Users, an emerging human resource for R&D? From eliciting to exploring users' needs

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Abstract: Users are emerging as a viable new resource for product design. I studied the effects of investigating users in an innovation process. Traditional methods such as market studies and user-interviews as well as a user-centred design study failed to surface a number of critical user-requirements, which led to major re-designs after the market launch. An activity theoretical analysis of the investigations helps to explain the poor results obtained, and to suggest some ways to improve the methods of investigating and collaborating with users. Users' needs should be understood as a gradually emerging relation between the environment and the user. Adequate support must be provided for users to articulate their needs. While utilising users in product development looks a promising new direction, it also requires new orientation, means and skills in research and design.

Keywords: user; user-needs; new technology; product development; activity theory; methods.

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1 Users as an emerging human resource in design

Recent changes in products and product development emphasise users as a new potential resource for design. Products have become increasingly 'smart', as Norman puts it [1]. Technical sophistication has required engineers to focus on increasingly narrow domains of expertise, while increasing complexity makes the interface-design more difficult. At the same time, customers are no longer technical experts, but laymen who expect more convenient and usable products [1]. Both developments demand new resources and skills from design teams in understanding the user-requirements and user-practices. Such skills are often not readily available in traditional design-team staffing of marketing,

product development and manufacturing, but such know-how has been sought from 'user-advocates' such as industrial designers and usability specialists [2,3, cf. 4]. Recently, also end-users have been increasingly considered as a viable resource for design, owing to advances in methods of involving users in R&D [5,6]. In particular, participatory design (PD) has developed a variety of methods of involving users directly in product development projects [7], and reported encouraging results with usability and usefulness achieved [6,8,9]. However, as Grudin reminds, PD methods have been mainly applied in in-house development and it remains an open question how well they suit mass-produced products that are used in a number of different contexts [10,11]. Moreover, even if PD methods proliferate in the future, more traditional methods are likely to prevail in industry [10,12]. This emphasises the need to further study the commonly used methods for investigating users for product development, as well as assumptions behind those methods.

The aim of this paper is to provide some qualitative basic research for understanding the pre-requisites and dynamics in investigating and involving users in R&D. The paper does not seek to present a ready-made methodology or an experience report, but theoretical and empirical elaborations on which the existing and new methodologies may draw upon for improvement.

A natural point of departure for such a discussion is the concept of user-need as it is used in marketing, management and product design literature, as it is highly influential among the practitioners of product development [2,4,13]. An analysis of users' needs, as suggested by the literature, prevails as the standard starting point for most product development projects. In these contexts, the term user-need is mostly used without a clear definition, mixed with wants, preferences, requirements, and so on. It is perhaps best understood as a psychological metaphor translating the wider-scale notion of 'market demand' into the complex behaviours of individual buyers and users (cf. [13]). In practice, the preferences, opinions and dispositions that potential customers show in relation to certain product characteristics are elicited and measured [4,13,14].

Recently, critical management literature has questioned the adequacy of traditional market research methods in providing information in cases where either the technology or the user-groups are new [12]. User-centred design takes the critique further by claiming that the quality and grain size of marketing information does not provide information genuinely relevant for defining IT applications [15]. However, neither of these traditions has provided detailed theoretical explanations for their claims (cf. [16]).

In Section 3, I propose an alternative approach to conceptualise the nature and the emergence of user-needs, founded on the cultural historical activity theory [17–21]. This approach sees user-needs as a developing relation between individuals and their social and technical environment. I utilise this perspective in analysing the shortcomings that various methods, user-interviews, market surveys, a design-study and pilot projects, featured during the innovation process in a small high-tech company. The analysis presented here is part of my five-year case study of the producer-user interaction in the company, International Security Technology (IST). The data presented here draw from a historical analysis of the innovation process based on available documents and interviews with key participants.

2 Key problems with traditional understanding of user-needs

The traditional view to user-needs, outlined in the introduction, starts from an individual user who has needs and wants for a singular piece of technology [13]. This approach has three important limitations in understanding new technology. First, it is not sensitive to the way technologies are used with an array of other artefacts [22,23]. As Suchman points out, new technology enters the life and work of users' which is already crowded with previous technologies. Making the various artefacts work together requires an artful integration in situated use, as the technologies most often have different logics of use, originating from different times and contexts [23,24]. Slicing the human subjectivity into preferences for characteristics of a particular detached piece of technology does little justice for the way people actually use technology.

Second, the traditional individualistic view neglects the collective aspect of technology utilisation. Few technologies are used by an isolated user, but most of the technology use is related to actions conducted by other people [15]. This collectivity in technology use is most striking with some medical instruments and groupware, where the use is a joint accomplishment of a number of people in a work community [22,25–27].

Third, and the most important for us here, the standard view takes users' preferences and needs as something given or pre-existing that can be recognised and met. While this presupposition may fit established and stabilised product lines, it has severe limitations when the technology or its users are new, resulting in difficulties with established market research techniques with the new technologies [12]. I shall argue that this is because users cannot have articulated preferences or needs for a product that differs radically from their present practice and knowledge.

How then should we understand the emergence of users' needs and preferences for new technology? Perhaps just because user-need has a metaphor-like existence translating demand into individualised preferences and requirements, its underlying assumptions have not been scrutinised. Consequently, the conception of human – technology relation embedded in the metaphor remains vague, at best. Paying attention to how needs are conceptualised in psychology provides analogue to which the metaphor can be compared and may also provide more refined ways to conceptualise the nature of users' needs.

In psychology, needs are mostly regarded as internally arising states that energise the organism to some overt action. However, intrinsic need-states, whether they are regarded biological, social or cognitive in origin (cf. [28]), do not explain to which action or object the need is directed. The directed needs are usually called motives [28]. The important issue here is how the need-states turn into motives and motivate particular actions in which artefacts are used. Current views pay homage to Allport's [29] principle of functional autonomy of motives: the reduction of a need-state may motivate behaviour in the early stages of learning, but once new habits and skills have been formed, they become motivating factors in themselves [28]. This points to the importance of analysing the socio-technical systems where action and learning takes place [30].

In the standard view of marketing and design, cultural and social aspects are regarded as a broad context that socialises individuals. Directed motives are treated as a result of individual learning, conditioned through marketing, advertisement, et cetera. On the other hand, needs and motives are regarded to pre-exist social and technological change. Motives are met, more or less, with alternative products [13]. As a consequence, it remains a mystery how new motives could be formed, how new artefacts would shape

existing motives, and finally, how individual motive formation is connected with social practices.

3 An activity theoretical perspective: understanding user-needs as emerging societal phenomena

Potentially useful sensibility (and concepts) for more adequate understanding of user-needs may be found in the tradition of cultural historical activity theory. This tradition puts emphasis on the cultural and social mediation in all human action and cognition [17,18]. A person is seen to emerge in a coconstruction of particular communities in which he participates, the arrays of artefacts that mediate his activities, and the active developing person himself. While humans are shaped by communities and artefacts, these are also in turn shaped by each acting person [17,18,31]. Thus, the analysis of human conduct should not be separated of the historical contexts in which the people have grown and lived. In this case, this means the communities where their needs have been shaped into motives and motives into artefact mediated action [17–19]. In this view, the notion of user-need, if we want to hold on to it, should be understood as an evolving relationship between the users, the communities in which users participate, and the technological environments the use takes place.

This relationship can be elaborated further in regard to human-technology relationship. The principle of cultural mediation posits that human cognition and action are mediated by mental and material means available for the subject in the situation of where he acts [17]. The way users relate to new technology depends on means and representations available. The way users regard technology is mediated also socially, e.g. by the users' work practice [18]. This way the socio-cultural settings have crucial importance in the way in which users relate to particular new technology. Users are able to give realistic and critical comments on the workings of the new technology only to the extent that the technology is made concrete enough in relation their actual work practices (cf. [6,8]).

Activity theory points also the fundamental historicity of human-technology relationship. On the one hand, this means that the means and representations so vital in mediating user-technology relationship are not restricted to the ones given in the current situation, but many of them have been developed earlier and elsewhere. Studying the cultural context in which the new technology enters might reveal some more or less collectively shared mediating representations and imageries, through which the users perceive the use and the value of the new technology (cf. [21]). On the other hand, the historicity points to the emergence and development inherent in the user-technology relationship itself. 'Needs' for new technology are only gradually articulated for the users themselves. Miettinen and Hasu [20] have suggested that users' needs are first seen as unresolved problems, dilemmas or contradictions in a users' activity. Needs are then defined as anticipations and desires in relation to the horizon of possible solution the new technological device might offer. Finally, the actual usefulness of the device, and users' actual need for the device is realised only when the device is made to work in collective activity with other artefacts and people.

Instead of standard view of marketing and product development that equates user-needs to preferences that users have for a given new product in an arbitrary environment, activity theory emphasises the context dependency of those preferences,

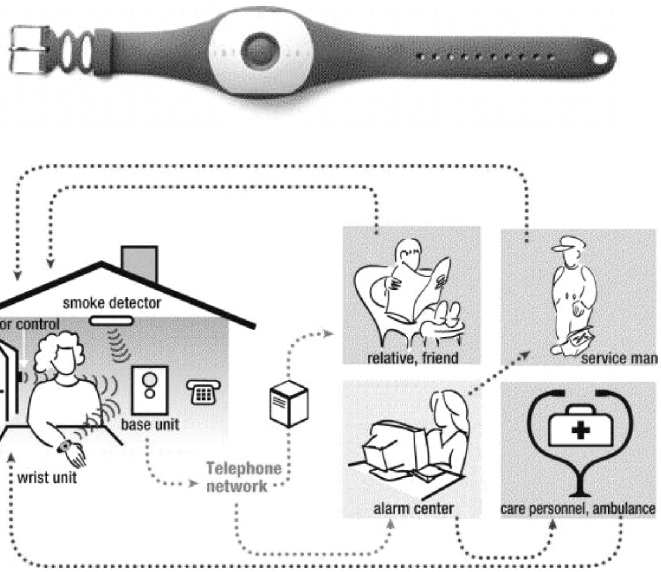
and provides tools to analyse that. User-needs are a relation between a subject, the activity in which he participates, the community in which he works or lives and the set of technological means he employs. Furthermore, activity theory studies this context constantly evolving in temporal dimension. User-needs first emerge as anticipations, then as future projections and desires while only the end result is 'user-needs' as such entities that marketing and product development literature usually treats them. The mediation and development of the user-technology relationship have their practical implications in investigating user-needs. The following sections clarify these implications by analysing in detail the methods in which user-needs were investigated in the innovation process of Wrist-held safety-device, Wristcare.

4 Case: how designers learned about the users and use during the Wristcare-innovation process

4.1 The technology in brief

The innovation studied is a wrist-held safety-device, Wristcare, developed by International Security Technology Ltd. (IST). The device is aimed at bringing enhanced security for the elderly and the disabled, by monitoring the user's health continuously and making an automatic alarm if the user's physical condition suffers a major rupture. Otherwise, the device works like a traditional safety phone: it has an alarm button, and all alarms are mediated by a receiver unit and telephone network to a predestined end: to relatives, to an alarm centre, or the nurse on call. This person then makes the decision on the appropriate action; for instance, calling the user, her neighbours, maintenance or ambulance. The use of the device is thus based on transmitting the alarm in the network of care.

Figure 1 The Wristcare device and the related technological system (Pictures are company marketing material)



4.2 Learning about users during the innovation process

Elderly care has not been technology intensive, but recently high-tech applications have started to find their way into these growing care and service markets. The vast differences between the assumptions and the cultures of high-tech development and the elderly living create great challenges for learning for both designers in making the technology suit the users, and for users to make it work in their daily lives. Many, if not most, products have failed miserably.

Safety phone development, on which Wristcare invention is based, is one of the few successful and widespread technologies in use by the elderly. Wristcare tries to transcend the traditional safety-phone format with more high-tech features, namely, with adding sensors to wrist-unit that can monitor user's condition. This solution is based on the inventors' long experience with the development of traditional safety phones. Traditional safety phones, even with accessories, could not plausibly detect such instances when the user-needed help but could not press the alarm herself. The solution was further prompted by ideas from medical diagnostics, process automation and from the existing 'passiveness sensors' in safety phones.

In addition to previous experience, the idea was based on a number of investigations made during the phase of initial invention in 1992–1995: Technical feasibility was investigated with the State Technical Research Centre, VTT; European markets were surveyed with a strategy consultancy and local technical university; Some potential end-users were interviewed over the concept by the key inventor.

The concept was defined as a one-for-all design, especially focusing on the private home use for the still relatively active elderly found within a heightened risk of incidents. This user-representation served as a reference for further technical development. The investigation results were unreserved about the potential of the Wristcare. Only the unorthodox ways of technical measurement raised some doubts.

During the years 1995–1997, product development was regarded as an issue of finding the right sensors and ways of measurement, as well as developing adequate algorithms. Further insight about users was generated in a design and usability study that was conducted in 1995–1996, but it had hardly any immediate effects, even though it raised some critical points to the current line of product development.

The first onsite pilots took place in 1997, and market launch in 1998. The product developers regarded the device as a success in technical terms. However, the experiences from situated use indicated that there was a mismatch between the requirements in the use of the device and the abilities of the users. To work flawlessly, the device needed sensitive use described in 25 page manual, including certain, even though simple procedures in wearing, stripping and storing the device; cancelling off unwanted alarms, cleaning, et cetera. Even though some users were happy with the device, some had problems even in understanding how to work the single manual button, not to mention handling Wristcare the way the design presumed. What followed was an unexpected number of false alarms and unreliabilities that had to be worked on.

Between 1998 and 1999, the company launched multiple initiatives to fit the devices into the social and technical environment. Numerous adjustments and new developments were made, ranging from adjusting the algorithms and measurement to training and building a new integrated system for rest-homes. Many of the previous assumptions about the users were reconsidered: who they were, how they worked the technology and how their condition could be monitored.

The third round of development followed the increased funding which the company managed to raise in 1999–2001. A new generation of the system was designed, in which the appeal and usability of both the wrist-device and the monitoring software were worked on. Simultaneously, IST attempted to standardise the various and often local solutions into defined product-packages made in the second round of development. Also, a new measurement parameter was added to overcome interpretation programmes, in addition to re-working some components with problems. The outline of the innovation and learning process is further illustrated in Table 1.

Table 1 The outline of IST product development and learning about users

1980–1992	*Background know-how*
	Development of safety phones in Nokia and Sostel Ltd.
	Work with remote medical measurements and process automation.
	Problems of traditional safety phones as a springboard.
1992–1993	*Idea formation and early development*
	The idea to monitor condition from the wrist with various sensors.
	Process automation as an analogy to physiological measurements.
	Investigations on technology, marketing and the user response.
	Users seen as a unified group of still relatively active people.
1994–1996	*First phase of product development*
	Technological development and testing both in-house, and with VTT.
	Gathering user knowledge through a usability and design study.
1997–1998	*Pilot testing and market launch*
	Device worked technically by and gross as expected.
	Various problems surfaced in situated use.
	Use in homes and rest-homes, further pilots
	Problems and wishes for further development.
	Second phase of product development
	Various technical and social attempts to better accommodate the new technology into user activities and networks of use.
1999–2001	*Third phase of product development*
	The second generation Wristcare, improvement of appeal and usability of the wrist-unit and control SW.
	Bringing in new technical features to enhance monitoring.
	Internationalisation

The interesting issue here is: how did various investigations and contacts with users contribute to the development of this innovation? So far, there seems to have been three major cycles in the use and development of the device, where the device and its use have been re-fitted to each other. Most importantly, even though the innovation was based on long experience with similar devices, and the company did conduct user-interviews, two market analyses and a design study, it was only the situated use in pilots that revealed the deficiencies in a manner that redirected the product development. Some might argue that some problems in the match between design and use are always

inevitable, and the rest were due to the insufficiency of investigations by a small company. However, the course of events in Wristcare case is certainly not uncommon in innovation processes, and we shall see that there is also a clear pattern, which a more systemic explanation reveals.

5 Activity theoretical analysis, part 1: the historical constitution of need for the Wristcare

To assess the investigations that IST conducted to inform its product development, we need to create a deeper understanding of what the users' preferences or 'user-needs' for Wristcare consist of. To gain a fuller picture of the collectively shared representations involved in the way users appreciate the device, I analyze the social history that has formed the representations and anticipations for the kind of technology as Wristcare. This can then be used as a background against which to view the means and representations the designers of Wristcare provided for the users during their investigations.

In the most abstract, Wristcare is based on a psycho-social need for the safety of those who feel vulnerable in their daily living. However, our biological undercurrents explain relatively little of our needs for new technology. It would be absurd to claim that the granddad of the 1920s would have felt a need to have constant on-line body monitoring. He might have considered the possibility nice, but his regard to VCR and a personal moon rocket would have been on the same plane of relevancy. More likely, however, he would have regarded Wristcare a rather miserable idea: The elderly lived in close relations to their usually numerous offspring and neighbours, why on earth would someone need such a nuisance for?

Since the 1920s, three important aspects have changed in the living of the elderly that have laid the ground for the 'user-needs' for Wristcare. First of all, demographic transition in western societies has shifted the balance of the responsibility of care from children to elderly during the last 70 years. Longer lifetime and the post WW2 baby boom heighten that development to the extent that the relative amount of the elderly to working people is to double the present about the year 2020 in most of the European countries. This prenecessiates the allocation of ever more resources to elderly care in society [32–34]. Second, family structures and care in families have gone through a major transformation during the 20th century. The elderly have become increasingly isolated by a number of factors including but not limited to: The increased pensions and standard of living, that enable the elderly to manage their life on their own; the increased mobility of people, making relatives and friends live further apart from their elderly; women entering full-time work; the state taking over care-responsibilities with rest-homes, home care and so on [34–36]. Third, the state-provided care has undergone important transitions. The material standard of care rose considerably until the 1980s, accompanied by increasing institutionalisation. This institutionalisation meant both increasing medicalisation of old age, as well as increase in the sheltered housing [37,38].

The most recent trend has been to seek out cost reductions by avoiding institutionalisation and by supporting home care by technical appliances. Thus, the societal change has created an increasing amount of increasingly independent but isolated elderly whose natural connections to relatives and friends have diminished. These connections have been patched by home-care services, which the state, in turn, would like

to patch up with cheaper technical aids. This societal development has become an ever more attractive terrain for private services and technical aids.

As mentioned, safety phones are one of few applications that have won a widespread position in elderly care [39]. One of the reasons for the popularity of the safety-phone systems lies in the familiarity of telephones to elderly people. By the 1960s, it was almost a norm to have a telephone in a household, making the current elderly to learn its use already in their active years. The safety-phone service also resembles the operator-connected telephone of the early days, which adds on to the familiarity of the safety phone service [40]. The telephone is also one of a few applications that the elderly use daily, together with TV, radio, refrigerator and oven. This keeps the strongly analogous safety phone system natural and easily approachable [40], a key factor of success for the technologies for the elderly [40,41]. User practices, infrastructure, government subsidiaries and a good reputation mark a few socially and technically relevant aspects of how the telephone and safety-phone services have influenced the potential users, their significant others and care providers. The need, or rather, anticipation, of significance for Wristcare is grounded in the existence and development of the safety phone-services and telecommunications.

Even though popular among the elderly, the safety phone development has been driven mostly by technologists, who have advocated ever more complex systems against the possible threats. The dynamic is very much like in the case of burglar alarms where producers market both the threat and the need for ever more sophisticated remedies. In 30 years of safety-phone business, the tendency has been to cover all the possible instances of emergency by creating more approachable alarming devices, and, on the other hand, sensors for detecting whether user has been struck incapable of making an alarm. While users have grown accustomed to being monitored by sensors, for instance, in refrigerators, beds, doors, infra red cameras and so on, the indicators for passiveness have yielded poor results, creating false alarms and rendering the systems expensive and intrusive.

The innovation in Wristcare is to move the monitoring from around the house directly to user's body, analogously to medical monitoring. While Wristcare was not intended to achieve such precision and directness characteristics of hospital devices, its online monitoring nevertheless strikes the images of medical technologies that have come to mark the increased care and reliability in the most vulnerable moments of life. Moreover, Wristcare's image as an advanced piece of transmission technology lends support for trusting that the company is in up with the latest cellular and other telecommunications developments and that this technology would indeed be realisable and reliable.

To conclude, the representations of societal change of individualisation and isolation, of safety phone services, of medical monitoring and of rapid development of telecommunications mediate heavily the way in which potential users and user-representatives perceive and anticipate the use and use-value of the device like Wristcare. In the following section, we shall see some practical implications that follow from neglecting the importance of the above cultural representations to the way in which users perceived the device in investigations on users' perception of the device.

6 Activity theoretical analysis, part 2: assessing the pros and cons of the methods used in investigating user-needs for Wristcare in generating design-relevant knowledge

6.1 The problems with brief and loose descriptions: market surveys and user-interviews

Soon after the initial concept had been formed, IST commissioned two expert surveys on Wristcare in Europe in 1993 and 1995. In addition, the key innovator interviewed some potential users over the concept, who regarded the product-concept in a positive vein. The expert surveys positioned Wristcare in a macro-scale to existing technologies, especially to safety phones. Studies identified the key players in the technology and existing services and gave an overview of the existing markets and estimated growth of sales. All these featured positively, no direct competitors were found and no immediate threats were in sight. This lent support to the innovation process, which certainly was one of aims of these studies. As Grönbaek et al. [42], point out a vague description in a market study supported the desire to appeal to as large a market as possible.

In terms of the design-relevant knowledge, the main contributions of the expert surveys were broad assertions over possible restrictions and conditions that the device must meet, such as "it must sooner or later face tests for medical technology in Germany" [43]. It is telling that the only critical insights about the context of use and potential problems were mentioned in 1995 in passage on France, where the safety-phone service was still in its infancy, and the researcher thus had a difficult time in gathering the preferred kind of data. This one page in a 40-page report is the only place where later crucial information of the age and condition of the safety-phone users, problems in organising the alarm-service and buying dynamics are even mentioned [44].

Three systemic reasons may be pointed out for the lack of finding design-relevant information. First of all, user-interviews and expert surveys did not cross-validate each other: experts commented on macro-scale issues of the market and organisation, while users related the technology to their personal lives. Neither commented on the systemic constellations where Wristcare would be purchased and used that linked these two levels of description. Second, the expert surveys put a pre-planned structure over the information that was deemed relevant, not encouraging to find unexpected information. Third, and most importantly, all three studies described Wristcare briefly and loosely as a safety phone that monitors health and makes automatic alarms [43,44]. No concrete restrictions on its functionality were offered when the studies related it technologically to pagers, safety phones and monitoring technologies. This was emphasised by the de-contextualised ways of data gathering such as phone-interviews. As Wristcare concept suited well the representations outlined above, and none of its functionality was revealed to restrain imagination, the device was seen to fit the existing contexts of use and had very positive apprehension in all the target groups. At the same time, and not coincidentally, hardly any significant suggestions for improvement or on potential problems for design were found in these studies.

6.2 The strengths and restrictions of a 'design-space': user-centred design interviews

In 1995, IST hired a designer to make a design and usability study for the Wristcare. It consisted of a literature survey and repeated rounds of interviews on safety-phone use and wearing of wrist-devices, assisted by models and mock-ups of new design. The study produced fine-grained data for the mechanical design of the wrist and receiver units, and created new preliminary models of these units. Second, the study revealed weaknesses both in the appeal and usability of the competing safety phones that could be turned into competitive advantages by better designing Wristcare. Third, the literature survey provided a number of critical remarks on the use and purchasing of the safety phones. It identified high requirements for the ease of use, the wear of the bracelets and problems with false alarms, and above all, that safety phones had an appeal as devices for the very last times of life, bought usually only when the condition of the user was already quite poor [45].

At the same time, the investigation restricted itself to immediate design solutions and regarded the critical points of literature survey as problems of design, not something that the company should engineer more extensively into their product. Possible problems in the functionality, fitting infrastructure and organisation of service for the new system were left to a notice.

Contrary to market research, the design study created important knowledge also for other aspects of system development than its own purpose of mechanical design. Some reasons may be pointed out. In the design study, the contact with users was more extended than in earlier studies. The repeated face to face interviews allowed for unexpected information to come up. The use of concrete representations such as existing devices, pictures and mock-ups were reported having enabled users to comprehend and comment on the device. These representations also created a middle ground between the users and the designer, where both could play their ideas out. The creation of this kind of 'design-space' seems to have helped in obtaining critical and sufficiently fine-grained data for re-design. At the same time, this space might have detached the users somewhat from their actual daily living. This might have contributed to the failure of developing further the critical points that the literature survey had revealed: the design session did not include them, and there were no means to encourage bringing them up.

The results and preliminary models of the design study had almost no immediate effect on IST product development. The company was already locked in a previously chosen path, was running on a very tight budget and, consequently, did not prioritise the results until the second generation of the device in the year 2000.

6.3 Why did pilot use generate so much design-relevant information?

Why did so many issues and needs for improvement follow from the pilot use? In the case of Wristcare, an important reason was that the early studies did not provide this information, and the suggestions of the design study were not incorporated into the product. Further reasons were, at least, that the product developers themselves were involved with the users and received first-hand experience on the issues. Moreover, now that the product was in the market, problems in use, possibly affecting sales became a reality pressing for action. In addition, the firm had a gradual market launch strategy, and for the first devices now in use, more resources could be allocated. The question was

no longer about risking the ongoing development by changing the direction, but on improving the achieved model.

Several factors point also to the above theorising on the emergence of user-needs. Pilots were the first contact with the real, not ideal-typical users. Second, the technology had full functionality, so users could relate to it more comprehensively, and from the developers' side, it became harder to contemplate over the problems in optimistic vein. Third, the technology was incorporated to the daily lives of users, which provided also a sufficiently long exposure time. This was critical for Wristcare, because both the down sides (for instance false alarms, uncomfortable wear) and use-values (making the needed alarms) became visible only in sustained daily use. Finally, this was the first time when the device was fitted into the whole social and technical environment that surrounded safety phone service.

7 Discussion

Actor-network theorists have pointed how established technologies are nested in our lives so tight that our actions make no sense if separated from the 'ensembles' of material and social actors [46–48] Cooking is no more taught with fire, but our dishes depend on electric stoves, steel kettles**,** recipes, and cooking skills accommodated to these actants [49]. Only at this point do users begin to have genuine needs for the new technology, that is, if the application was taken away, it would disrupt the work and lives of people. However, with regard to a specific new piece of technology, becoming a part of such an ensemble is a result of a long process that should be viewed against the inertia of existing social and technical formations. Based on activity theory, I proposed that user-needs should be understood as emerging as a part of the development of socio-technical context. User-needs should not be treated as something already existing and waiting to be collected. Instead, they emerge and grow more defined only gradually. This should be recognised in methods for gathering user-related information and in the efforts to involve users in product-development work.

The IST case seems to suggest that some of the common ways – user-interviews, marketing research, and user-centred design methods – are what I would call "representation hungry", with regard to generating design-relevant knowledge. Available means and representations mediate the way users relate to new technology. Representations provided by designers, sketches, mock-ups, scenarios and so on form only a part of relevant representations. Images and imaginaries (both individual and socio-cultural) govern the way in which the technology is apprehended, inasmuch as the concrete characteristics of particular technology at stake are not clarified. In the IST case, loosely framed marketing studies and user-interviews re-produced the expected image of the technology, not bringing in much critical or deeper insight for development work. In the user-centred design study, direct user contact and the systematic use of mediating representations – pictures, models and mock-ups – generated important insight on the mechanical design the study was focused on. However, it seems that this kind of 'design-space' created an artificial location that closed off the considerations of the context of use in the actual work and life of the users. The situated use in pilot projects produced a concrete artefact that clarified the users' experiences and needs that had to be fitted into the technical and social infrastructure. This yielded most important understandings on the users' needs for the designers.

At the same time the urgency to understand users' needs in the early phases of the innovation process has not disappeared anywhere. Recently, there has been a growing awareness of unexpected new uses and other aspects of mutual adaptation of technology and users [12,50]. While unexpected use and mutual adaptation highlight how it makes no sense for the designers to try to fully determine the use of technology in advance, they do not relieve the designers from the burden of trying to make technology fit the practices of use. The new technology has to first be used before it will be used in new and advanced ways. This takes time and desire from the behalf of the users and is not likely to take place if the technology is not genuinely useful and desired (cf. [22]). Aiming for mutual adaptation and unexpected uses might put even more emphasis to initial understanding the practices of users.

Results from Wristcare case suggest, like some other studies, that traditional methods like market surveys, expert interviews, and competitor analyses, and so on, may perhaps suit cases where the technology, users, and practices of use are well known (cf. [12,14]). With plenty of uncertainty, like in Wristcare case, traditional methods may not facilitate users sufficiently in evaluating the technology, which led to users' guesswork their opinions about a loosely framed technical concept on the basis of its cultural images.

In such cases, the technology should be represented in a more adequate way. IST case seems to advocate direct user contact where the technology would be represented carefully not only on design details, but also with regard to how that technology differs from existing technologies, practices of use and even significant infrastructure. There are approaches more or less compatible with the findings of this paper. While the results certainly support methods like full-scale modelling [51], more critical stance must be taken towards approaches in which future technological practice is not carefully represented. Such approaches include focus groups, future workshops and scenario work if the technology and the future environment of use are not sufficiently represented in conducting them. I see as fundamental that the representations of new technology are built to promote users' ability to transcend current conditions, but, at the same time, to enable users to resist designers' solutions and rationalisations of their work. An example would be that the technology would not be presented as a single concept or use script, but, more widely, as a horizon of possible alternatives that would be specific enough to allow critical comments. These alternatives might be best created by simulating potential shortcomings, problems and new possibilities in three or four user scenarios, assisted by mock-ups and other relevant means for heightened representation (cf. [51]).

In other words, the message here is not "listen to the customers" or even "do participatory design" as participatory design can well be done in a manner that all but overlooks the emerging nature of user-needs. Instead, the message is that before one rushes into studying user-needs, there needs to be critical evaluation of what may be the ways in which the technology may bring novelty to user practices, and then careful consideration what kind of methods are suitable for exploring them, and whether they need to be modified. Historical analysis is a vital tool for specifying what are the dominant representations available for the users when they relate to a design.

It remains open how far conventional methods such as market surveys and expert interviews are able to incorporate enhanced ways to represent the technology for the users, and accordingly, how adequate they can be rendered as tools to investigate user-needs for radically new technology. Whichever the case, implications are clear for human resource development. While more active role of users seems to hold valuable and expansive potential in product design, it requires new means, skills and competence in

design teams. More emphasis should be laid on evaluating the kind of method that is appropriate in learning about users in each particular product development project. For cases where technology and its use are not stabilised, either appropriate user-centred design methods need to be learned or established methods rendered more adequate. Neglect of such considerations may, in the worst case, lead to the waste of resources in use of inappropriate procedures and heighten the risk of developing unsuccessful products.

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