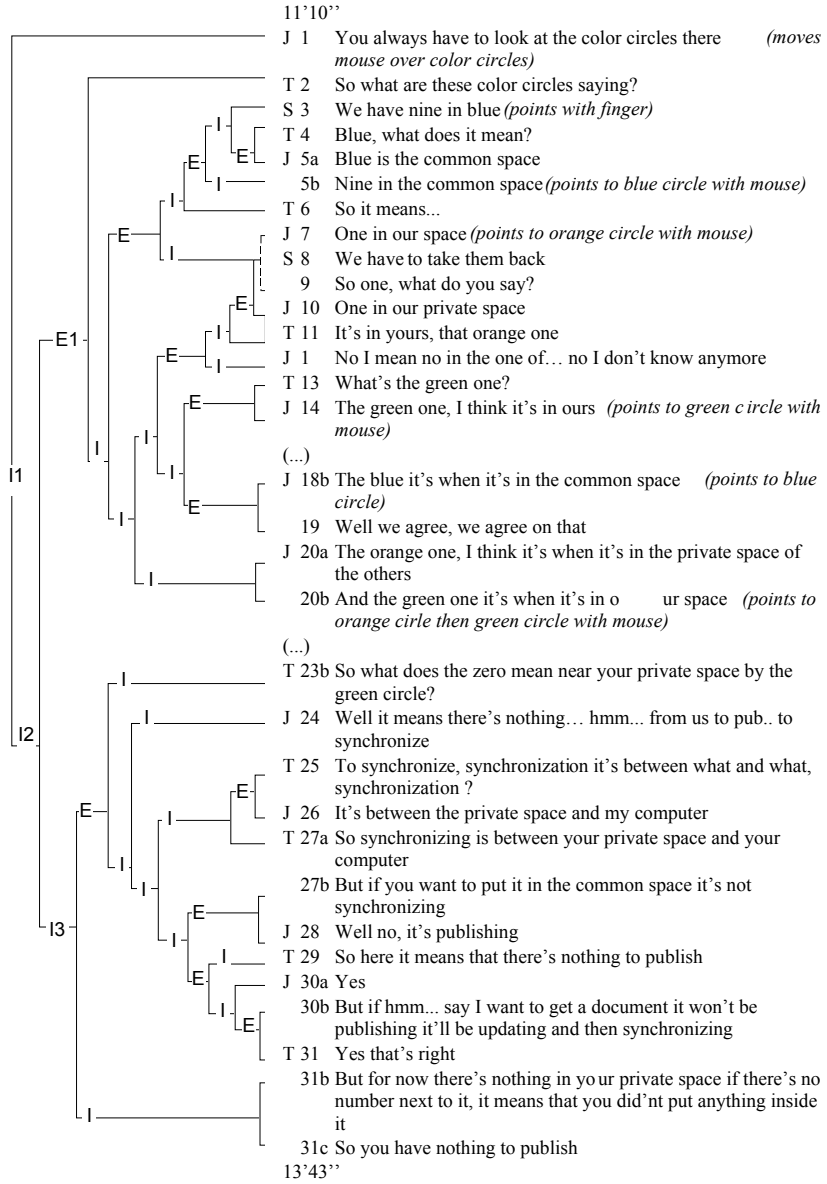

Figure 5. Functional and hierarchical aspects of the conversational sequence.

The children's second error regarding the state expressed by the green circle and the number, raises the question of the model of relationship with others and the self-appropriation induced by the system involving the different colors and files

represented. Ergonomics is very important in the appropriation process and thus in understanding the state of the cooperative activity. Here again, vizualisation of the file-sharing model was very important. This is what was achieved in Coopera 2 (Figure 4).

4.3. Usability Factors

4.3.1. Micro- and Macro-Levels Analysis

Let us present the three factors of usability. The excerpt presented here points out some ergonomic difficulties that must be taken into account. The analysis of the conversation made it possible to understand the emergent meanings and to made ergonomic recommendations. But difficulty anticipating future actions is not just an ergonomic problem. It also depends on the teaching scenario (it is necessary to motivate and engage the children in a cooperative activity) and on cultural aspects (it is necessary to know what "to cooperate" means, to have an idea of "who I am" and of "who the partner is" in the cooperative system). In other words, we were working at both the micro- and the macro-level.

At the micro-level, we were interested in the ease and difficulty of use. Bastien and Scapin's criteria (Bastien & Scapin, 1993) are used to interpretate the ergonomic value of the various versions of the platform. In the excerpt (Coopera 1), the criteria for failure were meaning, incentive, and density of information (Figure 7).

Thus, the micro-analyses allowed us to work on both the ergonomic and cultural factors. J's second error was both ergonomic and cultural: J focused on the use of the platform but not really on cooperation with others. In contrast, the teaching scenario was analyzed at a macro-level. It was conducted via discussions with the children and their teachers. Let us note, however, that this scenario was strongly related to the other two factors. Indeed, the utility of a platform depends on the scenario, which determines how much it will be used. In other words, even if the ergonomics is correct and the cultural framework is good, the platform will not be useful unless the teaching scenario provide the incentive to cooperate. These three factors are interdependent. They are presented below.

4.3.2. Ergonomics

The ergonomic facet of an interface is fundamental. Interfaces are the bases upon which users will build the meanings needed to manage their cooperative activity. One of our main objectives was to allow the children to grasp the dynamics of cooperation. This had to require little cognitive effort when children looked at the interface icons. In the first two experiments, the pupils have trouble interpreting the icons and understanding the situations they encountered. Then difficulties arose primarily from ergonomic problems with the first two versions, ToxicFarm and Coopera 1 (Figures 1-3). Neither of these versions provided a concrete view of the file-sharing model. The only visual artefact that showed the cooperative activities was the color code. It was too abstract and required a lot of cognitive effort to be interpreted. This was further complicated by the complex architecture of the pages and by an organization of icons that was not very explicit, although this point had been improved in Coopera 1. However, the user-friendliness of Coopera 1 was worse than that of ToxicFarm. A planet metaphor was used for navigation, but it did not help in understanding the cooperative activity. This confused the users. They were not the ones moving from space to space since the moving objects were files.

The modifications made to ToxicFarm to produce Coopera 1 were mostly translations and changes in the interface so that it would appear more attractive to children. Coopera 2 was the result of deeper changes in the interfaces. Homogeneity was enhanced. The new view of the cooperative activity was much more meaningful for children, and the use of the system was greatly simplified: all commands appeared on the same interface, in a rich Java client that had only been used for synchronization in the previous systems.

4.3.3. Cultural Aspects

The cooperation dynamics cannot be

separated from the emergence of group awareness, which results mainly from the ability of actors to think about the place, the role, and the activities of all members of the project. More precisely, group awareness is characterized by the ability to discern intentions and expectations of others' actions toward oneself, and by intentional behaviors toward others. Putting children in this relational dynamic situation requires translating the system properties into signs. This translation was expressed when the children read the interface icons. They not only had to understand their primary meanings (common space for blue) but also had to relate them to their meanings in the cooperation dynamics. When they converted properties into signs, the users were not interacting with the system but with other users through the system.

This translation process was a problem for Coopera. It was observed during the first experiment with ToxicFarm, which led us to set up animations. The purpose of the animations was to allow the children to appropriate the relationship to themselves and to others through Coopera, and to grasp the file-sharing model that supported this relational model. The animations took place in the classroom with all of the children. The concepts in the system were imitated with real physical objects such as tables (representing spaces) or sheets of paper (representing documents), which the children could manipulate during the animation. This setup (inspired from the Vytgoskian theories) was chosen based on the fact that concept acquisition depends on how the concept is experienced. This experience must not be only cognitive, but also physical and emotional.

4.3.4. Teaching Scenario

The teaching scenario is an important part of tool usability. The task to be accomplished has an impact on the motivation and satisfaction of users when they work on the system. This in turn has an impact on system appropriation. Other important aspects of teaching scenario are the time frame of the project and the level of cooperation induced by the scenario, which has an impact on the relationship between the users. This in turn affects the relational dynamic acculturation carried by the groupware system.

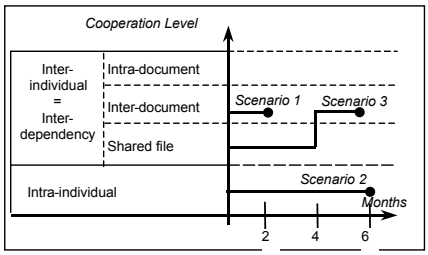

Figure 6. Cooperation level of the teaching scenarios.

Regarding this last point, we defined several models that could be set up in the system, each with a different level of cooperation (Figure 6). In the first model, called intra-individual, each user work alone and there is no cooperation between users. The second model, called inter-individual/shared file, is the first level of cooperation. Users are grouped into teams that share the same file but there is no production dependency. The third model is called inter-individual/inter-document. It is the second level of cooperation. Users are grouped into teams that share the same file, and there is a production dependency. The last level is called inter-individual/intra-document. In this highest level of cooperation, users in a class are grouped into teams. They share the same file and produce the same document.

The scenario of the third project (Coopera 2) was the most appropriate for cooperation among 5th grade children. They had had enough time to get accustomed to the system and to do their job. They were interested in the goal of the project and were motivated to cooperate. Specific constraints related to the way the classes were organized had to be taken into account. The first one was the frequency of use. The children used the platform only once a week. The highest degree of cooperation that could be set up was the creation of the interdependency between the productions of groups on the same team. The second constraint was that all children had to use the system within a given time. Interdependency between productions could only be set up as a second step.

5. Discussion

The main difficulties faced by children were related to the execution of the cooperation dynamics. They did not perceive the others' intentions intuitively. Moreover, they did not generate intentional activities toward the others. These difficulties resulted mostly from the historical-cultural factor. The cooperation scheme proposed by the platform broke away from their general knowledge of group work. It is not common, at least not in France, to work on the same files as others and to allow others to work on a personal production. Even with the classroom animations, the children needed several sessions of working with the system to learn this relational mode. Indeed, they had to start working with the fundamental functions of the platform before intentional behavior emerged and group awareness was achieved. These functions were synchronize, publish (commit), and update.

At this level, ergonomics is important. It is fundamental that the pupils be able to use these functions with a minimal cognitive load. Besides, the teacher's role was crucial in the generation of group awareness. During the sequences, the teacher was the one to explain to the children the intentional behaviors they had to perceive and adopt. He would allow them to internalize these intentions. Regarding this point, the pedagogical merits of the platform are not limited to the support provided to produce a common result. It forced the children to be less centered on themselves and to think reflexively about their place and their actions in the course of a cooperative project. Thus, group awareness was not a *sine qua non* condition to use the platform. It was a goal to reach through its use. The platform allowed the children to get accustomed to the functions needed to set up a cooperative dynamic and to explain to them the relational mode supported by the system. They also helped to prepare teachers for their role in the children's appropriation of this relational mode and thus of cooperative behavior.

Furthermore, we observed a break between the mode of cooperation supported by the platform and the effective cooperation of the pupils. Then we state that the implementation of the dynamics of conversation does not rest solely on the technical and ergonomic properties of the computer environment, but on the whole instrumental device set up.

Three devices can be highlighted that composed this instrumental device (Figure 7). The first is the "teaching-scenario device". It is obvioulsy composed of the teaching scenario, which has been co-elaborated with the teachers, but also of the instruments used to introduce it to the pupils. The second is the "computer device". It concerns the cooperation platform and the softwares used by the users during their activities. The third is the "device of animation", composed of two animations in the Coopera project. One is mainly concerned with the file-sharing model, the other is mainly centered on the appropriation of the mode of cooperation. This computer device also includes the instruments used for these animations.

In fact, it is the articulation between these three devices which is fundamental, more than the devices themselves. This is why our proposal is to extend the concept of usability to the instrumental device as a whole, i.e. the three devices and their relationships, so that the efficiency of the cooperation depends on the variables that link the three devices.

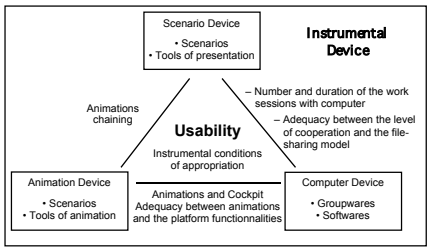

Figure 7. Articulation between the three devices that compose the intrumental device.

Two variables are resulting from the relationship between the teaching scenario device and the computer device. The first concerns the number and the duration of the sessions of work with computer and the second concerns the relevance of the mode of cooperation. Concerning this last point, the point is to define the relationship between the level of cooperation of the teaching scenario (see Figure 6) and the file-

sharing model. Thus, the relevance of the mode of cooperation will be high if the pupils are strongly committed to cooperate.

The variable resulting from the relationship between the animation device and the computer device is related to the good adequacy between the form and the contents of animations on the one hand, and between the form and the functionalities of the cockpit on the other. This relationship is very important since it allows the users to convert the properties of the cockpit into signs. In other words, the good adequacy between the animations and the properties of the cockpit allow the mobilization of the acquired knowledge during the animations, when the cockpit is used by the pupils.

Lastly, the variable resulting from the relationship between the teaching scenario device and the animation device is related to the sequence of animations in the scenario. According to the Vygotskian theories, any cognitive function must be handled, in a certain way, to be acquired. Then we can state that the animation relating to the file-sharing model must take place before the animation relating to the mode of cooperation.

When considered separately, each variable did not make it possible the appropriation of the mode of cooperation by the pupils, nor the file-sharing model which supports it. The adequacy between the animations and the features of the cockpit is essential to support the conversion of the properties of this cockpit into signs. This conversion is what we call appropriation, and we highlighted it with our dialogical analysis of interactions, based on contructivist theories. This led us to program the animations during which the pupils have internalized two kind of knowledge, first the properties and the functionalities of the file-sharing model, and second the mode of cooperation. Co-intentionality depends on this knowledge.

6. Conclusion

In this paper, we have analyzed a conversational sequence that occurred during a work session with a cooperation platform for children under design. We have shown that the children knew how to use the platform. They knew how to execute the commands. They were able to participate in a group activity. However, they still had difficulty relating their actions to the file-sharing model. The methodology we used, based on a dialogical approach of analysis of conversations, helped us to identify these problems for three main reasons. First, the observation and analysis setup was centered on a real situated activity of children. Second, they were encouraged to talk and could therefore express their feelings. Third, we allowed them to physically experiment with the concepts of the platform during preliminary animations. These points showed us that to analyze a cooperative situation, we cannot limit ourselves to the ergonomic point of view. Ergonomics, culture and scenario are intricately connected. The cooperative activity can only be understood is only possible if these three factors and their relationships are considered simultaneously.

In some ways, our work pertains to appropriation (Dourish, 2003), firstly, because we took an interest in how the structure of the technology supported the cooperation between the children, secondly because our methodology allowed us to analyze the social and cultural aspects of the platform and to understand their consequences for its technical design. Of course, this methodology is costly and time consuming, and it requires lengthy analysis. It is not the most reactive method and we will have to convince industrial partners that time is not the enemy. But, combined with a flexible software development methodology, the gain certainly meets expectations. So we used a dialogical analysis of conversations in order to evaluate the computer environment under design and, then, in order to make some recommendations for the development of this computer environment.

Finally, we are aware that our proposal requires more work and that further efforts are still needed to model the relationships between the three highlighted factors. However, we hope to have convinced the reader that our proposal for usage analysis is a relevant one. In future studies, we plan to (i) propose formalized criteria for the evaluation of such plaforms, (ii) contribute to the development of those platforms based

on such evaluations, and (iii) promote the situated-action paradigm for use analysis. It seems difficult to simultaneously explore the three dimensions presentes within a single experimental framework, but actual use in a real situation must be observed if we want to contribute to develop the usable and acceptable tools.

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References

Bastien C, Scapin D (1993) *Ergonomic Criteria for the Evaluation of Human-Computer interfaces*. Institut National de recherche en informatique et en automatique. Paris, France.

Brassac Ch, Grégori N (2001) Situated and Distributed Design of a Computer Teaching Device, *International Journal of Design Sciences and Technology*. **8/2**, 11-31.

Crabtree A (1998) Ethnography in Participatory Design. *Proceedings of the Participatory Design Conference* (93-105). Seattle, WA, 12-14 November.

Dourish P (2003) The Appropriation of Interactive Technologies: Some Lessons from Placeless Documents. *Computer Supported Cooperative Work*, **12**, 465-490.

Dourish P (1995) Parting of the Ways: Divergence, Data Management and Collaborative Work. *ECSCW'95*.

Dourish P, Bellotti V (1992). Awareness and Coordination in Shared Workspaces. *CSCW'92*.

Feiler PH, Downey GF (1990) Transaction-Oriented Configuration Management: A Case Study. *CMU/SEI-90-TR-23 ESD-90/TR-224*.

Godart C, Rabhi F, Oster G, Skaf-Molli H, Perrin O, Molli P, Ray P (2004) The ToxicFarm Integrated Cooperation Framework for Virtual Teams. *Distributed and Parallel Databases*, **15/1**, 67-88.

Gutwin C, Roseman M, Greenberg S (1996) A Usability Study of Awareness Widgets in a Shared Workspace Groupware System. *CSCW'96*.

Hutchins E (1995) *Cognition in the Wild*. Cambridge: MIT Press.

Kaptelinin V, Nardi B (2003) Post-Cognitivist HCI: Second Wave Theories (Panel report) – *CHI 2003*. Ft. Lauderdale, Florida, April 5-10.

Kuuti K, Bannon LJ (1993) Searching For Unity Among Diversity: Exploring The "Interface" Concept. *Proceedings of INTERCHI'93*, pp. 263-268, April 24-29.

Levinson S (1983) *Pragmatics*. Cambridge: Cambridge University Press.

Nardi B, Gilbert N, Mantei M, McCarthy J (1993) Mixing oil and water? Ethnography versus Experimental Psychology in the study of computer-mediated communication. *Proceedings of INTERCHI'93*, pp. 3-6, April 24-29.

Searle JR, Vanderveken D (1985) *Foundations of Illocutionary Logic*. Cambridge: Cambridge University Press.

Suchman L (1987) *Plans and Situated Actions. The Problem of Man-Machine Cooperation*. Cambridge: Cambridge University Press.

Trognon A, Brassac C (1995) Formalizing the Theory of Intentionality. *Journal of Pragmatics*, *23*, 555-562.

Vanderveken D (1990) On the Unification of Speech-Acts Theory and Formal Semantics. In P Cohen, M Pollack, J Morgan (Eds), *Intentions in Communication*. Cambridge: MIT Press.

Vinck D, Jeantet A (1995) Mediating and Commissioning Objects in the Sociotechnical Process of Product Design: A Conceptual Approach. In D MacLean, P Saviotti, D Vinck (Eds), *Management and New Technology: Design, Networks and Strategies* (pp. 111-129). Bruxelles: COST Social Sciences Serie.

Vytgosky LS (1978) *Mind in Society: The Development of Higher Psychological Processes*. Cambridge: Harvard University Press.