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SITUATED AND DISTRIBUTED DESIGN OF A COMPUTER TEACHING DEVICE

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ABSTRACT. Based on an approach that incorporates the fundamentally situated and distributed dimensions into the design of a computer teaching device, we propose to reflect upon the concurrent organization of this activity. An analysis of the conversational interaction, whose basic flow is outlined here, brought out several points. Firstly, it became clear that, right from the beginning of the design process, a high priority must be placed on arranging situations where all concerned actors are present and can work together on the product being designed. Another essential point is the status of the "designer" and how it relates to that of the user, whose presence very early in the design process seems crucial. Finally, the critical role of the artifacts produced and manipulated in this dynamic design process must not be overlooked. Our claim that there is a dire need for "concurrent engineering" is more far-reaching than might appear at first sight. We show this to be true by means of a fine-grained analysis that enabled us to account for the sequence of actions carried out by a group of designers, from the dual standpoint of the language they used and the intermediary objects they manipulated, and to shed some light on how designers actually work. In our minds, saying that product design is part of the general paradigm of situated and distributed cognition means acknowledging that the design process takes place along three dimensions: cognitive, social, and instrumental.

Keywords: distributed and situated design, conversational analysis, intermediary objects, computer teaching device, concurrent engineering, user.

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INTRODUCTION

Just like the processes used to make manufactured products, the research and design methods applied to the development of computer tools are undergoing extensive change with the large-scale movement to integrate the

collective production of new ideas into today's engineering (Champy-Remoussenard, & Grégori, 1998; Grégori *et al.*, 1998*a*). This implies that the design of all kinds of software (Spérandio, 1993; Coutaz, 1995), including systems to be used as teaching aids (Linard, 1996; Rouet & Tricot, 1998), cannot escape the so-called "concurrent engineering" trend (Bocquet, 1998; Bossard, 1997; Brissaud & Garro, 1998; Darses, 1997; Darses & Falzon, 1996). The development of educational softwares, and more generally of any computerized learning device, falls into this movement, which, in our minds, is a very positive one, not only because of the quality of the final products generated but also due to the fact that it encourages the designers of such tools to think more deeply about the nature of their task as "inventors".

In this article, we shall attempt to demonstrate the "capital gains" afforded by setting up situations where the designing actors are co-present. In addition, we shall show how bringing the user into the picture very early on produces radical changes in the dynamics of the software development process.

We rely on a method that allows us to look closely at how different participants act in such a design situation, and to conduct a fine-grained analysis of the sequence of actions they actually carry out (Brassac, 1992; Ghiglione & Trognon, 1993; Trognon & Brassac, 1992). The framework of the design process is created by the universe of possibilities that are opened up by the ideas, avenues, and solutions this sequence of actions generates throughout the process. We shall approach this collaborative process by regarding it as the locus of cognitive phenomena called "distributed" (Hutchins, 1995) and "situated" (Conein & Jacopin, 1994; Suchman, 1987).

The first of these two adjectives, "distributed", refers to the fact that the actors are jointly responsible for the series of decisions that make up the process; the second, "situated", refers to the fact that the sequence of events relies on the manipulation, by those actors, of the objects of the world. In other words, the schemes and acts of the interacting agents – viewed through the dual angle of their "discourse" and their "manipulation of the physical world" – will predicate our analysis of the cognitive interaction that takes place in the multimedia teaching-device design situation we shall study here.

The first step will be to present our theoretical position as interaction psychologists, and the methodological techniques we use to study this type of cognitive activity in subjects. The second step will be to describe both our role in the execution of a contract funded by Anvar[1] for the design of a computerized educational tool, and the exact situation in which the data was collected. In direct reference to the data, we shall then analyze the conversational sequence that enabled the actors to arrive at a "solution". In doing so, we shall see how the group's behavior casts doubt on the sequential approach to the design process. This will lead us to point out the merits of true collaboration between two "designers" and a potential user, at a point in the process where the product is still in an unfinished state. In conclusion, we shall advocate extensive reliance upon this type of intersubjective process, in conjunction with the use of a fine-grained method for analyzing the decision-

1. French National Agency for the Enhancement of Research.

making moments that account for the situated and distributed facets of the dynamics of design.

I. THEORETICAL FRAMEWORK AND METHODOLOGY OF THE STUDY

As stated above, the present study was conducted in a concurrent engineering framework. This approach can -- and should in our opinion – be used in the design of any product or production system. More specifically, compiling and incorporating expertise at such and such a time or place in the course of the design process requires reconsidering the dynamics of the exchange between the various actors. The present investigation focuses on these times and places, where crucial steps are taken in the design process.

We shall play the role of social psychologists analyzing cognitive processes. For us, the situations studied are ones that necessarily involve the co-presence of actors whose interactions are mediated by both the use of language and the manipulation of objects. As such, our privileged port of entry into the concrete aspects of these exchanges is "interlocution". Our method of analysis revolves around the chain of conversation, and strives to account for the manipulation of objects, both those initially present and those that appear in the course of the work session. In presenting the method, we shall begin by studying the conversational exchange, and then go on to discuss the manipulation of artifacts.

1. Distributed design and interlocutionary logic

Our angle of approach is based on analysis of conversations. 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, 1988). 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 (for more details, see for example Brassac, 1994), 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 is the basis of interlocutionary logic, described in detail in Trognon and Brassac (1992) and in Ghiglione and Trognon (1993). The 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 (Brassac & Stewart, 1996). 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, submerged in a potential, subtly indeterminate meaning, jointly mould the still-transient, still-negotiable meaning in a process-driven way. This is the view of conversational exchange that will be used in our analyses. But let us first look at the second facet of the sequence of actions produced by the conversers: the manipulation of objects.

2. Situated design and intermediary objects

Bringing 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 design situation, if not elsewhere, has become very obvious to us in the many corpus analyses we have conducted (Brassac *et al.*, 1997;

Grégori, 1999; Grégori *et al.*, 1998*b*). It has forced us to recognize the merits of including object manipulation in our theoretical account.

The "coupling" between cognitive entities and the physical world is highly crucial to the paradigm that micro-sociologists with an ethnomethodological allegiance call "situated" cognition. This coupling refers to the relationship between cognitions and techniques (Havelange *et al.*, 1999), i.e., it grants a special role in human cognitive phenomena to the tool, the device, the object. This line of thinking was behind the work done at that CRISTO laboratory (inspired by Latour's theories), which led to the concept of "intermediary object" (Jeantet *et al.*, 1996; Jeantet & Vinck, 1995). Without going into detail about the arguments used to demonstrate the importance of intermediary objects in design-related industrial devices – on this point, see the excellent article by Jeantet (1998) – let us talk briefly about the usefulness of this notion to us here, and about the different meanings we propose for the adjective "intermediary" in the situations we stage.

Clearly, in a discussion between actors, different types of objects can enter into the picture. In studying the phenomena that take place during collaboration over a tool to be developed, it became apparent to us that certain objects play a critical role in the decision-making process. Some examples we found were the materialization of a decision by a given symbol written on a diagram, or the notation of a certain dimension on an industrial drawing, or yet again, the opening of such and such a window on the screen to indicate a possible pathway for development. We have already discussed this issue at various times, and in regards to various design situations. In one case, the sequencing of various drawings and mock-ups was shown to play a critical role in designing an apparatus for positioning and holding wooden plates on a machine-tool (Grégori, 1999; Grégori *et al.*, 1998*b*). More specifically, a chart drawn by one of the participants became an object that materialized a decisive moment in the design process, by virtue of the fact that it brought together several kinds of potential technological solutions, at the same time as it served as a support for deciding which of the different solutions should be used. In another study on the distributed writing of a user's manual (Grosjean & Brassac, 1998), the mere drawing of a line depicting a separation into two distinct parts was the mark of an irreversible decision. In drawing this line, the writer enacted his interpretation of the user's wish, making it plain to the others that the manual would consist of two parts, even though the discussion had been leaning towards a two-volume solution. Another example was found in a study where a dimensioning standard for the collaborative work of some industrial draftsmen was set and materialized by a simple number marked on a layout (Brassac, 1999). In all of these cases, the use of the paper-and-pencil object did not show up in the actors' discourse; the object served as an effective intermediary between them, and was used to actualize an enacted decision that could not have been detected by looking at the interlocutionary sequence alone.

In the present article, we are going to analyze another such example (a window opened on a screen). Some parts of this example have already been presented in Brassac & Grégori (1998), Champy-Remoussenard & Grégori (1998), and Grégori *et al.* (1998*a*). Our analysis will show how this manipulated object acquired an intermediation function at three levels, by

simultaneously acting as an intermediary between the subject and the world (thereby anchoring the cognitive process in the physical environment – the situated facet), as an intermediary between the actors (thereby enabling the joint construction of a cognition for which they were co-responsible – the distributed facet), and as an intermediary between the time-before and the time-after the decision. Let us first present our working framework, and then go into greater detail about the situation we proposed to the designing actors.

II. DESIGNING COMPUTER TEACHING DEVICES: AN EXAMPLE

1. Objective

The design project under study here was financed by Anvar. The involved parties were two universities (an engineering school and a school of humanities)[1] and a small company in Nancy, France. The goal was to provide teachers with a computerized tool for generating computer teaching aids on a specific subject matter. It had been decided that the subject matter of the prototype to be designed would be "Automated System Maintenance", so the education research team first created a series of pages on this subject and put them in a local database. The various pages included text, pictures, animated drawings, and exercises. Rather than develop a totally new interface, the multimedia technicians decided to start from Microsoft Word 97, now widespread.

2. Developing the prototype

The "prototype" was a tool that users (teachers, instructors) could employ to generate a computer device for learning about automated system maintenance. It could either bring up pages from the local database or download information off the internet. The idea was to have the teacher load all the necessary documents, and then organize them as desired to prepare a lesson (including a theoretical part and exercises) about a topic chosen from among several possibilities (troubleshooting, how a piston works, the role of a distributor, etc.). When completed, the teacher could propose the lesson to learners via an intranet. In other words, the tool could be used to build as many computerized lessons as desired, in accordance with the teacher's goals.

Figure 1 shows the user interface of the prototype as we imagined it before the beginning of the work session presented below. Three buttons, WEB,

1. The CRAN (*Centre de recherche en automatique de Nancy*), headed by professor Gérard Morel, was in charge of data links and multimedia formatting. The "teaching" team in the project consisted of a group of researchers in the education sciences, headed by Patricia Remoussenard; to whom we would like to express our gratitude for having made this project possible, and a group of researchers in the psychology of interaction, headed by Christian Brassac.

LINKS, and PAGES (in French: *WEB, LIENS, PAGES*), appear in the tool bar. The LINKS and PAGES menus give the user two possibilities for accessing the contents of the local database. In the first case, the instructor wants to incorporate pages (PAGES button) or parts of pages. In the example in Figure 1, under the French heading *"Maintenance des systèmes automatisés"* (maintenance of automated systems), the instructor has inserted a curve taken from a page in the local database. In the second case, the user can establish hypertext links that connect his/her lesson to the chosen database page. This could be useful, for example, if the teacher thinks the learner might want to know about a concept that is not a fundamental part of what has to be learned. In this case, he can leave it up to the learner whether or not to read this linked page. Two points need to be made clear here: (1) the LINKS and PAGES menus have the same contents, and (2) this is the interface of a tool to be used by instructors to build computer lessons; learners will obviously not have access to these three menus when they are running the lesson.

When the education research team suggested having a potential user (a teacher) try out the prototype, it was still in an intermediate state. Let us stress again that it had incomplete parts (such as links to internet search engines, which were not yet functional), and that the database was only partially linked up to the prototype (only a few pages were available).

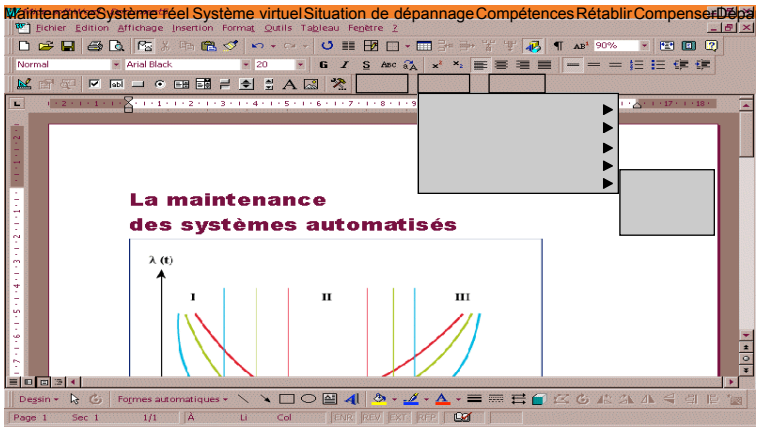


Figure 1. Prototype interface.

3. Staging a situation with the prototype

For the first series of work sessions, a potential user, that is a teacher, for the topic in question was asked to work on the prototype, in the presence of the product developer, and one of the authors, as observer, who had helped prepare the teaching materials in the local database. The developer and the user were facing the computer; the observer was behind them. The developer began by instructing the user to operate the prototype for the purposes of defining his

needs if he were creating a computerized lesson. The goal was both to make the potential user discover the prototype's capabilities, and to find out what was lacking in the database. The session lasted about an hour and a half. It was videotaped using one camera aimed at the participants and another aimed directly at the screen.

III. THE USER AS A DESIGNER

Now let us see what happened during the session. Our analysis will be presented in two steps, an overall analysis, followed by a closer look at the conversation itself. However, in an attempt to be as precise as possible without getting too technical, we shall try to highlight the critical moments in the session and avoid excessive detail.

1. Overall analysis of the corpus

For the session as a whole, the most notable observation was that the session revolved almost entirely around the "evaluation" of the prototype. Although the technical quality of the prototype was rapidly validated by the user, its usability turned out to be poor, and this became the center of all of the discussions. In the end, to express the problem that came up, the actors used the "Insert Object - Create from File" capability of Microsoft Word in illustration. From there, they went on to find a solution. This is why we have put quotes around the word "evaluation", because at a more fundamental level, the actors were not just evaluating, they were also designing.

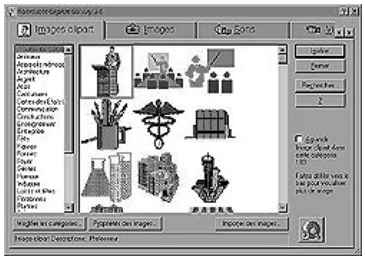
To isolate the elements of the object under analysis here, and also the sequences that marked off the pathway leading up to that object, we employed the documentary interpretation method used in ethnomethodology (Garfinkel, 1967). Application of this method yielded four main sequences that ended in a sort of "solution in principle", defined by an object and agreed upon by all designers. The problem detection process was facilitated by the fact that, as we shall see, the actors' agreement about the solution was explicitly stated. The interlocutionary analysis showed that the goal being pursued was the prototype's fulfillment of a usability criterion and determination of what that involved. After about an hour of discussion, the user made the following statement: *"Well, me, in fact, I'm convinced, this is it"*, thereby declaring that the proposed prototype was now satisfactory in his eyes, not only from the technical standpoint, but also in terms of its usability, what he could do with it, the significance he could give it, i.e., what we shall refer to as its "usage". The pathway to this solution is what we hope to demonstrate here.

Table 1 divides the work session dialogue into the four main sequences, separated in the table by horizontal lines (01-06, 07-13, 14-27, 28-42), followed by the user's final declaration of approval (43).

Table 1. The four main sequences in the work session.

Time	Conversational exchanges[1]		
00'30"	*dev*	01	So in the prototype here, the goal is to // that someone can create a lesson (...) So I'll show you how you use it
01'32"	*usr*	02	Yes okay
	dev	03	Then after that, you can try it (.), knowing that right now in the database, everything's not in there (...), it has to be filled up
	usr	04	Yes yes okay
	dev	05	And so, we, what we propose today, is that as you work with it we try to build a lesson together (.) We're going to fill up the database (...)
05'55"	(...)		
13'20"	*dev*	06	So to start a lesson you open Word (...)
	dev	07	Here's how it works (3s) It's not very complicated I think
	usr	08	(smiles)
	dev	09	Do you find it complicated?
	usr	10	<u>But</u>, for a teacher no, but for a (2s) for a student uh
	dev	11	Ah no a student doesn't do that (.) that's for the teacher who's creating the lesson (...)
	(...)		
15'06"	*usr*	12	Okay
	dev	13	So what you also need (...)
27'55"	*usr*	14	Uh-huh (3s) good okay (3s) this isn't going to be easy huh
	(...)		
	dev	15	What would you have called easier?
	usr	16	(...) The problem is that, in there, we don't know what's in there (...) You, you know what's in there (...) but here, for now, nobody but you uh knows what's in there (.) there's <u>no</u>
29'06"	*dev*	17	Ah, yes (...) I see what you mean (...) So it should also be set up here so that when you choose a link (...) so that before you select you can say, I want to see what it is
	usr	18	That's right
	dev	19	And that, <u>well</u>, I didn't do that//
	usr	20	//No but you can see, well, that's what's important, otherwise it's unusable
	(...)		
30'00'	*dev*	21	On the other hand suppose (...) the database were full and there were 50 things in there (...) Can you imagine the teacher (...) going in there to see each item?
	usr	22	Well wait a minute now! When I look in an encyclopedia (...) you know what I do?
	dev	23	You search all around

1. The following coding conventions were used: *usr* stands for the user, *dev* for the developer, and *obs* for the observer from the education research team. Brackets ([...]) indicate a cut (passages of dialogue not given here); a double slash (//) means interruption of another person's remark; a single slash (/) means an unfinished remark by the speaker; a number in parentheses (9s) indicates a pause in seconds; a period in parentheses (.) stands for a very brief pause; and an underlined <u>word</u> indicates vowel lengthening.

	usr	24	Yes obviously, so you have to search but you search in things that, well here, that means nothing at all to me (.) So you've got to have it
	dev	25	Yes
	(...)		
	usr	26	And that, for me, I (.) I'm not going to breeze through it. It's impossible to use it as is
	dev	27	I agree (.) (...)
52'54"	*obs*	28	You could have a preview here too (...)
	dev	29	Yes! So yes yes yes yes. That means here uh by clicking somewhere (...) say here, uh yes, here I have a list, I say I want to see that, so you click right maybe or, I don't know, or I add a function and there we go, it gives us, it gives us the contents. Okay
	(...)		
	usr	30	Besides in Power Point, well uh or that type of thing (.), well you know the
	dev	31	Preview
	usr	32	Ah yes
	dev	33	Yes yes, it's a little like that here when you do In/ when you do Insert Picture uh Create from file, uh-huh, it's/ actually, a thing like that would even be good you know
	obs	34	Yes
	usr	35	Yes, there, that's it
53'43"	*dev*	36	That! now that, that would be ideal
	(...)		
			
			Figure 2. Insert Object dialog box in Microsoft Word.
	usr	37	That's what's missing um
	dev	38	That's what's missing!
	usr	39	Right now, in this tool
	dev	40	There
	usr	41	It's obvious
55'42'	*dev*	42	There
59'41'	*usr*	43	In fact, I'm convinced, this is it.

2. Conversational analysis

First sequence: Description of the work schedule by the developer. We found four sequences leading to final "approval" by the user. The first sequence (speaking turns 01 to 06) took place at the very beginning of the session, when

the developer (*dev*) told the user (*usr*) how they were going to proceed. Let us simply look at how he presented things in turns 01 and 03. After having said that the object he was talking about was the prototype he had developed (*the prototype here*), he stated its purpose (*create lessons*), and then announced a work schedule for the session (action 1: *dev shows how to use the prototype;* action 2: *user tries the prototype*), while warning him about the current unfinished state of the tool. The user accepted this plan, or in any case, did not object to it, by agreeing with each action (02, 04). Regarding the second action, note that we cannot be totally sure whether he was agreeing to try the prototype or with the fact that it was currently unfinished and had to be filled in. Whatever the case may be, it is clear that the user did not object to the plan stated by the developer, and in doing so, at least implicitly committed to trying out the prototype. In 05, the developer leaned on this acceptance (*and so*) to announce the goal of the work session, as he had planned it at that point: *fill up the database as [usr] operates it* and try *to build a lesson together*. Again, the user was supposed to operate the prototype, something he still did not oppose. But, although in this intervention (01-04), it was conceivable that the user's trial operation of the prototype would result in an evaluation, this assumption could no longer be entertained. The explicit purpose of the work session, a goal that had been requested by the team of designers (in 05: *we, what we propose today*), was to build a lesson together to fill up the database. Now in order for that to happen, the prototype had to be truly usable. For the time being, the user had no objective reason to doubt this property; only the developer could declare it to be uncertain, which he did not do. In 06, he began the planned and validated work schedule. This closed the first sequence, devoted to stating the work session objectives and schedule.

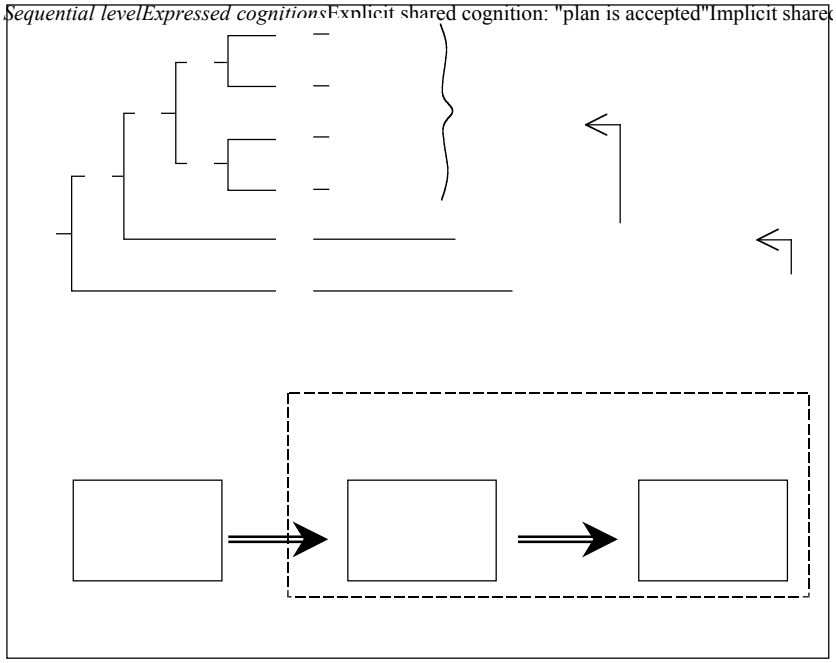


Figure 3. Validated work schedule.

Figure 3 illustrates these points. It presents the hierarchical and functional structure of the first sequence (Moeschler, 1985; Roulet *et al.*, 1985) and depicts its dynamic nature. Taken separately, each pair of interventions, 01-02 and 03-04, forms an exchange; taken together, they form an intervention which, because it represents a truth condition of intervention 05, is hierarchically subordinate to it. In order for the work objective to be valid, it had to be recognized and accepted by all. The same holds true for intervention 06. The very execution of the plan made the declared work objective retroactively valid (at least for the time being). This work schedule is a sequential one, since each action is a necessary condition for the occurrence of the one that follows: demonstration preceded user operation, which in turn preceded filling up the local database. Later, after the work session was over, an evaluation would take place in view of improving the prototype; it would deal with both of these actions, that is, the ones the technician had specified in 05 when he explicitly defined the work objective. In addition, we can see here that the developer and the user implicitly agreed with the fact that the prototype was usable.

Second sequence: Challenging the usability of the prototype. Now let us go on to the second sequence, where the usability of the prototype was questioned by the user. Following speaking turn 06, the developer gave a demonstration of how the prototype worked. This lasted a little over six minutes, after which he proffered 07, which marked the end of the demonstration. He then continued with a positive evaluation about the operation of the prototype: *it's not very complicated I think*. The assumption underlying this appraisal is what interests

us here. After demonstrating the prototype, the developer's statement that it was not very complicated was in effect an assertion that it was usable. Let p be this proposition, that *"the prototype is usable"*.

If we go along with the work schedule accepted by the two parties, then the developer could be expected to prompt his partner to move on to the second phase: user operation. Yet the user did not reply explicitly to the evaluation, but smiled instead (08). This smile was introduced into the discourse by the developer, who delivered the interpretation he made of it. The user's smile was a likely manifestation of a cognition that he dare not express himself openly. Now since the developer had just given a positive appraisal of his own work, his reaction to the user's smile was the assumption that it expressed disagreement, that is, a negative appraisal. This, in any case, is one way to analyze the relevance (Sperber and Wilson, 1989) of the reformulation that followed. Note the double transformation here: (i) the developer changes from a negative form to an assertive form, and (ii) he posits that the user thinks the assertion is true. This reformulation did have an effect, because while in 07, the developer implicitly implored the user to make a statement about the evaluation he had just expressed, in 09 his request was more explicit, if for no other reason than because he assumed his partner's belief was contrary to his own, even though in fact, the user had said nothing about it (except by means of a smile). The user was thus asked (i) to *explicitly* confirm that his smile did in fact mean refutation of the developer's assessment, i.e., to confirm the developer's hypothetical interpretation of the smile, and (ii) to *implicitly* support his position, since if it were true that he did not the share the developer's positive opinion of the tool he had designed, then he had to explain why. This is what the user did in 10, where he considered two cases, the teacher's and the student's, with user operation being regarded as uncomplicated in the former case but complicated in the latter. This second case was then declared invalid by the developer (11, accepted in 12), leaving only the first case, operation by an instructor, which was the user's own situation. He, the user, should therefore have no trouble using the prototype. In his argumentation, the developer was thus able to maintain the truth of p, although momentarily threatened by the user's attitude and subsequent remarks. The prototype he had proposed for testing still held its status as a usable tool.

Let us review the main flow here. In planning, the developer saw himself showing the user how to operate the prototype, and then having the user try it out in order to fill up the database. The first part of this plan seems to have been executed, since the demonstration was followed by an evaluation phase whose outcome, as we have just seen, was apparently positive for the other two actors. Yet they did not go on to the second phase, the user operation phase. Why? First of all, because the user made no attempt to do so, and secondly, because the doubt the user cast on the usability, even though "nullified" by the developer, led the developer to continue talking about potential future improvements in the prototype (13).

Third sequence: Denial of the prototype's usability. Between the second and third sequences, the user questioned the developer about a number of issues, including the suitability of the interface chosen and the re-use of parts already developed for this project, none of which directly challenged the

prototype's usability. These exchanges led into the third sequence, which began with the user's second challenge of proposition p (14). Then he justified this position (16), arguing that if the prototype was hard to use, it was because users could not find out the contents of the pages they were supposed to bring up to build the lesson. In other words, a user is forced to choose pages without knowing *what's in there*. Let q be the proposition that *"a user knows the contents of the menus."* The following notation can be employed to express the user's intervention: ¬ q ⇒ ¬ p. The argument the user gave this time to challenge the prototype's usability was not the same as earlier: it went much deeper. Now let us look at the second part, where the developer came up with counter-arguments (21). This is a classic debate (Trognon & Larrue, 1994) where two opposing points of view are expressed: according to the developer, operating the prototype was not complicated (p), but according to the user, it was (¬ p). Then one of the antagonists, the developer, invalidated the other's proposal by showing that it was untenable due to the very fact that it would make the prototype into exactly what they were trying to avoid (21). If the device had to include the capability of seeing the page contents before choosing them (q), then the sheer number of items would very quickly render the task highly complicated for the user, thereby failing to combat the problem the developer and user had set out to solve: making the prototype easy to use! In this way, the developer tried to restore p by proving that q was not tenable. And if q was not tenable, then the challenge (¬ q ⇒ ¬ p) failed, thereby tending to support p. But this counter-argument was brushed aside by the user, who called upon on his own experience using a similar tool, a computerized encyclopedia (22, 24), to show not only that his position regarding q was valid, but that it was highly relevant to the issue raised. The developer then recognized his "defeat" (25), insofar as he joined in with the user in stating the argument. Next the user asserted that he had "won the argument" about the truth of ¬ q by explicitly mentioning the current state (¬ p): *it's impossible to use it as is* (26). The technical validity of the prototype was taken for a fact; that is not what was being denied. Its usability, on the other hand, was another story. The developer's initial positive assessment (07) had now been refuted. At that point, the thing to do was to find a way to make it true, which is what the group attacked within the next few minutes. The initially planned and subsequently validated work schedule was thus implicitly corrected by the two partners' actions. The goal was no longer to operate the prototype in order to fill up the database (at least not at that particular point in time), but rather to find a means of making it "operatable". Hence, our statement here that, in this sequence, we are no longer dealing with a simple challenge, but a genuine *denial*.

In short, what happened was that a new constraint had been created and expressed: *"in order for the prototype to be usable, one has to be able to find out the contents of the menus."* If we take the propositions used so far and write the constraint in the form of an implication, we obtain: p ⇒ q. This constraint defined a new work objective, which was satisfied in the manner described in the next paragraph. The expression of that constraint is what signalled the end of the user-trial phase and the beginning of a design process.

We can see, then, that the entire first half hour of work was devoted to defining this constraint as a cognition shared by the developer and the user.

Fourth sequence: Overcoming the problem and designing a solution. For more than twenty minutes, the group[1] continued to explore the capabilities of the prototype. During this discussion, the observer (*obs*) asked the developer if *here* (referring to the prototype's pull-down menus added to the Word interface; Figure 2) it would be possible to have a preview *too* (28), where *too* referred to the developer's earlier remark that this feature could be added for searching on the internet.

The developer's reply here is interesting (29). In his answer, he mentioned ways he could satisfy the request, such as using a right click. In proposing these ideas, he was coming up with solutions of the type "enhance the existing system" (the prototype). As such, he was suggesting that he modify the prototype in order to take the observer's remarks into account. Then the user spoke (30), and as he had done during the third sequence, he relied upon his experience as a user of other kinds of software to talk about what he wanted. Here again, the developer assisted him in expressing this need. Thus, in the course of an exchange that took three speaking turns (30-32), the user reconfirmed the need to preview items.

The developer's next action was decisive. In his desire to give an example of what we might call the "preview system", he opened the Insert Object box in Word (33; Figure 2). In doing so, he "discovered" that this type of dialogue box could be used as a model for the prototype the group was striving to design. Let us look closely at intervention 33. The developer began by announcing that he was exemplifying the preceding statement as he described his action verbally on the screen: *Yes yes, it's a little like that here when you do In/ when you do Insert Picture uh Create <u>from</u> file.* Then he started a kind of commentary about his actions, which he interrupted with an assessment of what he saw in front of him (Figure 2): *it's/ actually, a thing like that would even be good you know*. All of a sudden, what was planned as an example became a model. What could have served as an illustration of a request (*it's a little like that here*) becomes a reference (*a thing like that would even be good*).

Although this intervention was crucial in determining the rest of the session, it did not suffice. It is because the partners, and especially the user, accepted this assertion (34-35) that it became the mark of a decisive change of direction in the design process. The developer went even further, speaking of the *ideal* solution (36). Then the group produced a series of comments about this interface model, until the declaration – highly emphatic and fully shared by the user and developer – *that's what's missing in the tool*, via which the user was also reaffirming the inadequacy of the prototype in its current state (37-42). A way of achieving <u>q</u> was thus instantiated. It followed from there that the second premise governing the design process ($p \Rightarrow q$, or $\neg q$ thus $\neg p$) had

1. From this point on, the group consisted of the user, the developer, and the observer. With the change in the orientation of the session, the observer was called upon to interact more and more. Now that the goal had become to design a new state for the product, he naturally responded to these requests.

been falsified, which in the interaction, amounted to at least temporarily restoring p. A few more minutes of exploring this solution were needed before finally, after about an hour of discussion, the user felt *convinced* of the quality of the prototype (43), i.e., its usability.

Figure 4 illustrates this sequence of actions. According to the work schedule planned by the developer and accepted by the user, the work session was supposed to consist of three steps. We have diagrammed these steps in functional and hierarchical format. The first two steps (demonstration, then operation by user) each correspond to an intervention because each one was supposed to be the responsibility of one of the actors, here, the developer and the user, respectively. The third step (filling up the local database) was an exchange, since the plan for it was to have the developer and user collaborate in this undertaking (05).

However, we saw in the course of our analysis that the planned schedule was not in fact followed, mainly because the user denied the premise that the prototype was usable. More specifically, we saw that the denial was the outcome of a series of challenges regarding this property, and was expressed by means of a joint action between the developer and the user. Before the product's usability was actually denied, i.e., before the constraint was openly stated, one can imagine that the developer's plan had merely been postponed and could be resumed later. But as soon as the constraint was put into words, and shared by the partners, it triggered the redefinition of the work schedule, the necessary discarding of the original plan, and the initiation of a new sequence aimed at satisfying it, that is, a design sequence.

From the structural standpoint, the organization of the work session was thus totally disrupted. The idea was now to work together on figuring out how to satisfy the constraint. This generated an exchange (E1) where the first intervention (I1) was the denial, the second (I2) was the solution of modelling the prototype after the Insert Object feature of Microsoft Word, and the third (I3) was the acceptance of that idea. The ensuing positive evaluation by the group marked the end of this sequence. These elements made up the "guiding intervention" (Ig) of the sequence, which gave its name to the transaction that took place during this hour of work, this distributed product design session.

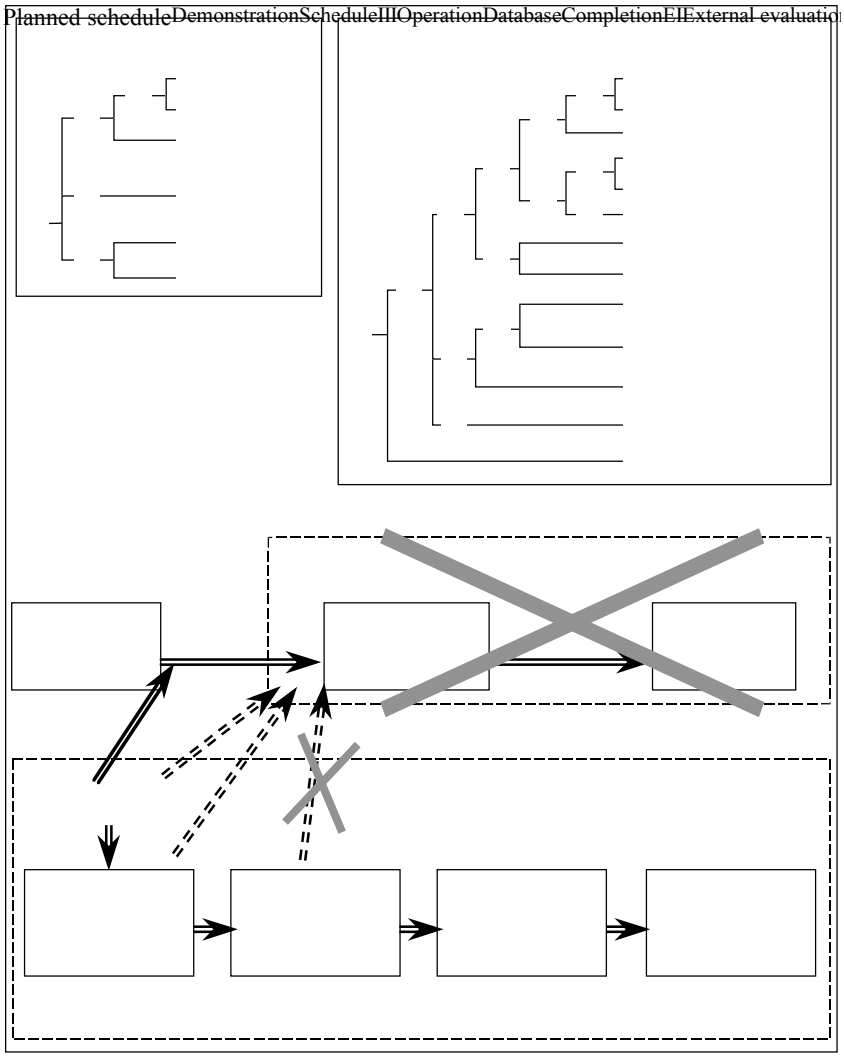


Figure 4. Actual organization of the work session.

IV. DISCUSSION

The actions of the conversers are what made this work session into a design session. More specifically, the design process was achieved by the formulation of a constraint (Darses, 1994) that called for immediate satisfaction. This situation was not "supposed to be" a design situation, at least not one dealing with the prototype's usability. Yet the formation of a shared cognition about a

lacking property (usability) became the grounds for establishing the requirement the group would attempt to satisfy. In doing so, they were also carrying out a design activity.

The role of mediation in this process is quite obvious. One can see it in the user's role. The assertion of his need, which led to the formulation of the constraint, is what in effect took the developer away from his essentially technical point of view and enabled him to consider another standpoint, that of a user. But mediation also took place via an intermediary object, a window on the screen, which caused a sort of *representational breakthrough* regarding the product. The occurrence of this event on the screen enabled the group to see its design in a new light. We saw that before that event, the changes proposed were superficial. If we draw an analogy here with social representations (Guimelli, 1994), we might say that only peripheral aspects were affected by the changes. But the modification involving the Insert Object box would affect the basic structure of the representation. There was a radical shift here in the perception of what this product was and what one could do with it, as clearly manifested in the upcoming speaking turns (36-42). Starting as a tool for linking users to data, the product became a genuine search tool, one that could efficiently look up information in a single environment. Before that event, the procedures required to get data from the local database were very different from those needed for gathering information off the internet; afterwards, with the addition of this new, essential capability, the preview feature, it was possible to use the same interface for both.

We have stressed the respective roles of the user and the tool in this situation. We would not like to give the impression that we are undermining the role of the developer. Of course his role was crucial, not only because he proposed solutions and because his skills allowed him to assess the user's demands and needs, but also (and *especially*) because he assisted the user in expressing those demands and needs. He contributed, right along with the user, in formulating the constraint that became crucial to the design process. While it has already been demonstrated that concurrent engineering "provides the best fit with cognitive processes" (Darses, 1997), we were able here to reinforce this affirmation and extend it to the social and instrumental dimensions of design.

This paper presents a typical example of the approach we are hoping to promote. The work session set up created an opportunity to take an in-depth look at the tool in question, and the result was a drastic change. The interaction situation made that possible, since it paved the way to *integrating* different viewpoints about the tool under design. The presence of the artifact, Microsoft Word's Insert Object dialogue box, was absolutely necessary. It is because the group had this object in front of them that they were able to bring it up and assess it as a model. Here, the object acted as the discourse referent, generating a shared universe upon which the actors could lean in order to progress in the design of the product. It played the role of a third party that enabled the group to change focal points and construct a new design perspective. Before this object "came to be", the group was working more towards improving the existing product (see interventions 28 and 29); after its emergence, the very perception of the tool, its *function*, was modified.

Finally, although the primary aim of this analysis was to prove the utility of work situations like these, we would like to emphasize that, over and above this basic value, our conversational analysis also turned out to be very instrumental in bringing out the structure of the transaction that took place, a structure which can be applied later to understanding the mental representation users have of a new software architecture, and to draw up specifications for on-line help systems (Saint-Dizier de Almeida, 1997). The future looks bright, for this method can make an invaluable contribution to providing effective learning tools to a body of users whose needs have been made known very early in the design process.

V. CONCLUSION

As stated in the introduction, we advocate addressing the issue of the design of computerized teaching devices, whether multimedia tools or otherwise, by taking an approach that necessarily includes the following two features: (1) potential users of a new product must be brought into the picture very early in the design process, and (2) the situated and distributed aspects of design, viewed as a cognitive process, must be taken very seriously. We feel that our analysis has demonstrated the relevance of this dual methodological constraint.

In fact, these two aspects were tightly linked in the "situated" design session we staged here. The co-presence of the developer and the user, but also of the head of an education research team, enabled the "distribution" of the cognitive process in question. The actual use of the tool, in the here-and-now, when it was still an unpolished, unfinished prototype, made it possible to anchor this process in the objects of the world.

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