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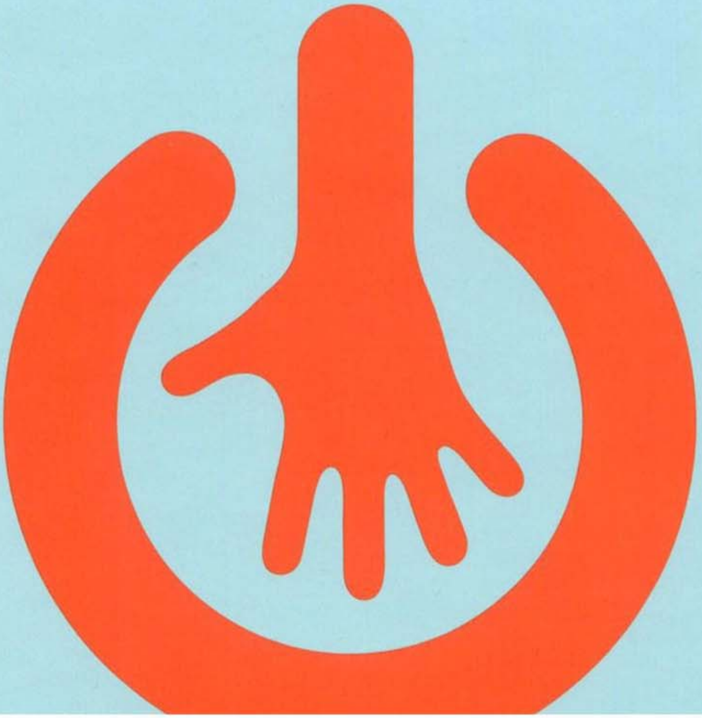

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THE HANDBOOK OF HUMAN-MACHINE INTERACTION

A HUMAN-CENTERED DESIGN APPROACH

EDITED BY
GUY A. BOY

8

Socio-Cognitive Issues in Human-Centered Design for the Real World

Saadi Lahlou

ABSTRACT

In order to avoid resistance and hidden costs in the deployment and maintenance phase of complex socio-technical systems, we developed a participative technique which addresses the deployment and maintenance issues early in the design process: "experimental reality." It enables realistic stakeholders' involvement at an early stage of design, by developing the new system in actual context of use. This approach implies a different way of managing development projects, and in contrast highlights some shortcomings of current practice.

This chapter provides; (1) a framework, installation theory, to sort out and address the problems encountered by design projects for complex socio-technical systems, (2) a quick presentation of activity theories, and (3) an illustration of our design technique in the domain of information technology systems supporting collaborative work in a large industrial organization.

1. INTRODUCTION: DESIGNING FOR REAL-WORLD SYSTEMS

Although we design for the future, this future is supposed to start at the end of the design project. This is usually pretty close, and by the time the new system starts it will still have to be compatible with a lot of the current world-as-is-now. This chapter addresses this issue.

The world in which we design comes with some already installed basis: physical (equipment, devices), social (laws, customs, norms), and cognitive (habits, education). Even the users are "second-hand": they are not new to the system being designed in the sense that they have already been educated and trained within the current system. The designer will have to cope with this pre-existing installation. *Installation* *theory* (section 1) provides a framework for comprehensive design and a checklist of the three levels of reality which the designer should address.

If we want to design in a user-centric way, we must be on the user's side. But observing what users do is not enough. Current behavior of the users is a biased indication of what the users want, precisely because current behavior is framed by present installation. User-centric design should focus on what the users actually want: their motives, their goals. We found Russian Activity Theory to be the most efficient for complex system design among the variety of theories we tried. Section 2 presents a remix of this theory, adapted for design purposes with some additions of current distributed cognition and psychology.

In section 3 we address the case of designing Information Technology (IT) systems. These are specific because they are by nature communicating with the rest-of-the-world—hence they must adapt to the fast-changing technological context. The need to support openness and connectivity confronts their design with the Sisyphean "never-endingness" of continuous upgrade. We present a design technique, "experimental reality," tailored for this problem. This is illustrated by the example of conference rooms.

2. DESIGN AND CHANGE MANAGEMENT: MAKING NEW IN THE OLD CONTEXT

Designers of a single object or service may (sometimes) find it possible to draw the limit of the problem-space they should address and work with a clear set of specifications to redesign on a blank sheet. But designers of large socio-technical systems are often cornered into "upgrading" a previous system and keeping some continuity with the current state of things. This is because of the complexity (relations between parts of the system) and the impossibility of the redesign of some of the parts. For example, a new IT system, a new transportation system, a new plant and even a new building must take for granted a series of limiting socio-technical specifications. They must fit into the existing frameworks of the environment which surrounds them (the organization, the transportation network, the trade, the city, and so on). Designers must then cope with existing users, installed basis, and existing rules.

Subsection 2.1 introduces installation theory taking inspiration on how the global society deals with these issues to generate some design guidelines. Subsection 2.2 provides some indications to involve users in a realistic design process.

2.1 Installation Theory

This section introduces "installation theory," a general framework describing the evolution of socio-technical systems. Although installation theory is general in scope, it is useful for practical applications as it clearly delineates three levels where action should by taken to ensure acceptability of change, smooth operation, and future evolution. These levels are:

- the physical level of artifacts where we design affordances;
- the psychological level of representations and practices where users are trained to acquire adapted competence;
- the institutional level where rules will be created and externalities controlled in order to keep the system running and updated.

The existence of these three layers has direct implications on the process of design, and especially on the way the users and other stakeholders should be involved in this process. Designers should always think of the system as a *socio-technical* system: human operators and users, and the rules, are functional parts of the system, just as is the physical installation of machines and software. The view that we design "a technical system operated by humans" is naïve: what is designed is a socio-technical system where the physical parts are operated by human parts (and in fact sometimes also vice-versa, physical parts operate human parts). This means, in the design process, that operator's training should be planned for as well as hardware maintenance.

Considerable work in social science has been devoted to the study of how social systems are created, maintained, and how they evolve. To make a long story short, fit socio-technical systems (those which survive) are continuously recreated by their own users, at local level and during normal operation. This is true for a production plant, the Internet, or society at large. All these systems are social constructions (Berger and Luckmann, 1966), in which the new users are educated and trained in such a way that they will use, and maintain in the course of use, the existing system. Giddens (1984), in his *structuration theory*, showed how the structure of a system has the dual property of being the result of continuous reconstruction by the practice of participants, and of producing these practices.

When one thinks of any concrete example, this somewhat abstract statement becomes clearer. For example, a company, a workflow, or even an aircraft will continue being operated, maintained, and slowly upgraded as the result of the practices of the professionals who use them. Their very role as professionals is in fact to maintain and operate the system. This illustrates the fact that usage reconstructs structure. Rules of practice or norms which format the system are built from practice. It is less trivial for hardware but examination of how hardware is maintained and redesigned shows that it is precisely tailored to be inserted in the fabric of practice, in the light of experience. Classic design guidelines always insist on this feed-back loop.

Conversely, user's behaviors will be elicited, guided, and constrained by the surrounding cultural system. Installation theory (Lahlou, 2008) addresses this aspect by distinguishing three major layers in the "installation of the world" which determine individual behavior. At a given moment, the world can be considered as an *installation* (in the artistic sense of assembling patterns in space to modify the way we experience this situation). This installation guides subjects into their activity track, at three levels: physical, psychological, and institutional.

At the *physical level*, artifacts have affordances which both limit some behaviors and call for some other. A classic example is the door handle (Norman, 1988), which (usually) signals how it should be handled and turned, and also affords only these movements. In the same vein, a workflow will prompt for specific entries at specific places in the screen, and will accept only "relevant" ones. The *physical level* is the one which is most classically addressed by designers.

But the physical level cannot be used by humans unless they have in their mind and body the adequate cognitive installation to interpret this physical level. For example, there are many possible ways of (mis)using even a door handle, and someone who has never used one may well stay trapped in the room even if the door is not locked. This does not happen often in our societies precisely because users have been educated to use doors. They have a mental model of what "a door" is and how it should be operated. This mental model is shared by the population: it is a "social representation" (Moscovici, 1961; Abric, 1994) that has been adapted to the actual collection of doors in the society by a double mechanism of adaptation (Lahlou, 1998): people learn how to use doors, and designers make doors according to the representation of doors. People experience difficulties in interpreting new "things" for which there is no social representation. In such cases, they tend to create a new representation by "anchoring" (Moscovici, 1961) on something they believe is similar, and try to apply existing interpretation schemes from "similar" objects to the new one. This is why designers should be extremely cautious when giving new things a form factor or name: what is evoked may serve as a basis for anchoring. *Social representations are the world's user's manual. These representations are installed in the user's minds, just like the artifacts are installed in the Physical environment*. They constitute a large installed basis, which is very powerful and inert considering the efforts one must make to train users.[1]

So the second level of determination of behavior by the installation of the world is the embodiment of representations and practice in users, which have also been designated as *skills* (Rasmussen, 1983, 1985), *competencies*, and so on. The cost of installing adequate skills in the users of a system is often several orders of magnitude greater than the cost of the hardware itself because there are installation costs: knowledge cannot be distributed over a population as a commodity; learning is an interactive process. Installation costs should also include (although this is never counted) the time and effort spent by users and other stakeholders of the system in order to implement the proper psychological installation in the user population. It is worth noting that while physical installation is usually within the sole control of the owners of the system, psychological installation is inevitably a co-construction with users.

Of course, since using a system is using both the artifacts and the skills, it is good practice to reuse existing skills; this is called *designing for cognition* (Lahlou, Nosulenko et al., 2002, Lahlou, 2009). This is a way to turn around the issue of installation costs. A good example of leveraging the power of an installed basis of skills can be found in the design of web-services, which tend to use common conventions of interaction with the mouse and keyboard, or the navigation in virtual worlds (World of Warcraft, Second Life, and so on) which all use similar keyboard conventions for moving the avatars.

As said earlier, and especially in large populations of users, the installation cost (persuasion, training, evaluation of skills) is often too high to be even considered seriously in the design project. The designer must then integrate in the design some kind of device which will gradually install these skills as the system is used. Viral dissemination of practice and skills is ideal from the designers' perspective, because

1 Note that just as representations are embodied, practice also is. Enacting and interpretation (e.g., using a door, entering a password) is embodied both as a cognitive level (mental interpretation: this is a door) and at motor level (the very motor action of opening the door).

the costs are outsourced to users. Users may have a different point of view, though, so designers should be careful. Since many designers take this approach, users are confronted with an unbearable cognitive load to learn *all* systems, and end up not reading *any* user's manuals.

In any case, this installation at psychological level should be considered and a solution proposed at designed stage, otherwise the user organization will incur massive costs.

Let us look now how change monitoring happens in real ecologies (societies) to see how that installation takes place. This will introduce the third layer of determination, institutions.

In a society, representations and objects follow a co-evolution process: representations are constructed by the practice people have of objects. Conversely, objects are made after the pattern of their representation: ladders are made to look like ladders; firemen are trained to behave as firemen; email software is built after the representation of email. And this is the reason why representations match with objects (Lahlou, 2008).

A first lesson to learn here is that if we want new systems to be usable and sustainable, we have to make sure the representations that designers have of the system are informed by the actual representations of the system among users. If the system follows the user's mental model, it will be used more easily. Designing for cognition means finding among the user's existing (cultural) portfolio of skills and representations the ones which could be readily reused for this specific system and tailor the system accordingly. Conversely, the differences between the new system and previous representations should be highlighted in order to avoid misunderstanding.

This seems trivial, and of course designers do usually try to take into account users' representations. Nevertheless, in practice, the designers often delegate this investigation to "specialists" (ergonomists, ethnographers, social psychologists, marketers or other social scientists), and, however skilled these intermediaries may be, something is lost in translation. We strongly advise that designers, on top of these surveys done by someone else, and after them, do engage in *direct* informed discussions with the users to make sure they have correctly understood the users' representations and expectations. We will see in section 3 that we have ourselves adopted an even more radical approach, inspired by the Russian psychology of engineering, where designers, social scientists, and users discuss the design together.

Coming back to societies, at a social level, the co-evolution of objects and representations is monitored by domain-local communities of interest (users, providers, public authority, and so on) who set the patterns of objects, the rules of practice and so on. Because these stakeholders know the field from the inside, objects, representations and rules are adapted to behaviors. These stakeholders create *institutions*, which are both sets of rules to be applied to keep order and cooperation, and communities of interest aware that they play in the same game. So, institutions set common conventions which enable cooperation (for example, people should all drive on the same side of the road, not send massive attachments to large mailing lists, and so on). Conversely, they control potential abuse or misuse, and minimize social costs (Coase, 1960) also called "negative externalities." Many of the rules are already contained in the normative aspects of representations, but institutions are special in their capacity to enforce behavior, by social pressure or more direct means.

In the process of negotiation between institutions, stakeholders are involved on the basis of their implication in the system, they engage in negotiation processes in order to defend their interests or simply to fight against externalities. This complex interplay between institutions is not a market for information; rather it is a multi-party, sometimes a bit anarchic, series of trials and errors, and of local negotiation. There is no such thing as a general initial consensus conference or general negotiation: stakeholders get into the process as they become aware of the potential impacts of the system on them, which impacts are sometimes very indirect or unexpected. Some stakeholders help, and some oppose. But, as the sociology of translation (Akrich, Callon et al., 2006) notes, the projects succeed only if they manage to convene a sufficient mass of supporters.

What is to be learned at this stage is that there must be some organized authorities (institutions) who explicitly regulate the system, and especially its reproduction, by preventing abuse and misuse; and these institutions should have some capacity of coercion. The question to ask is "Who will sanction misuse and abuse?" Usually, the system should have an explicit "owner," but other regulatory bodies may have their word to say because they will have to be in charge of coercion. *These stakeholders should be consulted at some point, not too late*. Once again this seems obvious, but in practice the head of the design project is often taken as the single referent; which is hazardous because she will often not be the one in charge of the actual system. Also, he/she has his or her own interest, among which finishing the project in time and delay which means a bias towards overlooking issues which may be too long or expensive to solve within allocated resources.

Another take-away point from this observation of natural systems is that it is very difficult to predict beforehand who will be impacted by externalities. A reality test recruits relevant stakeholders on the basis of actual impact, and they come motivated to solve the issue because they have become aware of this impact. One way to mimic this recruitment effect in the design process, which we apply in experimental reality, is to make sure a real test will be carried long enough so as to observe these externalities. As externalities surface, the parties concerned get involved into the design process to solve the issues before the final system is launched. Otherwise, the new system will encounter "resistance," which means costs and delay. Resistance is a signal of pain in the organization and should be treated as a warning symptom rather than be fought against (Bauer, 1991).

So, at a given moment, individual behavior is determined by this distributed installation of the world: artifacts installed in the physical environment, interpretive systems installed in humans, and institutions installed in society. The co-evolution between artifacts and representations is done under continuous monitoring and control of stakeholder communities, which use institutions as social and economics tools to safeguard their interests. This is a factor of stability of this normative framework.

The designer of a new system should ideally set up such a distributed installation so that his system is sustainable and regulated. As it is a trial and error process, this takes time, and is never fully stabilized, so the need of a system designer remains throughout the life of the system. Unfortunately, the designer usually withdraws from the scene when the project is over; she is replaced by maintenance, management, consultants and subcontractors, or sometimes R&D, to fix the local problems … until a deep redesign is needed. This is fine for rather stable systems. But some other systems continue to undergo evolution, especially the ones which use fast-evolving technological bricks. For such systems, we advise that a specific unit remains which continuously explores DOME[2] possible improvements (Lahlou, 2005), tests them locally, and upgrades the system when a good solution is found. Keeping alive such a unit which capitalizes considerable knowledge (technical, social, organizational) can be a cheaper and more efficient way to keep the system updated than consulting or designing a fix only when badly needed, because in the latter case the designers will have to rediscover the system, and may have less organizational agency to mobilize the stakeholders. Section 3 gives an example of such a unit with the "mother room" of conference rooms at EDF.

2.2 *Involving Users*

Users are usually more conscious than anyone else of the shortcomings of the current system; so they can become, if they are made aware of what the new system could bring them, strong allies for the designers.

When using the system, the users focus on their local, current goals, and will try to cope with what is there as the "conditions given" within which they will try to attain their goal. In these moments, users will make no effort to cure the system, simply because it is not their current goal, unless a quick and local fix will enable them to make sufficient satisfaction. This is why we cannot expect too much from users alone. And this is why the organization calls for designers whose goal is precisely to make the system better.

Another issue with involving the users and stakeholders (as we advocate) is that these participants are usually bound within the current system. Especially, they will be quick to seize or imagine ways in which the new system will cause problems to some of their existing habits or privileges.

What we advise here is threefold: focus on activity, use the subcam and recruit friendly users.

On the one hand, design should focus on the user's activity, seen from the user's perspective. In doing so, the designer (and the rest of the project team) will be able to communicate better with the user, in his own language, and the user will feel involved in the problem. Technically, we use the Subcam (Lahlou, 1999, 2006), a miniature wide-angle video camera which the users wear at eye level (on glasses, a helmet, a bandana ...) during their daily activities (Figure 8.1). The subcam records what the subject sees, does, where the attention is focused; the sound track provides not only records of verbal interaction or talk-out-loud, but also cues of emotional state such as voice tone/pitch and breathing. It is a dive in the subjects' phenomenological tunnel.

Analyzing the Subcam tapes with the users themselves and focusing on the problems they encounter provides designers with an insight into the actual activity. It proved to be an extremely efficient way to produce solutions with the users. For analysis, we use Russian activity theory, which will be described in section 2.

The subcam is a precious help because the users can wear it in their usual context, in the absence of the design team. It provides a situated view, from the best point of

2 DOME: Dissemination, Operations, Maintenance, Evolution.

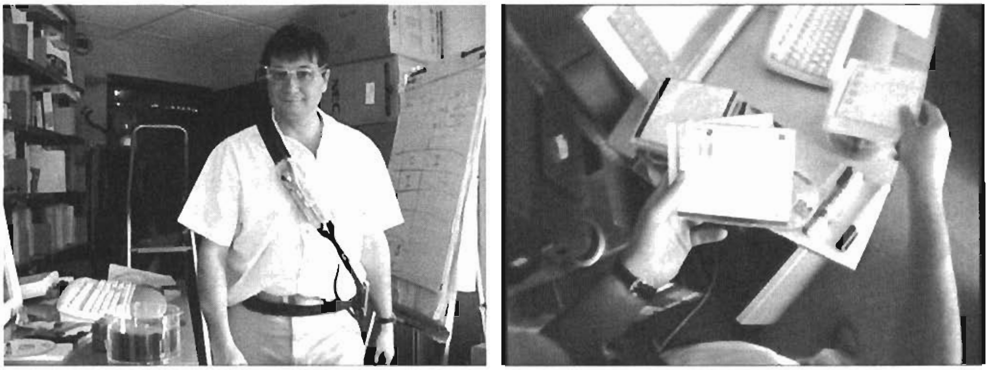

Figure 8.1 Subject wearing a subcam, 1998 version (left), frame from a subcam (right)

observation possible. Beyond a merciless account of what the actual activity is, the subcam enables setting up protocols supporting activity analysis. As we shall see in section 2, activity analysis is very powerful but it requires knowing the goals of the operator at every moment. Because the subcam provides a situated recording, the capacity of subjects to remember their intentions at each moment when they watch the tape is far better than in any other techniques; sometimes it is stunningly accurate even months after the fact.[3] Therefore, we use the tapes not only to spot the problems, but to collect, during self-confrontations of subjects with their subcam tapes, the goals and emotions of the subject as he was performing the task; which will then be a critical element in the activity analysis. As a side effect, the subcam enables designers to get a deep insight into what the user actually does, without the social filters and the mediations of language.

For the recruitment of subjects, we do not try to be representative in a statistic sense. Most users experience some difficulties in participating in a design process, especially since it does come on top of their normal work. Although most users would actually be able to provide valuable input in the design process, some, for one reason or another, are more motivated, more ready to verbalize their experience and collaborate. We call these "friendly users" (Lahlou, 2009; Jégou, 2009); they may be technology fans, friends of the project members, interested stakeholders, or simply curious people who are happy to test something new and participate in innovation. In our experience, a couple of motivated "friendly users" who will follow the project all the way bring more usable input than a large sample of "standard" subjects. This is especially true for the early phases of design, when a lot of compliance and good will is needed on the part of users to actually use a system in infancy, with a poor user interface and hazardous functionalities. Some of these friendly users can be involved to the point they participate regularly to design meetings, and serve as

3 We have the capacity to judge whether what the subject remembers of his state of mind at one moment is accurate, because when we watch the tape with the subject, and ask him "What you did next?", or "What were you up to then?", it is quite easy to verify if the subject is correct simply by watching what actually happened next on the tape. Reliving one's phenomenological trajectory in the world tends to re-prompt the same state of mind: look how, when moving around your house, you suddenly realize you forgot why you had just come into this specific room; usually, returning to the previous location and walking the path again will make you remember.

brokers or scouts with more distant users and stakeholders. As the system grows in quality along the design process, the team can involve less and less friendly users, until finally the system could stand the tests of unfriendly users.

3.2 *A Quick Presentation of Activity Theories*

Being user centric has rightly become a claim of modern design. There are different ways of being user-centric, though. One is to focus on the user as an object of study, and to analyze his interaction with the system. Another, more radical, for which we advocate, is the anthropocentric approach; which considers the human as the central element in the system (not just as a part of it or as a source of usability constraints for design), and designs the system from the perspective of the user. The difference is easily illustrated by the stand of the designer: in the latter, the final user is considered to be the legitimate source of specifications for the system, that is, "the client" (rather than the sponsor who is the client of "the project"); the designer works to help the users attain their goals, within the constraints given by the project and other stakeholders (for example, budget).

This may be a source of conflict with the official sponsor of the project, or the project manager, who consider *they* are the clients. But in the end, even though the project sponsor pays for the system, the users have to buy it. Therefore, for the sake of the system's success, the final user's voice should be taken *really* seriously. Too often, even though the design process claims to be user-oriented, the final user's voice is listened to only as long as it does not cause major problems to the project (for example, substantially increased costs or delays). More often than not, overlooking the user's voice at design phase will result in increased costs in the system's DOME (Deployment, Operation, Maintenance, Evolution). These costs are externalities for the project manager, and sometimes even for the project sponsor (who may be in the end of his carrier in the organization, or in a subdivision of the organization that will not be in charge of DOME; for example, procurement or R&D), but these costs will be incurred by the user organization anyway.

During design phase the anthropocentric approach often seems to be biased towards more user comfort and freedom that would seem strictly necessary for the system to operate in theory, but in the end, the anthropocentric approach pays because the users will be supportive of the system, and palliate its shortcomings. In fact, many goals of the users, which seem unnecessary or abusive to short-sighted functional design, often appear crucial to enable the flexibility and informal adaptation of the system in real conditions, therefore overlooking them can be disastrous, as we learned the hard way ourselves (see example of our design failures in conference rooms in Lahlou, 2009).

In practice we take an anthropocentric perspective by adopting activity theory approach, which is to study the activity of the operators. Activity is very different from behavior. Behavior is the sequence of actions described objectively by an external observer; activity is the sequence of intentions and actions as seen by the user.

Humans are specific in that they have motives, goals, plans; actual behavior is only one possible path that the operator took to reach his goals in the conditions given. For example, while "taking the bus" may be behavior, the activity would be to travel to a given destination. What is most important is not the means of transportation, but reaching a given destination on time with minimum cost and effort: if the operator finds another means of transportation that has better efficiency than the bus that day, he will probably switch to that mode of transportation. In that case, making a better system is not necessarily designing a better bus, but understanding the transportation bottlenecks of the population concerned and addressing the issues, which may be a matter of interconnection with other transport, modifying the location of bus stations, training users. When we talk about "the conditions given," this means not only the affordances of the physical layer, but also the sets of institutional rules. As another illustration, in the domain of accounting Suchman (1983) showed, with an ethnographic approach, that the nature of activity is rather to reach the goal (for example, pay an invoice) with the constraint of respecting the rules, than to follow a rigid procedure.

While in the West clinical psychology and analysis of individual subjects were developed, in Russia considerable progress took place on the analysis of groups at work. The success of the Russian orbital missions testifies to this advance (Nosulenko and Rabardel, 1998). In fact, the history of Russian psychology on the whole is focused on the problem of activity. Activity design was especially developed in the "psychology of engineering" analyzing the activity of the human operators of complex technical systems (Leontiev and Lomov, 1963; Lomov, 1977; Zavalova, Lomov et al., 1986). As underlined by Lomov, the pioneer of the Russian psychology of engineering (Lomov, 1963; Nosulenko and Rabardel, 1998) who coined the concept of activity design, the design should address both the tools and the human subject of work (Lomov, 1977).

Designing activity differs from designing objects. In activity design, one seeks to set up an environment allowing the subject to carry out his activity and to achieve his goal. Here, the artifact which is the initial object of the design (for example, a product, a software and so on) is only a small portion of the system considered. The rules and procedures, the representations, operator training, maintenance, and diffusion within the organization of the central artifact are also in the scope of the design and are not considered as intangible givens, but as aspects of the environment which could possibly be re-installed. A central element of the system is the operator himself. Theories of activity, originated in Russia (Rubinstein, 1940; Leontiev, 1974; Nosulenko and Samoylenko, 1998), are an essential source of renewal and development of current psychology and ergonomics (for example, Wertsch, 1981; Engeström, 1990; Bödker, 1991, 1996; Kaptelinin, 1996; Nardi, 1996; Bedny and Meister, 1997; Daniellou and Rabardel, 2005; Nosulenko and Rabardel, 2007; Nosulenko and Samoylenko, 2009). One must also be aware that there is no such thing as one single theory of activity: a considerable number of authors have proposed variants over a period that spans nearly 70 years. Analyzing activity is done with a couple of conceptual tools which are sometimes apparently close yet deeply different from concepts used in Western psychology, and the history of the concept is in itself a domain of research in Russia. Also, activity theory per se has a series of shortcomings for design. We present here our own short "remixed" digest which is what we use in practice.

Activity theory is *anthropocentric*: it considers activity from the perspective of the subject, where action is always intentional (it is aimed towards a goal, and directed towards objects-of-the-world).

A goal is a conscious representation the subject has of the future situation to be reached. A goal is a local means of satisfying one or several more general motives.

Motive is some perceived need; it refers to a state of dissatisfaction *internal to the subject*; while a goal is rather some state of the environment including the subject. For example, hunger will be a motive and dining at the restaurant a goal; self-esteem will be a motive and getting promoted is a goal.

Although the difference between motives and goals is essential to understand, and to get the gist of activity theory, it is often unclear in literature. Motives are an internal, psychological state, and goals are a means to satisfy these motives. There may be different ways of satisfying the same motive (for example, there are many ways of gaining self-esteem, there are many ways of satisfying hunger). In a workplace context, there may be many ways to fix a machine, foster a decision, and even to process an invoice, each being a specific trade-off between for example, speed, risk, cost, and quality; depending upon the situation, one may be better than another. So, subjects may change their goals on an opportunistic basis to satisfy the same motive, for example, buy a sandwich if the restaurant is closed, or subcontract a task if local resource is lacking.

Also a subject may carry several motives (for example, sociability and hunger) and will tend to choose goals which can satisfy several motives (for example, go to lunch with a colleague). Finally, there are many ways to reach a goal (for example, one can walk to the restaurant or take the bus). Hence, subjects will choose their trajectory to the goal in a trade-off involving functional efficacy (availability of resources, efficiency, hazard reduction, or cognitive cost) but also considering the motivational benefits which can be cropped along the trajectory (for example, walking is good for health, displaying professional proficiency is good for self-esteem, being compliant to hierarchy is good to avoid stress and so on).

As we can see, activity theory enables a detailed and realistic account of life, and activity analysis evidences the many layers of determination of behavior, while classical mere functional analysis will tend to overlook the subjective aspects involved in individual performance. When we redesign a system, understanding what features will actually feed motivation of the operator is crucial. Usually, satisfying the objectives of the system as a worker (say, keep a good standard of quality, enhance safety, and so on) are, from the subjective perspective of the operator, goals to satisfy personal motives (own self-esteem, wealth, health, recognition by group of peers, sociability and so on). Failing to connect the system's goals to individual operator's motives results in low motivation, minimal ("satisficing") performance of operators, and need of external control; while connecting goals to individual motives enables increased performance, mindful contribution, creativity, self-regulation, and good social climate.

Let us now go in more detail in activity analysis. Motives and goals are rather general levels of determination. In practice, to reach the goal the subject will have to create a trajectory from current state (conditions given) to desired state (the goal). To do so the subject goes through steps ("tasks"); each one having its own aim (sub-goal). For example, to operate an electric valve, the subject may have to first check actual state of valve and compare with expected state as given by his instruction sheet, connect the motor of the valve to the mains, operate the controls, check the valve has attained desired value, report, consignate valve, disconnect from mains. And each task may break into subtasks (for example, checking state of valve starts by checking one is in front of the right valve by checking valve reference number).

Execution of some tasks might reveal problems, and need conscious monitoring of motor and mental actions by the subject; while for some others a routine sequence of automatic actions is sufficient. When actions are automatic and are applied beyond conscious control (for example, changing gear when driving a car, turning on the cooker, typing a password, and so on) they are called "operations."

So activity appears as an oriented trajectory from a given state ("conditions given") to a consciously represented expected state ("goal"). Attaining the goal satisfies the motives of the subject. The trajectory of activity is a succession small problems to be solved of ("tasks"), which can each be seen as reaching a local sub-goal. The operator solves each task by taking actions (consciously controlled motor or mental moves) and operations (automatic, routinized moves taking place beyond threshold of consciousness). At each moment, the subject is confronted with the possibility of taking a different local route to reach the final trajectory, and may do so opportunistically in consideration of the local conditions given at this point.

A good design will result in offering the operator trajectories which are legible, efficient, and enjoyable because they feed his motives.

From the designer's perspective, the number of variables is enormous, and the tree of possibilities too big to be fully explored. It is simpler to fix a "one best way" that the operator should rigidly follow. This tailorist design strategy is applicable where the conditions are stable, for example, in a production line for material products. The one best way approach is more difficult to apply in complex systems where the configuration of the problem space may change during operation, or have a large array of possible states which must be regulated (transportation networks, aircraft, power plant). It is almost impossible to apply to systems in continuous transformation where some creative input from the operators or users is expected (managerial chain, information workflows, client-fed systems for example, web 2.0). In these more flexible systems, what stays stable are the motives and goals rather than the procedures to attain them, because the latter change opportunistically with the state of the system.

In these complex systems it is advisable to have a goal-oriented design. Any part of the process should be explicitly marked with respect of what is its specific goal in the global framework. This enables the operator to make sense of her activity to take the appropriate decision and evaluate results in the light of what is the goal to be attained. As in complex systems there is considerable labor division; the local goals of a task or procedure may not always be clear to the operator, especially if they are aimed at obtaining a distant effect (for example, avoiding externalities in some distant department), or at some long-term or distributed consequences such as risk management or overall quality control. If such sensemaking is not facilitated, local decisions may be taken to stick too rigidly to a procedure, or operators may choose what seems to be a locally acceptable decision but is fact is a less efficient route to reach the higher order goals. Not only does this goal-directed design enable operators to take better informed decisions and makes them feel empowered and participating, but it also helps to connect their activity to higher goals which may fuel their motivation.

This goal-oriented design unfolds from general goals of owners of the system (informed by customers' and end-users' perceived quality) and is subdivided at lower levels of the system as labor division takes place when these supraordinate goals are broken down into sub-goals. In practice, during design, trace of the goals at higher level must be kept explicit when the subsystem is designed. For example, to take again the example of the valve described earlier, the goals of comparing current state with instruction sheet, and reporting final state after operations, both aim at tracing an accurate state of current installation, checking the information system is accurate, and feeding the predictive maintenance system (which will trigger preventive maintenance on all similar valves in plant if systematic drift is observed). These tasks have minor use in the current operation, but have an important impact on overall safety: knowing this will motivate the operator to perform them with attention because they make his gesture contribute to important collective goals, rather than resent them as cumbersome overhead done for some distant quality control bureaucrat or anonymous computer system. An action without a goal is meaningless for the operator. It will therefore tend to be overlooked or poorly performed.

Also the subject must have a way to evaluate if the goal has been reached. Therefore a system should provide feed-back to enable the user turn to next action. In the example provided, this could simply be the fact of ticking a cell in a report sheet; electronic information systems can provide richer feedback including a "thank you" and a check that value is within range.

While documenting functional goals, making them explicit, and designing feed-back is a matter of good organization of the design project (which is similar to the good practice of comments in code in software development), it may seem a daunting task to collect individual goals, and motives of operators and users. In practice it is feasible only when the system as a prototype has reached a threshold of usability sufficient for it to be given for test to actual operators. Then, local goals can be made explicit with a talking-out-loud technique during performance, or a subcam capture followed by interview during self-confrontation of the operator with the tapes. One must note that if such protocols have been applied on a current version of the system before redesign started, usually many an interesting insight will have been already captured, which have informed design, and made explicit many tricks of the trade, expert shortcuts, and seasoned operator's criteria for evaluating their action.

When dealing with end-users who are not professional operators, which is often the case in "2.0" systems, we advise using the "perceived quality" technique (Nosulenko, Parizet et al., 1998; Nosulenko and Samoylenko, 1997, 1999, 2009). Perceived quality approach is an operationalization of activity theory, mitigated with communication theories and theory of mental image. Elements of activity are described (goals, motives, aims, actions, operations), and to each is attributed their subjective evaluation by the individual. Then, statistical techniques are used to characterize "objectively" the elements of activity (for example, physical measurement) and match them with their subjective evaluation. In contrast to classical techniques, the perceived quality approach begins with identifying the aspects of the object or system that are salient or valuable for a certain individual in the course of the given activity. Subjective evaluations which might appear at first sight intractable for the designers (for example, "good, "clear," "difficult," "disagreeable") are by this process gradually quantified, and attributed to objective criteria which can be modified in design.

In a nutshell, this method consists:

1. Obtaining a verbal description of what the user thinks (in very open terms) of performing the activity with the system to be evaluated; the verbatim are obtained by asking subjects to describe their activity as they perform it, usually by comparing the present situation with another (comparing two or more systems successively for the same activity, or comparing the "new" system with what their usual practice, and so on);

2. Extracting from the verbatim individual evaluations (for example, "this one is faster than the one I have") and finding out all dimensions used for evaluation (for example, fast/slow; light/heavy; clear/cluttered and so on);
3. Constructing a database where each evaluation is attributed to a specific element of activity (object, operation, and so on);
4. Statistical analysis of the database using evaluation dimensions as variables (for example, "verbal portrait" giving quantified profile of an object of activity on all characteristics; comparison of objects, comparison of operations on different objects, and so on).

This description of the perceived quality of activity is useful in comparing different systems or versions of the same system with quantitative measures. It also enables discovering which dimensions are relevant for the user, and spotting the problems. For example, we discover for which sub-goal or operation the artifact produces an impression of slowness in use. And it will then become obvious what technical affordances are at stake. The next step is redesigning the system to modify this affordance in order to better support the local goal.

In the course of "activity design," by focusing on creating the proper support environment to help the operator attain his goals, the designer will encounter several challenges for redesign. As predicted by installation theory, these challenges will be at the level of the technical system, the representations and practice, and the institutional setting.

As designing large socio-technical systems is complex, we find it easier to proceed by trial and error with friendly users, fixing problems as they emerge with the prototype in real use, and as stakeholders come to join the design process with their own requirements. This means setting up a design process, which enables this continuous and fruitful hands-on collaboration between designers and uses.

Our design approach, *experimental reality*, consists in implementing a continuous design cycle, taking place in a real setting, integrated in the normal processes of the larger organization. It operates in continuous process mode rather than in project mode. In a way, it is a step back from the current fashion of project mode management.

3. EXPERIMENTAL REALITY: A SYSTEM FOR CONTINUOUS DESIGN ADDRESSING NEVER-ENDINGNESS OF *IT* INNOVATION

This section describes experimental reality and illustrates it with the Mother Room system that was set up at the EDF Laboratory of Design for Cognition (3.1, 3.2). Then it lists the set of design targets for usability of information systems which we gradually came to adopt (3.3). Finally, we draw some lessons learned about the development cycle of IT systems (3.4), and describe some principles we found useful.

3.1 Experimental Reality

Experimental reality as a design technique has been extensively described elsewhere (Lahlou, Nosulenko et al., 2002; Lahlou, 2009) so this section will only provide a short illustrated overview.

Participative design is a method of action-research in which the experimenters voluntarily take part in focusing, in a constructive dialog with the designers (Ehn, 1992; Kyng and Mathiassen, 1997). This is usually done in a spiral design cycle where user consultation alternates with new design iteration, the user being given a version 1 to evaluate, then a version 2, and so on.

Experimental reality started one step further: we enabled continuous and direct contact between social scientists, designers, and users in a long-term process. In a nutshell, the idea is to install in a small unit a "next generation of work environments." This unit serves a continuous experimentation of possible improvements of the current system. The approach is specific in that this unit is not simply a living lab; it is actually functional and carries "normal work" in the organization. But it does so using the "next" versions of hardware, software, rules, and so on. As members of this unit experience specific problems because they test new systems but still must be compatible with the rest of the organization, they have a specific highly skilled maintenance and support team, and the benefit of extended clearance for external help, subcontracting, procurement, and exception to some internal rules—and of course of top equipment and cutting-edge technology. In exchange for which they are continuously monitored, report, and propose new solutions on the basis of their own experience.

What we can learn at the contact zone between the new and the old system in actual operation is obviously a major added value of the approach. The problems which occur there are a preview of deployment and future operations issues.

In practice, we constructed a living laboratory, a large vivarium (the K1 building of some 400 m^2: Figure 8.2) which is the arena where the team lived for such interaction: the team ended as a new organizational concept. The idea was to have a realistic test bed where future environments could be tested by real users, while their activity could be fully monitored. We wanted to monitor everything in order to capture systemic and emerging effects, especially in the process of adoption, for basic research purposes.

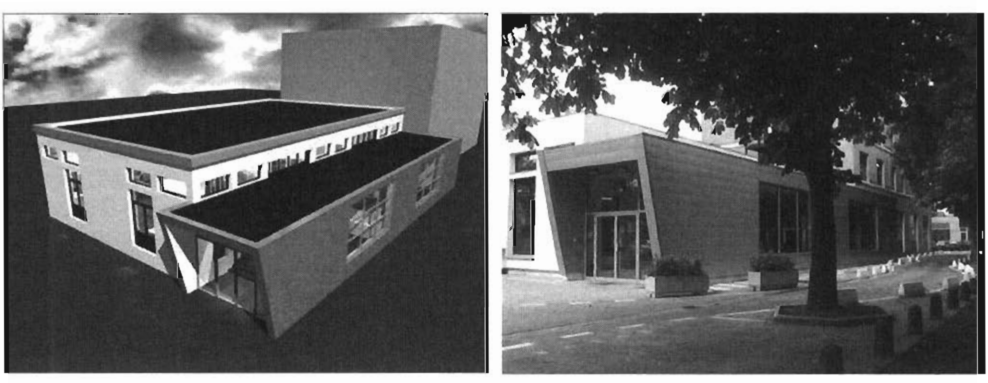

Figure 8.2 The K1 building at EDF R&D: CAD view and real view

Figure 8.3 The project space and the RAO Mother Meeting Room (lower left corner)

In experimental reality, proximity with users enables taking shortcuts because the possible iterations are discussed with users without a heavy formal evaluation systematically taking place. For example, designers would discuss possible improvements with users as the latter are using the system or reporting problems: "What if we designed it like this?"

In these discussions the users can propose modifications and explore possibilities with some quick prototyping tools, sketches, mock-ups and so on and get immediate feed-back of technical feasibility from the designers; while designers can test ideas and get feed-back on their acceptability by the users. Jégou (2009) provides examples of "quick and dirty" design techniques which empower such hands-on discussions.

Not only the idea proved useful for basic research since a lot was learned about innovation processes, but also the experiment was so productive (several innovations were successfully disseminated in the company) that the laboratory, initially created for a period of three years (2000–2002), was transformed into a permanent facility hosting the "mother room" of augmented conference rooms for the company.

As this concept of mother room illustrates best the nature of experimental reality and how it can be implemented in practice in large organizations we shall describe it in more detail.

3.2 The Mother Room

To study "augmented" meetings (with videoconferencing, online collaborative tools and so on) we provided a comfortable meeting room (Figures 8.3 and 8.4) which could be reserved for free, in an industrial facility housing more than 2,000 office workers (engineers; scientists, and administrative personnel). This provided a large flow of volunteer users (over 200 meetings per year used this room), which enabled systems-tests in many configurations. This "mother room," called RAO, is used to test new versions of room communication systems before they are disseminated in the company; as technology evolves, so as to keep the fleet of rooms up-to-date and nice-to-use.

Figure 8.4 The RAO Mother Meeting Room in 2002

The infrastructure of the room is oversized, with high bandwidth networks of various protocols (WLAN, Bluetooth, RF-ID, CPL, GSM, GPRS, IRDA, EDI, and so on), sensors, and so on, deep raised floors and a technical ceiling to enable relocating within moments any resource (data, power, voice, sensors, and fluids including HVAC since the plenum is pressurized. Clever plug-and-play infrastructure designed by our colleagues of the Intelligent Workplace at Carnegie-Mellon University (Hartkopf, Loftness et al., 2009) empower users to do all these manipulations themselves, and they actually do modify them up to several times a day. As all the furniture is foldable, stackable, and/or wheeled, the room can be instantly adapted by the users to the configuration desired for each meeting. Configuration of the digital resources (videoconferencing, displays, lights, and so on) is done with ServiceTags: users simply have to select the card with the desired action and put it on a (RFID) tag reader (Figure 8.5). A vast array of technologies is made available to the team of users and designers, with a rather open budget, and most important, clearance to buy non-standard equipment and service.

The whole building, and especially the meeting room, is instrumented for continuous observation and recording. Subjects may wear subcams. What happens in the room is continuously recorded by a series of video cameras: a dozen Offsats (time-lapse cameras with automatic movement recognition (Lahlou, 1999), classic digital video cameras and screen recorders which record not only what happens in the room but also on the giant screens, and logs.[4] This continuous monitoring

4 Because of this continuous observation, participation in the experiments requires acceptance to take part in sometimes invasive and continuous protocols of observation, and considerable trust of users in the innovative unit. These issues and how they were solved are described in detail in Lahlou et al. 2002, 2009. The participants are voluntary. They are informed of our approach and are interested in its results. They take part in the construction of the system of observation and with its maintenance; nothing is hidden from them. The key of the device resides in the psychological contract which produces their participation, by taking into account their own interests (and not only those of the researcher and those of the organization which funds it). The observation is possible and productive because the observers are

Figure 8.5 RFID ServiceTags on a reader

Note: On the left notice the 1€ coin for scale.

provides material for discussing the issues with users, documenting the changes, measuring the impact (for example, the time spent, number of errors, and so on), and evaluate the number of resources needed (for example, bandwidth) or the level of actual load on the systems. This measurement is an indispensable basis to evaluate the actual hidden costs and the return on investment. For example, we could measure precisely how much time, delay, transports costs and CO_2 were spared with multiplex IP videoconferencing, based on actual use and this fed the decision to deploy in the corporation. Tracing and measuring is also a critical resource in the incurring discussions with the relevant services and decision-makers when it comes to change the institutional rules and negotiate who will pay for what (cf. infra): nothing is more convincing than actual examples in such discussions.

Beyond this oversized and flexible infrastructure, the RAO room is served by two full-time highly skilled "wizards" who are in fact system engineers with a multidisciplinary training in informatics, networks, telecom and multimedia; and had the capacity to draw specialists in a large array of scientists of the R&D division, for example, for cutting-edge security issues, virtual reality, sensing, communication networks, parallel processing, and so on. Observation is supervised by social psychologists and cognitive scientists on permanent or long-term contract.

Experience shows that permanent staffing with several wizards is a critical requirement for success. Several (at least two) wizards are needed, because wizards also go on holidays, and when one is programming, daily or emergency maintenance must be attended to anyway. In our experience, the limitation of many university labs or under-funded industry "user labs" comes from the fact that there are not enough support personnel to ensure the smooth operation of real work. It would be unthinkable that a group who has reserved the RAO room for a videoconference could not perform the meeting properly because there is no wizard to help solve a

trusted: they are in the same team, they work within a few meters of them, and the subjects know what will be done with the data, and more still, that they have an immediate interest so that these data are of good quality in order to improve their experimental environment. The situation is similar to that of the patients taking part in experimental protocols which aim at discovering drugs which could cure them.

technical issue: the Mother Room is used for real operations. This is precisely what enables it to tackle real world-problems, involve real stakeholders, and to prove that the technology being developed is efficient and robust.

3.3 Usability Design Criteria

We set up a set of design criteria for usability of information systems:

- Zero training "no time to learn": use pre-existing user cognitive skills and representations (design for cognition).
- Zero configuration: users have "no time to install".
- Zero user maintenance, it is not manageable: provide instant hotline support.
- Zero impact on user workstation, because often users' workstations are locked: no specific client should be needed.
- Zero complication, two clicks maximum to get result, trivial GUI: the technology should disappear; in activity based-design only the goals of the user are relevant for the user, the system's goals should be transparent.
- Zero euro, "or, anyway, not on my budget": all costs are taken care of on the server side, paid by the owner of the system, not by the user.
- Immediate benefit for individual end-user "and God bless you if it's good for the group": again design focuses on user's real motives.
- High security and privacy level compliant with corporate rules: NO compromise with security.

Although these "zero" requirements seem tough, they are possible to meet especially with web services which need only a very light client, and have, with web 2.0 and sensing techniques, the capacity to offer a situation-adapted GUI. Still, the reality test is extremely severe, and many sophisticated items which seemed at first to be good solutions were abandoned, for example, various types of touch displays, early blue-tooth systems, and so on because, although they could be used by experts or friendly users, they would not stand the reality test of normal users in normal conditions. Lahlou (2005) lists a series of such practical issues.

3.4 Lessons Learned

Continuously keeping in-house a running beta-version of the future organization is costly but has many advantages. The first is that it enables testing in real conditions how far new solutions are usable within the local company culture and socio-technical infrastructure. Inter-operability at technical level is one obvious issue; but even more complex to evaluate are the integration issues of new modes of conducting activity with the new system. For example, the Laboratory of Design for Cognition was the place where in 2000 the nomadic workstation concept was tested within the company, with VPN secure access to the highly-protected company intranet. This enabled measuring the pros and cons of having company staff working in nomadic ways, including legal aspects and family life impacts, the actual costs and volumes of connection, and so on. The same was done with wireless infrastructure;

PDAs; reconfigurable meeting-rooms; upgrading to the next Windows OS; IP videoconferencing, online synchronous collaborative platforms; various types of biometric access; IP telephone; virtual architectures for servers; augmented reality with RF-ID tokens, online video-editing, to mention the most prominent technologies which were tested than disseminated. Most of these reality experiments were simply using commercial-off-the-shelf physical components as advised by Johansson, Fox et al. (2009); the challenge was in fact to create the adequate adaptations of the two other layers: representations and institutions.

Most of the time, the technical layer "worked" within a few weeks, but it took usually three to seven years for the other layers to be co-constructed with the rest of the organization, in a continuous struggle.

The development cycle usually followed the following phases:

1. In the beginning, the team spots a potentially interesting technology, and manages to source it (get a working version and a direct "R2R"—Research to Research—connection with the laboratory, start-up, R&D of provider). At this stage, the technology is considered as, at best, a useless gadget—if not a potential safety, security, organizational, or economic threat by most people especially the middle management, IT services, corporate security, and the procurement division. Unless the experimental unit manager has full clearance and coverage by the highest level of the top management (a blank check, basically), the experiment would stop before it can even start. Getting direct connection with the source is essential because at this stage the system may be unstable, changing fast, poorly documented and needing adaptations to the specific context of the organization, or simply "not yet really" on the market.[5]
2. During test phase, the unit must not only manage to make the system work internally, but involve powerful allies within the organization, and convince, on an individual, and often friendly and informal basis, the crucial gatekeepers, especially finance, top management and maintenance. It is crucial that members of the unit have a large and powerful network, and enough official support to access gatekeepers. A lot of what is done at this stage is informal, and the formal reports only reflect a minor part of what is actually tested, because the rest may be in contravention with current formal corporate rules.
3. When it becomes obvious that the technology is mature, stable, useful and profitable, a plateau occurs, where the use is tolerated but not officially part of corporate policy. During this phase which can be excruciatingly long, while nothing seems to happen on the surface, the technology expands informally and small lobbies of users try to get official access. A series of battles and benchmarks take place redundantly in many units against other systems and especially the current official solution, which is defended by internal lobbies, administration and external providers. At this step, defenders of the current solution fight with desperate energy to maintain the existing organization and routine, and will often put strong and indirect organizational pressure on the innovation unit to de-credibilize the new solution or even try to remove it with its source; for example, by financial blocks or accusation of jeopardizing security.

5 In our experience, vendors are often exceedingly optimistic in their presentations of their products, especially about the dates of release of a stabilized usable version.

4. Finally, the solution is taken over by the official structures. The frustrating part at this stage is that the work of the innovating unit is then completely forgotten or minimized: after all, this is (by the time the innovation is adopted) a solution that is commercially available off the shelf, so what? The non-technical aspects of the innovation problem-solving are hardly acknowledged, except by a few top managers.

It is the nature of innovation to "effract" the existing structures, and cause some level of resistance, fear, and conflict. It is also a general rule that the innovation will deploy only if users and stakeholders adopt it, and this means that the origin of the innovation must be forgotten. Therefore, such innovating units should not expect much official recognition. It was rather unexpected that ours finally obtained a permanent status. More often than not, the innovators' destiny is exhaustion and organizational death (Alter, 1993), while their innovations survive.

But, on the other hand, we got some strong support from powerful users; and a lot of informal recognition as "the place where new things are" and word of mouth was enough publicity so that, after a couple of years of existence, the unit was the place where naturally, and informally, innovators converged with a solution and users with an exotic problem, both in search of someone to talk to. At this stage, the unit, fueled by this continuous source of offers and demands, could operate as a reactor by enabling and supporting people who came with a problem and volunteered to test some of the solutions in the unit's portfolio.

One interesting feature of experimental reality organization-wise, which counterbalances its apparent subversive aspect, is that it has the remarkable property of enabling quite tight risk control. On the budget side, the costs of the unit are known in advance because they do not vary much with the projects, and there is considerable elasticity in the amount, size, and type of projects that can be monitored simultaneously by such a unit. On the administrative side, the perimeter of the enclosure where "non-standard" procedures take place is also quite well known, specific audit and control procedures can be implemented; and by the very nature of continuous observation, documentation and tracing of what happens is easy.

4. CONCLUSION

Current techniques of development and innovation, because they take place in the framework of "project management," tend to focus on local technical design issues and to overlook the socio-cognitive impact of the new system on the rest of the organization. This enables cutting down design costs and saving time; but tends to generate severe problems and costs when the system and the general organization have to adapt to each other at later stages, during dissemination, operation, maintenance and evolution (DOME).

The theoretical framework of *installation theory* describes the three layers of reality (physical, mental, and institutional) in which the designer must monitor changes by installing distributed devices of guidance and control for the new system. As these three layers are complementary and sometimes redundant, the designer is given some freedom for opportunistic choice, by addressing in priority the layer which gives the best efficiency/cost leverage. Experience shows that technology is not always the best angle to approach the problem.

It appears that, in large socio-technical systems, the complexity is such that it is extremely difficult to predict actual impacts of the innovation in the system, and especially its negative externalities upon distant domains in the organization and on the user side, where the system messes an already installed ecology of technical devices, mental habits, and institutional regulations. These externalities might mean massive future costs (for example, in employee resistance, training, maintenance cost and so on) which of course the project tends to overlook.

Experimental reality consists in testing the new system in a limited domain fully integrated in the rest of the organization (for example, a small service or operation). Beyond the usual benefits of participative design, experimental reality enables testing the compatibility with the rest of the system and the ways in which adaptation and dissemination is possible. It is therefore possible to anticipate future problems in a realistic way, explore solutions, and dimension costs and added value. By meeting the DOME issues at the interface of the new and the old system, it is possible, to some extent, to integrate preventive features at design stage. Furthermore, keeping the innovative unit alive along the life of the system in connection with the departments in charge of Operations and Maintenance (for example, using it to design the evolution of the future system) enables keeping alive the organizational memory and having a continuously updated system.

The method was successfully applied in a large corporation of the energy sector. We described in detail how this was done (especially in the case of videoconference rooms). We provided the list of our design criteria for usability, and also a series of principles and lessons learned in operating several innovations.

The experimental reality approach we advocate goes against the current mainstream trend of managing innovation "in project mode." It does not apply to all cases. Still, we believe that in many cases, especially in large and complex organizations like the one we described, because this approach solves problems before they occur on a large scale and at irreversible design stages, it can save a considerable amount of time, costs, and produce both happier users and a smoother organization.

REFERENCES

Abric, J.-C. (1994). *Pratiques sociales et représentations*. Paris, PUF.

Akrich, M., M. Callon, et al. (2006). *Sociologie de la traduction: textes fondateurs*. Paris Mines Paris, les Presses.

Alter, N. (1993). "La lassitude de l'acteur de l'innovation." *Sociologie du travail* (4): 447–468.

Bauer, M.W. (1991). "Resistance to change: A monitor of new technology." *Systems practice* 4 (3): 181–196.

Bedny, G. and D. Meister (1997). *The Russian Theory of Activity: Current Applications to Design and Learning*. Mahwah, New Jersey, Lawrence Erlbaum.

Berger, P. and T. Luckmann (1967). *The Social Construction of Reality*. New York, Doubleday.

Bödker, S. (1991). Activity theory as challenge to system design. *Information system research: contemporary approaches and emergent traditions. Proceedings of the IFIP TC 8/WG 8.2 Working Conference*. H.-E. Nissen and Sanström, Elsevier: 551–564.

Bödker, S. (1996). Applying Activity Theory to Video Analysis: How to Make Sense of Video Data in Human–computer Interaction. *Context and Consciousness: Activity Theory and Human–computer Interaction*. B.A. Nardi. Cambridge, The MIT Press: 147–174.

Coase, R. (1960). "The Problem of Social Cost." *Journal of Law and Economics* (3): 1–44.

Daniellou, F. and P. Rabardel (2005). "Activity-oriented approaches to ergonomics: some traditions and communities" *Theoretical Issues in Ergonomics Science* 6(5): 353–357.

Ehn, P. (1992). Scandinavian Design: On Participation and Skill. In: *Usability: Turning technologies into tools*. P.S. Adler and T.A. Winograd. New York, Oxford University Press: 96–132.

Engeström, Y. (1990). *Learning, working and imaging: Twelve studies in activity Theory*. Helsinki, Orienta-Konsultit.

Giddens, A. (1984). *The constitution of society: Outline of the theory of structuration*. Cambridge: Polity.

Hartkopf, V., V. Loftness, et al. (2009). Towards a global concept of collaborative space Designing User Friendly Augmented Work Environments. In: *From Meeting Rooms to Digital Collaborative Spaces*. S. Lahlou. London: Springer, 63–85.

Jégou, F. (2009). Co-design Approaches for Early Phases of Augmented Environments: Designing User Friendly Augmented Work Environments. In: *From Meeting Rooms to Digital Collaborative Spaces*. S. Lahlou. London: Springer, 159–190.

Johansson, B., A. Fox, et al. (2009). The Stanford Interactive Workspaces Project Designing User Friendly Augmented Work Environments. In: *From Meeting Rooms to Digital Collaborative Spaces*. S. Lahlou. London: Springer, 31–61.

Kaptelinin, V. (1996). Computer mediated activity: functional organs in social and developmental contexts. In: *Context and consciousness, activity theory and Human Computer Interaction*. B. Nardi. Cambridge, MIT Press.

Kyng, M. and L. Mathiassen, Eds. (1997). *Computers and design in context*. Cambridge, MA, MIT Press.

Lahlou, S. (1998). *Penser manger: Alimentation et représentations sociales*. Paris, PUF.

Lahlou, S. (1999). Observing Cognitive Work in Offices: Cooperative Buildings. In *Integrating Information, Organizations and Architecture*. N. Streitz, J. Siegel, V. Hartkopf and S. Konomi. Heidelberg, Springer, *Lecture Notes in Computer Science*, 1670: 150–63.

Lahlou, S. (2005). "Cognitive Attractors and Activity-Based Design: Augmented Meeting Rooms." Proceedings of Human Computer Interaction Conference.

Lahlou, S. (2006). "L'activité du point de vue de l'acteur et la question de l'inter-subjectivité: huit années d'expériences avec des caméras miniaturisées fixées au front des acteurs (subcam)." *Communications* (80): 209–234.

Lahlou, S. (2008). L'Installation du Monde. De la représentation à l'activité en situation. Aix-en-Provence, Université de Provence. *Habilitation à Diriger des Recherches en Psychologie*: 375.

Lahlou, S. (2009). Experimental Reality: Principles for the Design of Augmented Environments. Designing User Friendly Augmented Work Environments. In: *From Meeting Rooms to Digital Collaborative Spaces*. S. Lahlou. London, Springer: 113–158.

Lahlou, S., V. Nosulenko, et al. (2002). "Un cadre méthodologique pour le design des environnements augmentés." *Informations sur les Sciences Sociales* 41(4): 471–530.

Leontiev, A.N. (1974). "The problem of activity in psychology." *Soviet Psychology* 13(2): 4–33.

Leontiev, A.N. and B.F. Lomov (1963). "Tchelovek i tekhnika (L'homme et la technique)." *Voprosy psykhologii (Questions en psychologie)* 5: 29–37.

Lomov, B.F. (1963). *Tchelovek i tekhnika (L'homme et la technique)*. Moscou, Sovetskoe radio (Radio Soviétique).

Lomov, B.F. (1977). O putyakh postroeniya teorii inzhenernoj psikhologii na osnove sistemnogo podkhoda (Les perspective de la conception d'une théorie de la psychologie de l'ingénierie dans le cadre de l'approche systémique). In: *Inzhenernaya psikhologiya (La psychologie de l'ingénierie)*. B.F. Lomov, V.F. Rubakhin and V.F. Venda. Moscou, Nauka: 31–54.

Moscovici, S. (1961). *La psychanalyze son image et son public*. Paris, PUF.

Nardi, BA (1996). Studing Context: A Comparison of Activity Theory, Situated Action Models, and Distributed Cognition. In: *Context and Conscious: Activity Theory and Human Computer Interaction*. B. Nardi. Cambridge, MIT Press: 69–102.

Nosulenko, V., E. Parizet, et al. (1998). "La méthode d'analyze des verbalizations libres: une application à la caractérization des bruits de véhicules." *Informations sur les Sciences Sociales* 37(4): 593–611.

Nosulenko, V. and P. Rabardel (1998). Ergonomie, psychologie et travail dans les pays de l'ex-URSS. (Historicité et spécificité du développement). In: *Dés évolutions en ergonomie* ... M.F. Dessaigne and I. Gaillard. Toulouse, Octarès: 13–28.

Nosulenko, V. and P. Rabardel, Eds. (2007). *Rubinstein aujourd'hui. Nouvelles figures de l'activité humaine*. Toulouse–Paris, Octarès—Maison des Sciences de l'Homme.

Nosulenko, V. and E. Samoylenko (2009). Psychological Methods for the Study of Augmented Environments: Designing User Friendly Augmented Work Environments. In: *From Meeting Rooms to Digital Collaborative Spaces*. S. Lahlou. London, Springer: 213–236.

Nosulenko, V. and E. Samoylenko (1997). "Approche systémique de l'analyze des verbalizations dans le cadre de l'étude des processus perceptifs et cognitifs." *Informations sur les Sciences Sociales* 36(2): 223–61.

Nosulenko, V. and E. Samoylenko (1998). Activité, Cognition, Interaction, Communication: Certains aspects des approches élaborées en Russie. Paris, EDF/ANVIE/MSH: 1–40.

Nosulenko, V. and E. Samoylenko (1999). Synthèse des fondements de l'approche élaborée pour l'étude de la qualité perçue des produits et services (résumés et extraits des travaux publiés). Paris, CNET/ANVIE/MSH: 1–182.

Rasmussen, J. (1983). Skills, rules, knowledge; signals, signs, and symbols, and other distinctions in human performance models. *IEEE Transactions on Systems, Man and Cybernetics* 13: 257–266.

Rasmussen, J. (1985). The role of hierarchical knowledge representation in decision-making and system management. *IEEE Transactions on Systems, Man and Cybernetics* 15: 234–243.

Rubinstein, S.L. (1940). *Rubinstein aujourd'hui. Nouvelles figures de l'activité humaine*. V. Nosulenko and P. Rabardel. Toulouse—Paris, Octarès—Maison des Sciences de l'Homme: 129–140.

Suchman, L. (1983). Office Procedure as Practical Action: Models of Work and System Design. *ACM Transactions on Office Information Systems* 1(4): 320–328.

Wertsch, J., Ed. (1981). *The Concept of Activity in Soviet Psychology*. Armonk, NY, M.E. Sharpe.

Zavalova, N.D., B.F. Lomov, et al. (1986). *Obraz v sisteme psykhitcheskoj regulya tsii deyatel'nosti (L'image dans le système de régulation mentale de l'activité)*. Moscou, Nauka.