Co-design as a distributed dialogical design

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Abstract: *We propose the following four key assumptions, illustrated with three examples, to analyze and to organize and monitor design processes involving users. 1) Users redesign the designers' technology by using it. Thus, the coupling of the technology with the users' new activity is at the core of the process. 2) Design is a process distributed among various people whose interdependency has to be taken into account during the process. 3) Developing both the technology and the activities implies various levels of dialogue that we define, referring to Bakthin's work. 4) Focusing on one of these levels, we argue that a key issue is to highlight the various actors' differing perspectives during the design process.*

Keywords: *co-design, learning, instrument, participatory design, innovative dialogue.*

Introduction

To meet the challenges of sustainable development in agriculture, Meynard et al. (2006) argue the need for redesigning farming systems through an *innovative design*, i.e. a design that produces both new technical specifications and new knowledge -rather than using the available knowledge-. We share this point of view, but believe that this technical dimension must be handled in close relation to the "political" dimension that contributes to identifying a desirable future (see also Godard and Hubert, 2002). In this paper we present four theoretical assumptions to anchor the monitoring of co-design processes and their analysis. We view co-design as a process in which: (i) technical dimensions, on the one hand, and knowledge, practices and values, on the other, evolve jointly; and (ii) a desirable future is collectively discussed in order to define and implement acceptable solutions. In doing so, we hope to participate in debate on design in both the farming system research community and the design studies community.

Our perspective emphasizes the need to foster cross learning processes amongst designers and users in order to achieve the joint building of a technology, of a desirable future, and of the activity or the collective action in which the technology will be used. Many authors have already suggested involving users in the design process. We can roughly distinguish three trends. The first one is well represented by Von Hippel's work on lead users (see for example Von Hippel, 1986). In this trend, the main focus is on firms' competitiveness. Enrolling lead users in viewed as a win-win partnership: on the one hand, the firm that launches a new technology can anticipate some difficulties which might occur at the time of its marketing; on the other hand, the lead user firms can secure a competitive advantage due to quick access to the new technology and potential transfer of skills from the partner. The second trend is well represented by user- and use-centred design methodologies. These were devised to develop a more effective technological design process while acknowledging the fact that use and users are always crystallized in a given technology. Their aim is to take on board use and user issues so that the technology will fit the requirements set for it (for more details see for example http://www.upassoc.org). But in this approach users document the design process, without necessarily being actors in it (Caroll, 1996). The third trend is known as participatory design (for example, see Kensing and Blomberg, 1998). Participatory Design (PD) takes on board some political issues while the former two trends did not. More specifically, PD researchers recognize that technologies can have strong impacts on workers, and therefore claim that workers can legitimately contribute to the design process. Our own perspective is related to PD, but we argue that there is a need to take users' inventiveness into account before crystallizing certain uses and users' representations within the technology. We address this issue by focusing on the coupling that occurs between the technology and the user (Assumption 1). We also recognize that design is a distributed and interdependent process, but do not only tackle this at technology level. We argue the need to tackle it at a more political level, e.g. in putting into question the desirable future to which the design could contribute (Assumption 2). We then suggest, on the basis of the work undertaken within three design projects (see Box 1), that this can be achieved by identifying three levels of dialogue (Assumption 3) and by clearly monitoring these levels (Assumption 4). We present these four assumptions and their theoretical backgrounds, and use the results observed in our three case studies to illustrate some of the issues considered here.

Box 1. Three case studies in which we were involved and which we use to illustrate our four assumptions

1. DIAGVAR software (Prost 2008),
This software is dedicated to help seed breeders, agricultural advisers and people in charge of the national registration of new cultivars to assess new cultivars of soft wheat. Actually, the new cultivars are assessed in numerous cultivar trials and their assessors acknowledge that they do not take into account all the information produced in their networks of cultivar trials. Whereas they have data to characterize the cultivars in detail, they lack some tools to process these data. DIAGVAR combines agronomic and statistical methods (Lecomte, 2005) to further analyse the data collected on the trial networks. It first characterizes the limiting factors that affected the yield of the cultivars, by means of the indicators taken in the trials. It can diagnose not only the effect of pest issues and the lack of nitrogen supplies but also such climatic factors as frost, heat, water shortages or lack of incident radiation by periods of development. These are all factors that are not easily and usually observable by the assessors. DIAGVAR then ranks the new cultivars tested in the trials according to their resistance to these limiting factors.

2. A safety system (an alarm) to avoid chemical runaway (Béguin 2003).
The project was launched following many inquiries conducted in chemical plants where workers had been killed due to explosions caused by a "chemical runaway". In each case, workers who were on-site at the time of the chemical runaway all realized that something was wrong before the explosion, but they did not attempt to leave the premises until a few seconds before it occurred. There are several reasons for this, including the workers' wish to "recover" production and avoid destruction of the installation. But the main problem was their difficulty in assessing the time available before the explosion. The engineers therefore decided to develop an alarm which could help the workers to anticipate the critical moment, i.e. the explosion.

3. An alarm system to avoid systematic spraying against *Sclerotinia* in winter oil-seed rape (Cerf and Taverne 2008).
Sclerotinia is a fungus that can induce severe yield losses. In most French regions this occurs on average only twice every ten years, yet most farmers spray systematically against the fungus. This practice induces resistance in *Sclerotinia* stems to the current pesticide. Agronomists consider that avoiding unnecessary spraying is critical. The alarm system is based on various diagnostic tools (a grid to assess the level of infestation at plot level, a diagnostic kit to assess the level of plant contamination, and models which draw the contamination curve on a small regional scale). These tools can be combined in order to decide whether it is worthwhile to use pesticides. Decision-making is based on thresholds which include economic, technical and environmental criteria.

Four assumptions to drive and analyse co-design processes

As Dorst (2008) argues, “designers do not just design”. For designers, designing is also defining “the environment they work in, their approaches to design situations, the role they take in design projects, the coalitions they work with, the way they deal with stakeholders”. Indeed, each assumption is meant to clarify these points and the way we address them, as designers and as analysts of design processes.

Assumption 1: Focusing on the coupling of users with the technology

Whereas design methods frequently assume that the main goal of design is to develop a steady technology before implementing it, many authors have shown users' inventiveness when using new technologies (see Bannon 1991; Greenbaum and Kyng 1991; Henderson 1991). Users tend to take over the technology creatively, “*reinventing devices through innovative applications*” (Feenberg 1999). For example, users altered the French Minitel system and the Internet “*through* a posteriori *interventions adding human communication functions to systems that were originally destined to handle data*” (Feenberg, idem). Feenberg has a political view of this appropriation, studying it in terms of “technical democracy”. This political view is not our focus here but we think that the process of appropriation during the design process should not be ignored. How can it be taken into account?

From appropriation of a new technology to instrumental genesis

The first requirement is to recognize that, when it comes to a new technology, users do not act exactly as the designers had planned. Through a learning process, they seek to make the most of the technology and to enroll it, to increase their capacity for acting in their environment, based on their own understanding and needs. Rabardel & Béguin (2005) have called this process an “*instrumental genesis*”. The design of the chemical safety system is a fine example of such a process. A prototype of the device was introduced and used on a pilot site for 8 months. The prototype (i) displayed the remaining time before an explosion, and (ii) provided highly precise information on the temperature of the product (within a hundredth of a degree). When the prototype was introduced on the site, operators used it not as an alarm, but as a precision thermometer to monitor the process. This "instrumental genesis"[1] is linked to the workers' operating strategy: they operate the process by maintaining it at the lowest possible temperature threshold, thus keeping the “reaction over speed” at bay. But such a strategy has its own risk: if the product cools down too much, it "crystallizes" and becomes solid. This *overcooling* is a serious incident although quite different from the "chemical runaway". The alarm was very useful for keeping overcooling under control: the information on temperatures provided by the artifact was much more accurate than that provided by the other thermometers available on the site.

The second requirement is to recognize that, in this instrumental approach, the core of the design work is the design of an “instrument”, that is, a mixed entity in which the technology and the way it is used purposely by a user are intertwined. The main idea is that a technology itself is not an instrument. It is the user who grants it the status of a means for his/her action. It thus accounts for the process by which individuals, who are ultimately users, continue design in use according to a learning curve. That differs from the traditional engineering approach to design which defines it as a change of state during which a problem must be solved. To revert to the example of the chemical safety system, use of the alarm as a precise thermometer to handle overcooling was directly linked to the operators' action. This led us to explore how such an instrument would help to avoid chemical runaways while recognizing and exploiting the efficiency with which the operators managed the process.

Consequences to manage a design process

A practical consequence for the design process is that it should simultaneously articulate the specification of a technology by the designers to the inventiveness of the users as revealed through its implementation. Note that such a coupling can be problematic. In the case of the *Sclerotinia* alarm system, the users were reluctant to explore how to use the system as they lacked confidence in its predictive capacity and had no curative techniques to limit the infestation by *Sclerotinia* if the indicator gave a wrong recommendation (low infestation while it eventually became high over time). Other factors also prevented them from using the system, such as their understanding of the risk: they took into account not the frequency of attacks as the designers did, but rather the potential severity of yield losses. Other practical issues slowed down the use of the system, such as the lack of enough specimens of the prototype to distribute it to farmers and advisers.

Irrespective of the difficulty involved, we nevertheless assume that the co-designers should ground the monitoring of the design process on the coupling of the technology and its use. This theoretical assumption has two implications. First, it means that the designers must consider the technology

[1] With instrumental genesis we acknowledge the fact that users add functionalities to the designed technology, develop schemes for using the technology which were not anticipated by the designers, or modify the technology so that it fits with their current way of using artefacts to act and achieve their goals.

they design as an assumption and not as a fixed result. In each of our three cases, the prototypes were developed (criticized, modified, even rejected) with users in relation to their way of using them. Second, focusing on the design of the instrument rather than on that of the technology leads to the following question: how can the coupling between technology and use be kept alive in the design process? Answers vary among the projects and this point needs to be adapted to each design environment. As an example, the designers of DIAGVAR asked some users to simulate the use of the prototype according to scenarios. These scenarios were built according to what was known of the activity of the professionals who assess cultivars and the problems they face while doing so, as highlighted by a first diagnosis on their activity (Lecomte et al. 2010). For example, people acknowledged their need to optimize their trial networks in order to reduce the cost of assessment. We proposed that they run DIAGVAR software on their own recent databases, on which they had robust expertise, so that they could see how it could help them for that issue.

Second assumption: focusing on a distributed but interdependent design process

It is well known that design is an interdisciplinary activity which typically involves people of different professional orientations working in teams (see Bucciarelli 1994; Terssac and Friedberg 1996). Two principles underlie this collective dimension: *distribution* and *interdependency*.

The distribution principle stems from the complexity of the design process. Regardless of the object being designed (a factory, a vehicle or a farming system), it is too complex for a single person to be able to represent all of its inherent problems and to possess all the abilities to solve them. The distribution principle assumes that this complexity is distributed among the members of a working team. The second principle is interdependency: specialists must articulate their different contributions. Interdependency appears directly in the technology being designed. Any modification or improvement made to one component of the technology may have an impact on the other components.

From our perspective, users can be seen as use experts who have developed their own knowledge, practices and values, which most probably differ from those of institutional designers. That is why their way of experiencing the coupling with the technology is unique. For example, the designers (i.e. agronomists) of the DIAGVAR software assumed that the simulations run by the cultivar assessors on their own databases would reveal their expertise, practices and values. In debriefing sessions which took place after these simulations, the users challenged the biological and statistical assumptions that the agronomists had embedded in the software to describe the genotypes and environmental interactions. For instance, the users made explicit their understanding of the growth and development processes of the cultivars in their own trials, as well as their appraisal of the variability of the cultivars' response to environmental factors in their networks of trials. Their views differed from those of the agronomists, while highlighting some relevant discrepancies among users and designers. For instance, some potential users of DIAGVAR objected to the outputs of the software concerning the existence of one particular limiting factor in one specific cultivar trial. To take on board this problem, agronomists had to work on more accurate indicators for the given limiting factor and to test the sensitivity of the statistical methods used to identify that factor in a given trial.

Apart from the direct consequences for the technology, we assume that interdependency must be taken into account in the building of a common undertaking. We then follow a path similar to that of Hutchins (1995), who states that the organization of cognitive activity is more important than individual cognition to explain the achieved performance for a given activity. This is particularly true during design. Interdependency is not only at work at the level of technology; it also has to be considered at the level of the “desirable future” or at that of the learning processes. We expand on this idea in the following section.

Third assumption: focusing on design as a dialogical process

Many authors have applied communication theories to analyze design. Day (1995) and Brown & Duguid (1994), for example, proposed models in which designers try to design a "readable artifact" for the users. In relation to local development, Long (2004) argues that, at the "*social interface*" between the different actors of a process of change, there are multiple discourses which serve to promote dominant political, cultural or moral standpoints.

Design as a dialogical form between actors.

Even though language clearly plays a role that cannot be undermined, it is only one of the possible dialogical forms. We therefore assume that design may be a dialogical form based not only on language but also on a technical medium. But, to consider the design process as a form of dialogue between heterogeneous actors, we need to specify the status of the technologies within that process. While, as argued above, technologies reflect designers' assumptions, they also mediate the exchanges between the actors (Erickson 1995; Vinck 2001). Graphic representations, maps, scale models, prototypes and others convey the diverse assumptions made not only by designers but also by users, and show their disagreements or dilemmas. In that sense, they are points of articulation of the collective work, and media for the dialogues.

Bakhtin (1993), who worked on dialogue to study the recognition of otherness, argues that dialogue takes place when the actions of one interlocutor "replicate" or "respond" to proposals from the speaker. During dialogue, the interlocutor needs to take into account the words of the speaker and to formulate a response that uses these words as potential resources. The "response" is therefore double-sided: half-interlocutor, half-speaker. But the speaker may impact the thought and action of his/her interlocutor at different levels. Bakhtin distinguishes three levels of dialogue: external, internal and macro. We will now explain how we propose to characterize these dialogical levels in a design process, and will examine their consequences on design.

Three levels of dialogue enabling different learning processes among the participants

At the first level of external dialogue (the one most often called "dialogue"), it is the object of the discussions that evolves. In design, it is the object of the design, e.g. the technology, that evolves. We assumed that this first level of dialogue is the driving force for the development of the technology. The case of the safety system illustrates this point. We have already shown in this case (first assumption) how the workers assigned new functions to the result of the designers' work (the prototype of the alarm): they used it as an operating aid rather than as an alarm. This is a "response" by the users to the designers' assumption. Such responses may validate or refute the designers' assumptions, but will often set in motion the design process. In our case study, the designers took this response on board to develop a second version of the artifact, to which they added a display of the historical record of the temperature changes. This made it possible to interpret the thermal kinetic "trend" of the product, a strategic variable used by the operators in preventing crystallization. Designers relied on the users' response to produce a second version of the prototype. In this example, the artifact developed through the dialogue that it supported.

For the second level, Bakhtin speaks of an "*internal dialogue*". This term conveys the idea that dialogical processes most often produce internal tensions or dilemmas for the person, which may open onto a development at the level of the actors' activity (Béguin 2003; Engeström 1987). So we assume that this second level of dialogue is a driving force of the development of the practices and values of each participant. For example, during the debriefing sessions in the DIAGVAR case, the users acknowledged that their work organization may induce some difficulties in collecting the data required for running the DIAGVAR software. It turned out that this difficulty existed prior to the activity of assessment, even though the use of DIAGVAR increased it. This prompted the users to think about how they could reorganize their work. Several propositions were made and implemented, which differed from one actor to another, according to the specificity of his/her situation. This entailed changes in several dimensions of the activity of assessment, such as the tools used to collect and analyze the data from the trials, the division of work among different people (those carrying out the trials, those collecting data on trials, those selecting the cultivars to assess, aso), and the skills needed to work on the data (recognition of the need for statistical skills). Designers may also be challenged by this internal dialogue. In the case of the *Sclerotinia* alarm system, the designers took on board the need for advisers to use the system at local level within a network of fields, whereas they had first imagined a direct use by the farmers at plot level. They then had to develop new methods to assess the relevance and robustness of the thresholds of infestation at this level, by developing their own design activity. This internal dialogue is a driving force for learning in participatory design, as many authors have shown (for example see Bjerknes and Bratteteig 1995). We assume that this level is critical to develop the participants' expertise, practices and values.

The last level suggested by Bakhtin is the "*macro*" dialogue. Bakhtine also called it the "*great dialogue*", because it is supra-individual and goes beyond the current "external" dialogue of the interlocutors. The main argument is that people take part in the dialogue with their ideas, with all that they have already built, said or done. We assume that this level includes notably what each one has constructed as a "desirable future" and that will need to be collectively re-built. It is a crucial level for taking on board the political dimension of the design process. Dialogue is then not only an inter-subjective process. Through the building of the desirable future, everyone takes part in a collective history, which is often implicitly conveyed during the dialogue and to which everyone contributes through external and internal dialogue. We discuss this macro-dialogue level more specifically in the next section.

Fourth assumption: driving the design process through the "visibilization" of the macro-dialogue

From our perspective, dialogue does not mean that the actors will share the same knowledge, the same ways of acting or the same values. It contributes essentially to revealing contradictions, dilemmas or controversies that constitute a driving force of the design process. These dilemmas and controversies reveal matters of concern that have to be shared and taken into account by the actors during the design process. We assume that it is therefore crucial that participants can acknowledge their diverse stances and discuss them during the design process.

We use the term "visibilization" to denote the transformation of disagreements or dilemmas between the actors in a process of collective interpretation of the matters of concern, in which the actors learn and make decisions accordingly. Rasmussen (2000) has already pointed out the key role of making controversies and dilemmas visible and collectively graspable in organizations. Nardi & Engeström (1999) emphasized this role regarding work issues. In numerous situations, individuals and work are both invisible: they are dissolved into a set of indicators or procedures, whether formal or quantitative (Béguin, Owen & Waekers, 2008).

What do we mean by "visibilization" of the macro-dialogue?

Through an anthropological analysis of design activities, Bucciarelli (1994) showed that engineers with different professional backgrounds have different ways to grasp or to focus on the same object: a "stop button emergency" for an automation engineer is a "junction box" for an electrical engineer. Although they are looking at the same object, each one grasps different properties of that object. What is significant and relevant for the one is without interest for the other. They have different professional perspectives grounded on what Béguin (2003, 2009) calls *professional worlds*. Each professional world is potentially a source of matters of concern, of purposes and of potential solutions. During design, we assume that design is a situation in which different experts, driven by their respective purposes and ways of thinking and acting professionally, contribute to the macro-dialogue, and that the macro dialogue is the process that reveals the diversity of the professional worlds, as well as the need to articulate them.

How may visibilization lead to learning?

Obviously, designers and users do not share the same professional world[2]. Based on our experience, we think that many of the contradictions and dilemmas that emerge during the macro-dialogue between users and designers stem from the fact that they have different perspectives on the same situation or object. For example, the safety alarm was turned into an operating aid in the case of the chemical plant. However, the designers could not accept the idea that the users had assigned the function of an operating aid to the alarm. Such use violated a European norm, which stipulates that "monitoring systems" should be separate from "instrumented safety systems". Furthermore, while the device enabled the operators to prevent crystallization, what role did it play regarding the runaway risk? In this example, dialogue produced an unsolvable contradiction. But the process of "visibilization" helped to reveal that designers and workers did not share the same perspective: they grasped and worked on different properties of the same situation. Indeed, the introduction of the alarm had put two perspectives "face to face". The first pertained to overcooling and to the risk of the product solidifying. The operators had developed their skills in this "realm". Their professional world was a "world of cold". As noted above, the alarm was very useful for keeping overcooling at bay. Thus, the users embedded the alarm in their own professional world. But the engineers had a different professional world, a "world of heat" – with reference to an explosion. The technology or, more exactly, the knowledge upon which it was based and that it embodied, was the outcome of *chemical runaway expertise*. Finally, "visibilization" allowed the group to objectify the fact that users and designers focused on different characteristics and properties of the chemical process: none of them was able to grasp all its properties. But each of them recognized that all those properties were relevant and necessary to identify and solve different problems. Hence, the macro-dialogue reveals the range of problems that should be explored and solved during design.

How may visibilization change the design orientation?

Macro-dialogue may also orientate differently the "desirable future". In the case of the *Sclerotinia* alarm system, the farmers appraised the risk of infestation by *Sclerotinia* on the basis of the severity of the yield losses it could induce, while agronomists appraised it according to the frequency of a severe attack. Until then, they had used a relatively cheap pesticide but during the design process they become aware of the need to reduce their use of this pesticide due to the outbreak of Sclerotinia strains resistant to the pesticide. Alternative products were fairly expensive but farmers still feared potential high yield losses. Faced with this dilemma, the actors involved in the project started to think differently about the need to reduce pesticide spraying, and envisaged connecting the alarm system to insurance services. In this case, the different worldviews merged to create an acceptable future: less use of pesticides, and fewer risks of economic failure, owing to the insurance system.

Conclusion

In the traditional engineering approach, design is perceived as a change of state during which a problem must be solved. In this paper we examine design as an emerging process in which the relations between actors are both a source and a resource. To account for this emergent process and to foster it, we have proposed four assumptions which we view as drawing a coherent framework. This framework highlights the learning as well as the political dimensions of such an emergent design process. It changes the focus of the design process from the technology to the coupling of the technology and its users, and therefore assigns a key role to dialogue among designers and users around the technology under design.

[2] Most often, the dialogue between users and designers is defined as an exchange between scientific versus practical knowledge (Nassauer & Opdam, 2008). Even though scientific or practical knowledge is exchanged among the participants of the design process, our focus is not on knowledge as such, but on what the participants in the process decide to do with it.

In the famous metaphor of the "*reflexive conversation with the situation*" proposed by Schön (1983), design is described as an open-ended heuristic process in which the designer, striving to reach a goal, projects ideas and knowledge on a sketch or a graphic representation. But the situation replies and surprises the designer by presenting unexpected resistances. Such an approach is relevant for us: design is an emergent process which reveals unexpected matters of concern or problems that have to be solved. In focusing on the dialogical processes, we argue that sketches or graphic representations or mock-ups and prototypes are a crucial means for obtaining surprising feedback. Indeed, the participants in the design process "*reply*" to the assumptions embedded in a prototype, a mock-up or a graphic representation, and these replies "*surprise*" too, while revealing the various matters of concern or problems that need to be solved and grasped collectively by designers and users through an innovative dialogical process. To sum up, we can use a metaphor. Design is a journey which takes place between a "desirable future" and the achievement of an effective process of transformation. But to make this journey, players have no map, for the path is not given, it has to be built. Dialogues supported by "visibilization" are key processes which reveal the space that designers and users need to explore jointly in order to achieve a common undertaking.

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