Design in use: some methodological considerations

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Abstract
Design-in-use refers to ways in which users take over existing products according to personal needs, and practices beyond product design. It involves emergence of unanticipated uses, and transformations in the structure and characteristics of the product. In this paper, we describe theories put forth over the last decades describing interactions between designers and users, and present a state of the art of methods and tools used to support these. In our view, existing methods understate the importance of users' motivation to interact with designers. We propose a discussion of related issues as a first step toward the introduction of new methods to assist design-in-use.

Keywords:
Human-centred design, Optimization, Knowledge management.

1 INTRODUCTION

User involvement in the design process aims to gather knowledge of existing needs and practices to design products that are better suited to them. Several authors have contended that the end product "crystallizes" designers' representations of users and uses they make of the product [1, 2]. Real-world use can be thought of as a test of these assumptions. Although the emergence of unanticipated uses was first thought to be a mark of poor workmanship on the part of designers, "design-in-use" posits that design continues into the stages of product use through users' "tailoring" of products, or as Folcher put it, "operators' development of their own instruments to serve their individual activities" [3].

One view in the field is that user-designer interactions support a mutual learning process [4, 5]. In this paper, we contend that this process can further be described as the co-construction of an abstract space defining acceptable uses of the product. The second part of the paper lists theories put forth in recent years to describe user-designer interactions, specifically those concerned with defining this space. The third offers a state of the art of existing methods used in such interactions. In the final part, our analysis leads us to make first steps towards a transactional model of user-designer interactions, aiming to help explain and control the emergence of new uses of a product.

2 PRODUCT USE AS THE RESULT OF DESIGNER-USER INTERACTIONS

2.1 Use as a balance between compliance and appropriation

Several authors describe use as a double-sided process involving, on the one hand compliance to prescriptions in use and on the other hand redefinition of these constraints according to personal and situational factors [6-8].

Design with Intent (DwI) [9] refers to a number of concepts proposed in recent years to help designers define and convey specific uses of a product as being "preferable" to users. These include Norman's discussion of "affordances" [10] as directly perceptible mappings between artefact characteristics and potential uses; the use of various "barriers" [11] to guard against unwanted uses, be they physical, symbolic, functional or otherwise. As Lockton et al [9] point out, DwI has focused less on methods to convey intent and more on the underlying ethical concerns. How, when and why should one convey specific uses as being acceptable, and deem other uses unacceptable?

The response put forward by the "French-speaking" tradition of ergonomics [12] is to define variability as a fundamental element of human activity. Task-related constraints are greeted by a user-driven process of adaptation. Thus, although user behaviour can be broadly characterized, interactions between the user and situations-of-use preclude a complete and precise anticipation of use behaviour. This has led to broadening the spectrum of analysis and viewing use as a social phenomenon.

2.2 Use as social fact: communal acceptance and rejection of products and prescriptions of use

Proulx [13] describes two strands of research regarding the social aspects of product use that mirror the divide mentioned above. A first strand focuses on the social mechanics of acquisition and transmission of patterns in product use. Bourdieu's concept of *habitus* exemplifies this, since it defines social class as a unit for the dissemination of practices in everyday life [14]. Following this concept, users belonging to the same class also tend to exhibit similar tastes, and therefore potentially use similar products in similar ways. This first strand therefore views product use as a result of social determinism.

A second strand is concerned with the mechanics of product appropriation by social communities [15]. It stresses social acceptance of a technology as instrumental to the diffusion of innovative products and practices. Product functionality is only partly responsible for such acceptance. Proulx [13] thus describes cases of "civil disobedience" in user communities, characterized by the enforcement of alternate codes of conduct and values. "Copyleft" is an example of such an overarching concept framing a specific aspect of use, in this case reuse of a specific work within other works.

2.3 Synthesis: use as a "trial" of the product

Use can be viewed as a balance between prescription of use and user appropriation on two levels, that of individuals and of social groups. To quote Jouët [16] : "Appropriation is a trial. It is the act of composing one's self" (our translation). We agree with this, since product use involves an evaluation, on the user's part, of the product's capability to respond to specific needs. Noticing a discrepancy triggers either product rejection, or transformation of its uses and/or structure. In this we subscribe to Simondon's view of technology as evolving in Darwinian-type adaptation to user needs [17]. Only

successful solutions, both in terms of new products and of new uses of existing products, are kept and shared with the community.

This echoes directly to Von Hippel's discussions of user innovation processes [18]. Relevant transformations of the product may be shared within a community, by members he calls "lead users", who combine knowledge of specific and personal needs with technical know-how which allows them to propose and implement existing solutions. In most cases however, such knowledge is distributed. The emergence of unsatisfied needs triggers an examination of existing resources for innovation. Such resources can be personal in the case of lead users. But von Hippel also points out that product personalization may also stem from user-manufacturer collaboration. Repeated exposure to specific user needs allows manufacturers to select transformations deemed most relevant to users, leading to what he calls "manufacturer-centric" innovations.

However, Von Hippel points out, user-manufacturer collaboration is imperfect compared to user innovation. Users can freely share innovations within communities. This totally changes the balance of use prescription vs. product appropriation for several reasons:

- Values associated to product appropriation are very different. Appropriation is viewed in a positive light since it can give rise to innovation. Indeed, in some communities, contributing to the effort may be seen as almost contractual, since unreciprocated profit from use can lead to effects of social branding (e.g. the stigma associated to "leeching") [19];
- Values associated to use prescription are also different. In the case of open source software design, for example, prescription is superseded by overall contractual principles, e.g. total access to software code in exchange for crediting original authors [20, 21].
- The user-designer loop is tightened by the fact that they are generally the same people. Spaces for exchanges regarding existing needs or future uses function according to communal rules (e.g. meetings, forums, emailing, etc.) which differ from the user-designer or user-manufacturer relationship which is contractual in nature [22].

As we will see in the second part, one problem of existing methods for use analysis is the asymmetry they introduce between designers on the one hand and users on the other hand.

3 METHODS FOR USE ANALYSIS: SOME FORMS OF COLLABORATION BETWEEN DESIGNERS AND USERS

User centred design has fostered a varied set of methods for the analysis of product use. In this part, we provide a short state of the art of these methods. Following the distinction made in the first part of the paper, we examine existing methods according to two levels of dichotomy. The first level concerns whether methods are geared toward prospective or retrospective analysis of product use. The second level concerns whether the unit of analysis is the individual user or groups of users. We will conclude by presenting our view on the limits of existing methods.

3.1 Prospective vs. retrospective use analysis

Original models of user-centred design advocated retrospective evaluation of the usability of design solutions against user requirements. Such methods are classically divided in three categories [23]:

- User testing, which examines user behaviour with the product in the context of typical tasks, e.g. based on performance measurement or think-aloud protocols.
- Inspection methods, which requires a usability specialist to examine the product and apply domain-specific knowledge, e.g. through heuristic evaluation or cognitive walkthroughs;
- Survey methods, presented in the next part.

Two main elements stick out from this classic framework of usability engineering. The first concerns the gradual broadening of the spectrum of analysis from usability to the wider realm of "user experience" [24]. The second concerns the use of analysis results and extrapolation of the results to future situations.

An increasingly large toolbox

Usability, defined as "the effectiveness, efficiency and satisfaction with which specified users achieve specified goals in particular environments" [25], was long considered as a yardstick by which a product's quality was measured. It originally included three classic components: effectiveness, i.e. "the accuracy and completeness with which specified users can achieve specified goals in particular environments"; efficiency, i.e. "the resources expended in relation to the accuracy and completeness of goals achieved"; and satisfaction i.e. "the comfort and acceptability of the work system to its users and other people affected by its use".

Further, more recent, developments gradually came to consider many more aspects of "user experience" as measures of quality of use, e.g. beauty, affective, hedonic or experiential aspects, which call for new conceptual models of human experience or for new methodological tools. Methods used in the evaluation of these "non-instrumental" aspects can be based on various methods. Following Cahour's work on measuring affective aspects of product use [26], one can identify several key requirements in choosing the appropriate methods and tools:

- A robust model, built on a multidisciplinary theoretical framework, in order to clearly identify what are the methodological issues at stake;
- A choice of appropriate methods of inquiry based on the strengths and weaknesses of each method;
- A model of designers' needs, to interpret the results gathered and set up "higher degree frameworks".

Broadening interest to more aspects of user experience led to widespread use of methods from the realm of social sciences. Choosing the appropriate method depends in particular on project-related constraints. For example:

- *Available human resources*. Daniellou [27] thus distinguishes "the ergonomic intervention" (which involves a field-based inquiry by a professional) and "ergonomics without an ergonomist" (e.g. based on generic rules and guidelines). Likewise, specific methods such as those based on ethnomethodology require specific training to be chosen and put into practice ;
- *Ease of access to users and situations of use*. Difficulty in accessing specific users or situations, either for physical reasons (e.g. participants are unable or unwilling to participate; situations are infrequent, dangerous or similarly "out of bounds") leads to the frequent need to rely on simplified ("quick and dirty") solutions. Questionnaires and inquiries often rely on standard indicators to obtain

data regarding specific dimensions of the use of an existing product. Likewise, experimental methods may be used to construct and study situations that are beyond reach, at the cost of reducing their complexity and possibly the relevance of results to design [28];

- *Precedents and state of business in the field*. Some areas of design are the focus of much methodological toil simply because there is demand for streamlining the evaluation process. Website and software design have been the subject of several sets of guidelines. Banking on the success of innovative systems relying on Virtual Reality (VR), Bach and Scapin [29] proposed a set of principles for the design of Virtual Environments.
- *Stakes of user centred design*. This largely depends on how much time and money stakeholders are willing to invest in designing a product that is suited to user needs. For example, many designers argue that ergonomics should be integrated in the early stages of the design process, whereas methodology to implement this is still a bone of contention [30].

Foreseeing future use

One reason for the inability of designers to integrate use-related knowledge early on in the design process is that the introduction of new elements within human activity is likely to cause in-depth changes of habits in use. For example, Folcher's study of the use of a problem-solving database by telephone hotline operators [3] showed that contents of the database were reorganized by users according to the type of problems they solved in their everyday activity. Cerf and Meynard [31], while studying the activity of agricultural counsellors, found that a basin intended to be used as an automated parasite trap for rapeseed plants on a one-by-one basis was used as a tool to help decide when to start anti-parasitic treatment on whole fields. Both these examples illustrate strong "design-for-use assumptions", i.e. the construction of a mental models of what Daniellou [27] terms *characteristic situations of action* in the use of existing products, as well as potential situations of future use.

Extrapolation from one to the other is a form of counterfactual reasoning. As Roese and Olson point out, construction of counterfactual scenarios stem from localized changes in specific variables of existing scenarios [32]. Therefore, methods for prospective use analysis, i.e. projection into simulations of "what might happen", always depend on models of existing situations. Various methods depend on various postulates:

- Prior occurrence in other, similar situations can serve as a starting point for users to simulate what would happen with a different product. For example, Flanagan's critical incident technique may be used to identify problematic situations and likely causes of the problem, as levers to construct new scenarios and examine users' counterfactual behaviour based on premises such as "How could this have been avoided ?" [33];
- Users can rely on existing problem-solving strategies. For example, information-on-demand and Wizard-of-Oz type techniques [34] can help elicit user needs in terms of information and expected system behaviour in solving such problems.

In short, prospective analysis is usually based on fostering the construction and use of mental simulations. One last point we would like to make is that several media may be used for such operations.

- Storyboards describe the key elements of a situation on a series of panels [35]. By nature, a storyboard is a partial representation in both senses of the term: time-wise, it only shows part of the story and leaves the user to "fill the gaps"; content-wise, it shows a fixed point of view on the situation, which is chosen by designers. Film-based techniques [36] are richer with information but have much the same limitations. One key difference, however, is freedom regarding content. One can only film existing situations, but sketch any kind of situation.
- Interactive simulations insert the user in a scripted situation, while offering limited possibilities for interaction. These limits, which mostly stem from interface characteristics, are counterbalanced by the expected benefits of interactivity. Although simulations can rely on various media such as role playing or CAD simulations, Virtual Reality (VR) has been the subject of much interest, since its capacity to immerse the user in a potentially realistic environment, easily gather use-related data and afford a sense of "presence" have been hailed as the next gateway toward prospective use analysis [37].

However, as several authors point out [38-40], physical realism of simulations is not paramount to obtain reliable data regarding future use. The goal is what Burkhardt [39] terms "psychological realism" i.e. to place the user in a situation where his behaviour can be reliably said to be an accurate description of future use behaviour. This involves a shift in points of view from the present to the future situation. This concept of "shift" is also prevalent in recent work on "inclusive design", which relies on external apparatus to project designers in situations of use which are not characteristic of their typical everyday experience, e.g. an exoskeleton to simulate effects of aging.

3.2 Use analysis from individual vs. social points of view

From the I-methodology to the them-methodology

In the continuum between use analysis methods focusing on the individual and those focusing on large groups of users, one extremity corresponds to what Akrich [15] calls "I-methodology", i.e. methods whereby designers "put themselves in the user's shoes". One major drawback of such methodology is that it reduces the relevance of the designers' mental models by reducing the number of variables involved. Thus, major variables force designers to call upon stereotypical models of user behaviour [41] whereas minor variables are kept "out of sight". But what constitutes a major and a minor variable? We contend that "major" variables are those which designers, through everyday experience, know that they will likely have a large-scale impact on user needs and characteristics. For example, Oudshoorn and her colleagues [42] have gathered evidence for gendered representations of users in HCI design.

The opposite end of the scale, so to speak, corresponds to investigation methods based on the study of large user groups. Market studies and surveys exemplify this, and involve a large number of methods aiming to identify user habits and needs, market trends and key competitors, market segmentation etc. based on methods such as focus groups, polls and surveys, and the like. As Hyysalo [43] points out, "users' preferences for alternative product concepts are gathered measured and transformed into (preferably measured) characteristics of the emerging product. Other methods such as those involving participatory design, have been used to provide more reliable information on user needs. As both Hyssalo [43] and Darses and Reuzeau [44] point out, however, several different setups can be envisioned for user involvement,

whose primary difference depends on the degree of decision-making power allotted to users. In cases of low involvement, user feedback can be provided to designers for merely inspirational purposes. In cases of strong involvement, users can be part of decision making processes just as (if not more than) designers.

In short, the goal is to help transitioning from an "I methodology" to a "them methodology" in which a steady flow of information originates from the user, and even, ideally, an "us methodology", in which authentic forms of designer-user collaboration can be found. We now define this term

User collaboration in use analysis practices

When one examines the ways in which designers and users interact beyond the stages of product design, most situations of interaction involve problem-solving services, such as using a technical hotline. These involve a specific form of collaboration aimed toward diagnosis and problem solving [45]. The following remarks can be made concerning the characteristics of such interactions:

- Speed: Feedback is generally fast and has a single, clearly defined objective (product repair);
- Expectancy: Users can reasonably expect that their call will lead to the problem being solved and the situation returning to normal within a short time.

In contrast, design projects have less clearly defined objectives. The key difference is that a problem solving service can be thought of as a corollary to the act of purchase, whereas users providing feedback existing and future possible uses of a product are not bound by the same relationship. Based on a review of the literature, Kujala [30] pointed out that the effects of early user involvement on the product design process were complex and not very well known. According to her study, such involvement improves product development performance and product quality based on response to user requirements, but several factors are probably involved in this relationship and interact in complex ways.

Complex phenomena may also be at work when users are asked to participate, in some form or another, in the product design process. Walker and Prytherch [46], for example, point out that user motivation can have profound effects on the user's perceptive, cognitive and evaluative processes, thereby impacting any analysis. Likewise, and related to our earlier remarks about the use of VR in design, Morie [47] showed that motivation has an effect on the user's capacity to reach a state of immersion in a Virtual Environment. Similarly, several studies in social sciences gave shown that user participation to investigations experiments requires personal investment on the part of users, in terms of:

- Investment in the traditional sense, e.g. time, which is often the object of some form of compensation;
- Investment in terms of mental workload, related in particular to the construction of a mindset prone to yielding results relevant to design.

Lack of investment in this second area can lead users to question the usefulness of investigations, e.g. ask themselves questions such as "What am I doing here?" Thus, experimentations relying on simplified tasks or simplified versions of the product require some form of "suspension of disbelief" on the user's part in order to provide interesting results. Participant observation, which aims to reach a close and intimate level of familiarity with a given group of individuals, also requires some affective investment on the part of users [48]. One final example is the reliance on data mining methods, which rely on machines able to collect use-related data for extended periods of time. Lack of motivation can then lead to protocols being abandoned midway [49].

4 TOWARDS A TRANSACTIONAL MODEL OF USER-DESIGNER INTERACTIONS

One can view the main problem of designers as foreseeing future use, for which several methods exist. One set of methods, which we have just mentioned, consists in projecting users or designers within a mindset in which counterfactual reasoning is sufficiently close to factual reasoning that information gathered might be seen as a useful resource for design. Another relies on anticipating use through analysis of the behaviour of large user groups. One alternate approach relies on introducing rules of use, which users can either comply to or reject. The latter leads either to rejection of the product altogether, or to the emergence of unanticipated uses.

Rabardel and Béguin [7]'s view on accidents in unanticipated use rests on the idea of asymmetry of information between designers and users. For example, the user might stray from acceptable use (e.g. prolonged use of a sunbed) because of a misrepresentation in risks associated to such use and lacking knowledge of key facts (e.g. minimal exposure time before the probability of developing skin cancer rises significantly). Mutual learning between users and designers may help even out these effects of asymmetry. However, we contend that the complexity of real world use may prove to be "too much" to be circumscribed by even regular exchanges aiming to help mutual learning. Instead, we propose to view use as a process of negotiation between users and designers. Use can then be characterized as a sequence of acts of compliance and defiance regarding use prescription.

Designers' incapacity to predict all the possible forms of defiance, as well as the fact that some of these acts of defiance may give birth to further innovation, are responsible for the fact that such acts can be viewed as "tolerated violations" [50]. Amalberti's model of "migration of practices", represented in fig. 1, underlines that use may stray from the acceptable "safe" space of operation into an area of violations and deviances. This space of acceptable use is defined simultaneously by technological pressures (e.g. product functionalities), individual concerns (use appropriation by users) and safety procedures (i.e. designers' prescriptions in use)

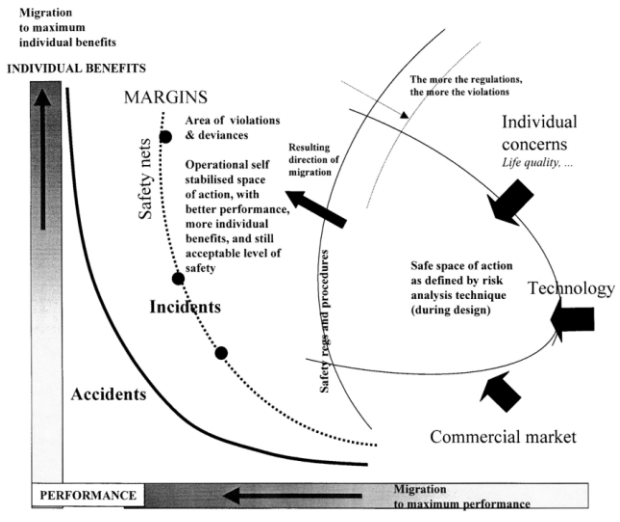

Figure 1 : The traps of overregulation, from Amalberti [50]

This model is concerned with the drift into accidents seen in major industrial systems. One major difference with strategies of product use is that safety is not the sole criterion at work, but is examined as well as other criteria

such as social acceptability or commercial profitability, Our contention is that, in order for unanticipated uses of products to be managed most effectively, both users and designers should take part in constructing this abstract space describing acceptable use. Furthermore, continued interactions between users and designers should focus on reaffirming the dynamic boundaries of this abstract space, thus defining use as a "pact" between users and designers.

The concept of "pact of use" relates in part to what Joule et al [51] call the "free will compliance paradigm". These authors describe a number of techniques to attain persuasive communication. These techniques mostly rest on the fact that users tend to carry out actions in line with set "attitudes", rather than commit to a counter-attitudinal action which implies realignment of their representations of oneself. Furthermore, they describe a number of factors which tend to foster strong commitment on the part of subjects, such as repetition, irrevocability of the action, or explicitly describing an action's consequences. One should note that several such attitude-shaping elements are at play in systems such as "barriers" [11] against unsafe use in software (fig. 2).

Figure 2 : a confirmation box in a software program

However, what seems to be lacking in this view of user compliance is a study of the source and form of prescriptions of use. Several authors in the past four decades have underlined that communication relies not only on the perception of content, but also on models of the situation and of participants [52-54]. In line with Akrich's original suggestions of studying the way in which outside influences "script" user behaviour [15], our future work will aim to model more precisely how users perceive these outside influences on use.

5 CONCLUSION

In this paper, we have laid groundwork for a model describing product use as a double-sided process of use prescription vs. appropriation. According to this view, most methods of use analysis appear to have a retrospective point of view, i.e. rely on collecting data about existing situations in order to optimize an existing product.

In contrast, product use may be seen as a possible source of innovation. This entails letting users "take over" the product to come up with new uses and forms, which can be disseminated in social groups to give rise to "trends of use". This operation is highly risky. Many technologies (e.g. P2P networks) are known to have disseminated "out of hand". New uses can also be dangerous to the product, to the user, or to society as a whole. For all these reasons, liberty of use is often counterbalanced by forms of prescription and use analysis methods now focus more closely on prospective anticipation of future product use.

Studies of use prescription have shown that particularly conflicting relationships can exist between designers and some user groups, e.g. hackers [13], resulting in dissemination of unwanted use. However, no form of prescription is absolutely reliable. And, as a review of the literature has shown, nor should it be. This complex relationship calls for new forms of strategic communication between users and designers [55]. Modelling underlying social and cognitive processes should yield interesting results for the design of tools and methodological frameworks to help users and designers interact around and during product use, and evaluate risks and benefits surrounding specific forms of product use.

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