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A USER-CENTERED APPROACH TO DEVELOPING EMERGENT TECHNOLOGY PRODUCTS

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1. Introduction

Product functionality is an indispensable precondition to consumer satisfaction and market success. However, the advent of new technologies, and the increasing complexity of products, means that delivering the right 'product experience' to customers, which is a major driver for the acquisition and use of new products, is becoming more and more difficult. Product experience arises through the user's reflection of a combination of functionality, appearance and useage. In the mobile phone industry, mechanics, electronics and software converge to create a product that should be very easy and intuitive to use; this makes such a product very demanding to design, as the achievement of this balance is quite difficult. Innovation in the mobile phone industry is highly technology-driven and characterised by very fast product development cycles. This is due both to the strong competition on the market, quickly developing technology and to users' ever changing opinions regarding what is acceptable or fashionable. The mobile phone market is driven by three parameters: cost, size and performance. The increasing amount of features that need to be placed into the limited space of a mobile phone often leads to conflicts in these parameters, forcing trade-offs in each new model. If new mobile phones are to distinguish themselves from the rest, the challenge of the concept development teams is to go beyond the focus of these cost-size -performance relations, towards finding new ways of bringing added value to users and enhancing their use experience. Experimenting with transformation to make the phones *playful* has been exploited as a means to achieve this. However, introducing features that will not only deliver different forms of performing a given function, but new services and possibilities of communication and entertainment, can bring radical innovation to the industry.
However, doing so challenges designers in different ways, for instance, how to anticipate the usage of a product that does not yet exist? Current participatory design methods do not allow designers to gain the insight required to develop such products. There is a need to develop methods to anticipate future product usage that can effectively be applied during a design process (Kanis, 2003, Rooden, 2001). The research described in this paper intends to contribute to this effort.
We present a case study where the focus is to identify the most important form factor drivers in TV-enabled mobile phones. As this is an emergent technology, the process requires finding suitable ways of involving users in the design process.
The aim of this case study is to illustrate the difficulties in eliciting and capturing user requirements in product development, when the products are based on emergent technologies. At the time of the study, television on mobile phones was not commercially introduced in the country (although it did exist in other parts of the world). This extreme case of technology push allows identifying the barriers for requirements elicitation. At the same time, it allows for the demonstration of how to overcome these difficulties.

2. The case study

In this demonstration case, two novice designers, without previous knowledge on mobile television were given the task of identifying the key form drivers that would make a mobile phone with television successful in the local market. This required them to go through a series of iterations from gaining knowledge to generating and testing design alternatives. At the same time, the design of the case involved users with no previous knowledge on the technology (TV on a mobile phone). The purpose of the user involvement was twofold: i) to identify the key user factors that would make a mobile phone with TV successful; and ii) to devise methods to transfer knowledge about the technology and its potential use to the users and back into the product development team. This required an iterative approach, from gaining knowledge about the technology, users and useage contexts and the mobile phone industry, to generating concepts and acting and testing them in different scenarios. The activities required a combination of methods such as user observations, usability tests with low resolution prototypes and interviews with knowledgeable people from industries related to mobile phones and mobile TV.

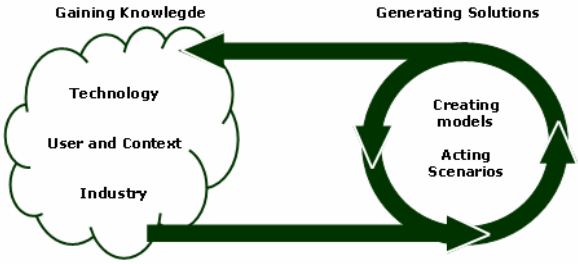

Figure 1. The iterative approach adopted for user-centred design

2.1 A User-Centred Design Approach to Implementing New Technology

User-centred advocates recommend the involvement of users very early in the design process. Users can be an important source of information and insight when (re)designing products they are familiar with. However, if a product development team is given the task to design a mobile phone with Digital Video Broadcast– Handheld (DVB-H) television, which users to approach and what to ask them? Most users are familiar with mobile phones, and most will be familiar with television, but most of them will never have used digital interactive television, and certainly not while on the move. Studying users' usage and interaction with adjacent technologies (e.g. television) can be informative. However, it is not certain that users' behaviour in relation to these technologies can be transferred to the new implementations. For instance, at home television can be used as entertainment, to be informed or simply as a mood changer (Knoche and McCarthy, 2005). Would the users give mobile TV the same use?

Involving users is an expensive, time consuming affair, and no current participatory design methods could help designers anticipate all aspects of how this mobile phone will be used. How then can designers identify the important product experience drivers? Most of it will come from the designers' own fantasy, experience with related technologies or simply technological possibilities and limitations. Digital television on mobile phones is not a feature that has been asked for by the users. If we designed mobile phones with this feature embedded, it is because technology allows it. Like DVB-H, many of the features in modern consumer electronics products are *technology-pushed* into the market (Rothwell, 1992). The designers and engineers need not only to design the means to implement the technology on the product, but also to design the whole user experience. In this kind of design, the users' contribution is very limited. Due to the amount of resources it requires, planning when to involve your users, for what purpose and to which extent becomes indispensable.

Lack of knowledge is considered perhaps the biggest barrier for requirements elicitation, both because the users do not have referents and because the concept designers do not have the required knowledge about the technology and its possibilities. This requires effective ways of communicating the content

and potential use of the technology to users, without conditioning their response. After all, the objective is to elicit useage requirements and to explore *new* potential uses, other than the ones forecasted by the technology developers.

2.2 Technology Analysis and Product Benchmarking

DVB-H is a technology that allows service providers to send broadcast digital television to subscribers on their hand-held devices. The technology is already implemented in some Asian countries, and the infrastructure is being put in place in Europe and some cities in the US.

There are four different ways of delivering video on a mobile device: Broadcast TV, Streamed TV, Video on Demand and a personal collection of videos stored in the user's device. In Stream TV, the user has control over the playback of the video (pause, forward, etc.). This requires an individual connection to the content provider as each user can be watching different content. Video on demand (VoD) allows the user to buy or rent individual clips that can be stored on the portable device for later playback. A personal collection is comprised of videos collected by the user from different sources such as a digital camera etc. Finally, broadcast TV uses the same principle as the regular television. A signal is broadcasted and all users on the same channel watch the same content without any control on its playback.

The reason for choosing DVB-H over other potential technologies available for exploration for this study (RDIF, WiFi and GPS) was the level of maturity of the technology, the possibility to provide additional entertainment and the possibility to deliver new services to users. For instance, by combining the DVB-H signal with the 3G network, it is possible to deliver interactive TV services such as tipping friends, interacting with a TV channel, participate in programmes voting for a favorite artist, participate in competitions and polls, buying directly during infomercials, etc. Additionally, the infrastructure is already in place, with tests performed in 2006 in various European countries.

As indicated above, cost, performance and size are the most important drivers that companies currently use to compete in the mobile communications industry. By researching the criteria used by specialised magazines and consumer associations to benchmark mobile phones, it is easy to get a reasonable idea of the target values for some of the parameters such as maximum width, maximum volume, expected battery life, etc. However, these benchmarking parameters are highly technical in the majority of cases and do not necessarily represent the criteria users subjectively use when deciding which mobile phone to buy.

2.3 Understanding Users and Contexts

A technology adoption cycle analysis proposes a way of characterising users according to the speed at which they assimilate new products and the reason to do it (Moore, 1991). In this case study the analysis was useful to identify both types of users and the contexts in which they were more likely to use the technology, e.g. business travellers waiting at airports or commuting to and from work. This knowledge was used to decide which contexts to explore.

Understanding the issues related to watching television on a mobile phone whilst commuting is something that cannot be achieved by simply observing users, as there were no available TV mobile phones in Europe at the time of the study. Therefore it was necessary to both observe how people behave in these contexts and to orchestrate the experience of what it would be like to watch television in these situations. The team spent several days commuting with the mock-ups of the phones in their pockets simulating having to use them. One of the members acted as a user and the other carried out observations. These observations yielded valuable knowledge in three areas:

- *The operations requirements*:
  - Ergonomically sound
  - Can be used while standing and sitting
  - Cannot require full attention for its operation
  - Possibility of strain inflicted on users eyes, hands and arms by keeping the screen on uncomfortable positions for long periods of time
- *People's behaviour*

- Users need to create an artificial personal space in crowded environments where physical distance cannot be maintained. They tend to do so by avoiding eye contact, looking at the void, etc. (Kaya and Erkip, 1999). Mobile TV can help create this sense of privacy.
- TV as a mood-management tool. TV is used at home as a prompt to mood changes, e.g. to overcome boredom. It is however not clear if this will be transferred to TV on mobile phones.

- *The context of use*
  - Commuting allows periods of time to watch broadcast TV. For the majority of the users the window of opportunity for watching TV on the mobile phone is short, and therefore content must be readily available in a *TV-anytime* fashion (digestible in small chunks).
  - People who commute for longer times will have the most time and opportunity for watching TV on a mobile phone. (Knoche and McCarthy, 2005).

At a bus terminal **In an airport** **Inside a train**

Figure 2. Selection of typical usage contexts

The extreme conditions of use (commuting) represent only a fraction of a day. Broadcast TV can be seen in many other usage contexts throughout the day, for instance, in the kitchen, in a café, at work as background environment or to keep up with the latest news, etc. To understand the requirements imposed by these usage scenarios, a further set of contexts of use were created, and furnished by carrying out a scenario-writing exercise. In the following we have chosen and abridged two examples of use scenarios.

For the context of use *Real-time TV entertainment*, the scenario was described as:

"Real-time TV on a mobile phone provides one with many different channels sending entertainment and information. There is always something to watch on broadcast channels. Live events can be seen from several different angles, due to the different camera shots on different channels. The TV switches on instantly whenever you decide to have a break during the day. You just rotate the screen and lean back with the phone in your hand."

For the context of use *Respond to the TV channel*, the scenario was:

"An Electronic Service Guide next to the display provides more information about the channel and services that are connected to the channel content. One channel shows a music-hits programme, another shows trailers for a movie theatre in town, whilst a third channel shows a live sporting event. By selecting in the guide related to the channel, you can send a text message with your comments, vote for your favourite music-video, order movie tickets, or bet on a sports result."

Other scenarios were considered, for instance, how to react when a text message arrives in the middle of a video clip? How to use the TV as a wake-up or as a reminder? How to transfer the function of the home television as background entertainment to entertainment on the go?

In addition to writing scenarios, personas were created in order to complete a vision for the product. The potential user profiles' characteristics were described with respect to a living context (city, country, etc.); commuting situation; ways of killing time; age-group & personal status (single/married, gender, career, education status); preference regarding product choice (reliable vs. cheap, label vs. no-logo etc.); future likelihood of having digital TV in home; and mobile phone use patterns.

2.4 Understanding of the Industry Context

Although it was not the objective of the case to make an in-depth evaluation of industry requirements, interviews with knowledgeable personnel at relevant companies were carried out. This included a mobile phone manufacturer, content providers from Mobile Networks and DVB-H technology developers. The results of these interviews show that the Mobile phone manufacturers impose heavy requirements to the concepts to be developed. Amongst others, the following six were considered: (i) there should be a TV on the phone; (ii) it has to be implemented using existing mature technologies; (iii) transformations on the phone should be on only one plane; (iv) TV should be viewed in landscape mode; (v) should comply with industry standard accepted sizes and (vi), should use industry standard components (batteries, screens, etc.). These six main guidelines were chosen merely for the purpose of this exercise, and in order to define the solution space.

2.5 Generating and Testing Concepts – Key Form Factors

Following these guidelines 25 foam models were made addressing all the scenarios developed. These models were tested by the designers themselves in all the different contexts mentioned above. The tests, where we *'act out the scenarios',* have given the designers great insight into what it would be like using this product. The results can be summarised in a set of *´key form factor drivers´* that the phone must have. A restricted list of these includes:

- Ergonomically sound interaction and possibility for one hand use
- Being able to stand upright on a flat surface such as a table
- Easy transformation to get the display in landscape view
- Maximum screen width must be specified
- The mobile phone should have an agreed maximum volume
- The display format must be agreed
- All models relate to being a mobile phone as the primary function and identity
- The number keys must be available whilst watching TV
- TV mode is independent of phone mode
- There should be a maximum limit for the number of transformations
- Level of symmetry should be agreed
- The mobile phone rests naturally in the hand in TV mode
- The display is protected when not in use

Although some of these form factor drivers relate, for instance, to the TV experience at home (we watch TV on symmetrical, landscape format boxes), or by fashion canons (look small), we also gained insight from the new usage scenarios, which opened up for a series of new form factors. These form factors supported the existence of TV in several different contexts. These contexts need, in turn, to be tested with potential users. In order to test whether the abovementioned form factors were appropriate and complete, a user feedback session was organised, as described below.

2.6 User feedback session

The aim of the feedback session was to obtain a ranking of the usage scenarios by the early adopters (users were interviewed previous to the study to determine whether they were early adopters, followers, etc.), in order to (i) determine which of the form factors included in the models better supported the various usage scenarios; and (ii) to test if the identified drivers were indeed the most important ones. Additionally, it was intended to find if there would be other possible drivers, not previously identified by the designers.

Five hard plastic models were constructed using rapid prototyping technology. All of them had the mechanics required to achieve the physical transformations. Special care was taken to ensure that all the phones complied with the aforementioned form factor drivers. All the screens were the same size and could be viewed in landscape mode, the phones had the same volume and the factors not being tested (e.g. keypad) were made identical.

To the feedback sessions, a panel of eight people were studied and subjected to a series of exercises. During the session, they were questioned about their consumption habits and technology adoption profile. They were also interviewed about their commuting practices, waiting time, usage of current

mobile phones, etc. The participants were then given four tasks to carry out, as described in the following section.

Scenario Ranking

The participants were asked to rank the five potential TV scenarios according to how they best saw themselves in each of them. The purpose of this task was mainly to have each participant relate to the different potential uses of TV on the mobile phone and actively get them to make up their minds on which one they found the most likely for them. This was a way of introducing knowledge to users on the potential use of the TV Phone. The effect of making the participants involve themselves was that they quickly were able to talk about their way of (imagining) using a mobile phone with TV.

Model Ranking

The participants were asked to rank the five models according to their own preferences. The models were briefly introduced by the researchers and afterwards the participants were free to explore and comment on them. The introduction of the models was limited to showing the phone mode, the TV mode, and an eventual closed mode (where relevant). This was necessary, as the transformations between modes were not being tested in this exercise, and in some models, they were rather complex.

Model and Scenario Acting

In this exercise, the participants were asked to interact with the mobile phone they ranked the highest in the scenario they ranked the highest. While in this situation, they were asked to imagine different situations, for instance, answering the phone when watching TV on it.

TV Interaction

Participants were asked to interact with the TV functionalities, e.g. switching on the TV the appearance of the menu for iTV, and the appearance of the text from SMS messages, arriving whilst watching TV. This created a space for adding to the participant's understanding of the possibilities of having broadcast TV and an electronic service guide on the mobile phone.

Final Interview

Participants were asked to express their opinions of the telephone, with respect to, for example, its size, the size of the display, and which different form factors would support a good user experience.

3. Results

It was a demanding task to prepare and execute the user feedback exercise, where the participants reflected upon future scenarios and design form factors, but we found it very important for the project.
Two interesting observations of the user feedback sessions underline the researcher's own affect on the actual user test situation. Firstly, we observed that the participants displayed strong preferences for those scenarios which reflected their existing TV-watching habits and their existing mobile phone use habits. Secondly, the exercise showed that the participants gave feedback relating only to the concepts and contexts presented to them; none of the participants suggested other ways of using the TV-enabled mobile phone.
A user-centred development process (including a focused user involvement for validation of particular elements) requires that the level of detail in the response material is highly prioritised and directly relevant for the value of the feedback. The result of this approach was that it provided insight into a series of design elements and provided valuable input, with respect to how to ensure that the introduction of new services and features be a positive experience for the user. At the same time the resulting drivers from the case, which reflected significant elements regarding the form factors, gave a concrete set of guidelines for the further conceptualisation work. This approach brought insight into the importance of combining knowledge from users and technology to balance the potential features to match the users' future usage patterns.
The result of this user-centred approach was that we very early became aware of how an emerging technology can provide new services, and subsequently, which of these the users may or may not find to be intriguing. By focusing the development process on which design elements would be important before the actual concept phase, it was possible to create a set of design elements with strong relation

to the potential new services. The involvement of users provided an insight into how important it is to keep a balance between the complexity of the form factor and the ability to provide new and different ways of using the mobile phone.
The favourite models selected by the participants should not necessarily directly translate to the concepts which the product development team should pursue – this was not the aim of our test. Instead, the results emphasised the importance that users give to certain form-factors in the telephone. The main drivers found for mobile TV were, in order of importance: (i) the phone must be able to stand upright on a table; (ii) whilst in TV mode, must be balanced and easy to operate with one hand; (iii) earphones must be used when watching TV; (iv) multiple possibilities for switching the TV mode off; (v) iTV menu only visible when requested; (vi) text messaging should be allowed whilst in TV mode.
The process of gaining knowledge about the technology and putting it in a suitable context for the users to be able to understand it and propose potential uses is challenging and required a variety of methods. Our process was developed underway in the case study, as we learned from each iteration prcess. An important result of the study was therefore to produce the model shown in Figure 3, which describes the process of user-centred design with the emergent technology that we chose in this case. The model maps the iterative process adopted and refined during the case, where the activities of knowledge acquisition; sub-conclusion of requirements and drivers; generation of solutions; and testing & validation are described. We have chosen in Figure 3 to present the specific model that relates to the case described in this paper, where the reader can draw the parallels to the initial generic model, presented in Figure 1.

4. Discussion and Conclusions

Early in the process it was discovered that asking users about the actual emerging technology would not yield greatly usable results. Moreover, substantial user involvement in the process is expensive, both in terms of money and time. The approach followed in our case was used to gather information, comparing the potential use of the emerging technology with adjacent technologies (namely, use of mobile phones and use of TV). During the user feedback session it was evident that users relied heavily on their own experiences with these two technologies in their respectively exclusive and traditional contexts when formulating their arguments. For this reason it is particularly important to decide in advance, how the users' responses will be used in the further conceptualisation and product development process. Furthermore, findings from these adjacent technologies are not necessarily transferable to the new technology. Comparing DVB-H with streamed TV, net-TV, and TV at home allowed drawing the possible uses of TV on mobile phones. Using adjacent technologies might also be the only way to communicate to users, what the new technology will deliver.
An additional obstacle when involving users in the development of emergent technologies is that since there are no currently expressed needs to be satisfied, i.e. there is no explicit demand, their receptiveness and interest is quite low. However, once the users were asked to 'act' the scenarios developed for the study, they understood the real potential of the technology and their attitude changed significantly.
Finding the main form-factor drivers was achieved by a systematic exploration of the technology, the industry related requirements, identifying the usage contexts and acting the scenarios with many different models. This exploration allowed for a highly focused user feedback session as the users were invited to help validate the already described drivers.
Rapid prototyping (in its broadest sense) is an efficient way of exploring the solution space. In the approach used for this case, having models along when 'acting' the scenarios has proven to be a valuable tool for both the designers and the user panel. A drawing can present an idea with many details, but discussing a grip or a movement of a handheld product is better achieved with a physical 3D model. These models can be very low resolution; foam mock-ups, for instance.
When focusing on finding the form factor drivers instead of a concept, one must test many aspects of the concept, such as grip and motion. Doing so is a complex task which cannot be evaluated on a drawing**.** The loops of acting out different usage scenarios with the models have been a way to easily test the generated solutions.

Acting out usage scenarios with physical models was also the approach we adopted to create product stories. In this way, it was possible to more clearly communicate ideas, but a shortcoming is the difficulty to document all the usage scenarios, as would have been possible if using storyboards.
An interesting observation made during the acting out of the scenarios was how people protect their privacy in places where the personal space is violated. Isolating themselves from the crowd seems to be a way out. Providing the users with something entertaining to focus their attention on appears to help when feeling alone in a crowd. From observing how people use their televisions at home, it became evident that they change from having television [at home] as the focus to having a television [on a mobile telephone] as background entertainment instead. This gives an opportunity for a positive adoption of TV as a background entertainment medium, as it easily competes with the alternative of reading – which is less likely in the usage scenarios connected to high 'on-the-move' activity.
Finally, we can conclude that the introduction and development of key form factors to the early conceptualisation of emergent technology products has given great insights when involving users, that otherwise could not have been achieved, due to the users' inability to envisage new usage contexts and therefore demands on the product.

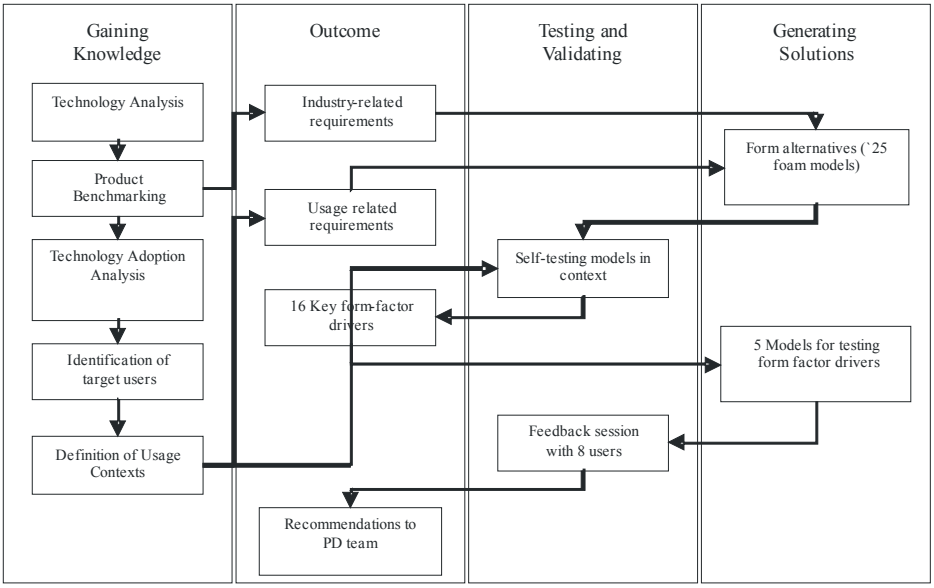

Figure 3. Process Mapping

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