Six Challenges Facing User-Oriented Industrial Design

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1.0 Abstract

Much has been written about the need to address the requirements of the user when designing information appliances (mobile phones, MP3 players, PDA’s etc.) but less is written about the challenges designers face in bringing this about. Using case studies this paper will examine six of the problems facing design teams in consultancies, Small to Medium Enterprises (SME’s) and multinationals tasked with the design of complex computer embedded products.

A case study of a successful implementation of technology-based product is presented. The factors that make it an example of good practice and the ways in which the designers have been overcome the six challenges are examined.

In conclusion, the challenges for the successful design and development of information appliances are summarised and ways in which they might be addressed discussed.

2.0 Introduction

Modern products are increasingly likely to be computers. Bill Buxton summarized the situation succinctly. In a keynote address to the 2nd Appliance Design conference regarding users’ perceptions of modern products he stated: "A PC is a computer you type into, a mobile phone is a computer you put to your ear to and a digital camera is a computer you look into". Increasingly, the product is actually the user interface while what we perceive of as the product is actually just packaging it. Products of this nature (MP3 players, GPS devices etc.) are frequently referred to as information appliances. In 2002 the total global sales of communications based information appliances was 94 million units. In 2008, more than 546 million device sales are forecast while web-based information appliances were forecast for a twenty fold increase from less than 0.5 million units to over 10 million in the same period. (ETForecasts 2003).

Much has been written about the faults in the way the design and manufacturing community approach this developing and increasingly important area of design (see Norman, D. (1999) and Cooper, A. (2004) for examples). The specific problem of developing processes via which to
design information appliances was identified some years ago (e.g. Thomas et al, 1995, Lee et al 2004, Buxton 2001 and Houde & Hill 1997) and a number of tools and techniques are either available or in development, a selection of which are briefly described below:

- **The Buck Method** (Pering, 2002) involves using an existing product wired to a PC;

- **Paper Prototyping** (Snyder, 2003) uses paper, card, and other ‘soft’ materials to build prototypes. Human operators make physical changes to product states according to the user’s interaction with the ‘product’;

- **Experience Prototyping** (Buchenau & Suri, 2000) is an ethnographic approach that uses improvisation and low tech. props;

- **Wizard of Oz simulations** (Maulsby et al 1993) involves human operators simulating sophisticated machine responses;

- **Augmented Reality** (Nam & Woohan 2003) uses a combination of real and virtual simulations;

- **DTools** (Hartmann et al 2005, and widely regarded as the best rapid hardware/software development tool so far) uses "smart" components combined with a state transition software tool

- the **Calder Toolkit** (Lee et al 2004) involves prototyping via ad hoc networks

- the **IE System** (Gill, S. 2003): a flexible system of hardware and software linking a prototype to a PC. For further details on some of these techniques and others see Gill, S. 2005b.

It is also worth noting that in 2D design there have been some interesting developments such as DENIM (Newman et al, 2003) which allows designers of web pages to very swiftly create designs from sketches using gesture recognition. Similar approaches may yet be useful for the development of information appliances.

As can be seen from the small sample above, a lot of research is being carried out, attempting to find ways for designers to overcome the problems of designing computer-embedded products. Why then is so much still written about unsatisfactory information appliances? (e.g. Nielson, 2004 and Kim, 2005).
Designers do not operate in a professional vacuum. This paper will demonstrate that the context of their operation is as important to the problems facing the design development of information appliances as the day to day design and prototyping issues themselves. Specifically, the paper seeks, through case studies, examples and discussion to explore the problems faced by designers and industry, the hurdles to be surmounted and the further work needed in order to achieve that.

3.0 Challenges 1 – 4 (Social Factors)
There can be a temptation to regard the facilities, expertise, problems and methodology for designing information appliances as common to all design teams. Papers such as Pering (2002) and Mohageg and Bergman (2000) only deal with how information appliances are designed in a particular setup (Handspring and Sun Microsystems respectively) while Avrahami and Hudson (2002), Greenberg and Fitchett (2001), Hartmann et al (2005), Lee et al (2004) and Nam and Woohan (2003) appear all to assume a similar set of problems for all designers. The author's own previous work (Gill, S. 2003) briefly acknowledges only two basic scenarios for information appliance design.

Research commissioned by the National Centre for Product Design & Development Research (PDR) has found a range of different design environments in which information appliances are developed. Not all designer teams face all the challenges listed in this paper, they occur according to company structure, the skillsets available, the time given to the project and even the financial circumstances of the company designing the product.

3.1 Challenge 1: Cultural Bias
In countries like South Korea and Japan consumers are happy to take time to deal with technology. In their paper examining the success in Japan of iMode, a mobile internet system, Barnes and Huff (2003) noted that "Modern Japanese culture is well known for its enthusiasm for electronic devices, especially among its youth." The result is that devices designed for the Japanese, Korean or Taiwanese markets tend to have a lot of functions, often at the expense of usability issues. Moggridge (2006) notes "(iMode had) interactions that, though not easy to learn, were mastered by teenagers as well as adults with enough patience". In the west there has been a backlash against function heavy products. Barnes and Huff note that in 2003 Japanese consumers were subscribing to iMode at a rate of 15,000 per day and that between June 2002 and May 2003 iMode in Taiwan reached 900,000 subscriptions. In contrast, they note "European versions of iMode became available to German and Dutch markets in early 2002 and France in November 2002, but have struggled to convince customers to subscribe." This enjoyment of technology
carries over into machines for use by the general public; Figure 1 contrasts UK and Japanese ticket machines, and Moggridge (2006) cites an example of an iMode operated drinks dispenser with a very complex, involved and distributed interface (dispenser, mobile phone, iMode, content provider).

![Figure 1: Japanese Ticket Machine & UK Ticket Machine](thetrams.co.uk)

Lee et al (2007) further examines the uptake of mobile internet through a post adoption study in the Far East. They attribute Korean, Hong Kong and Taiwanese attitudes to IT technology as being due to the “cultural lens” through which those cultures view it. Among other findings is the intriguing suggestion that a willingness to share is one of the possible social contributors to mobile internet being more successful in collectivist cultures (see below). Marcus (2002) examines the ways different cultures view colours, symbols, words and layouts, suggesting methods for ensuring cross-cultural acceptance in user interface design. Shen et al (2006) lends a Chinese perspective to the debate, arguing that many standardised interfaces create problems for some cultures. The paper discusses the almost universal use of western metaphors, representations, colour associations and navigational logic and notes issues such as the Japanese preference for not pictorially representing body parts or actions, a very common approach in the West. Khaled et al (2006) examines Persuasive Technology1 and how it might be cross culturally implemented. They suggest that one of the keys to understanding cultural differences lies in understanding the collectivist nature of many eastern cultures verses the individualist nature of the West. They note for example that in the individualist western culture the predominant negative motivational forces is guilt while in the collectivist culture the equivalent negative motivator is shame.

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1 The authors define Persuasive Technology as "any interactive product designed to change attitudes or behaviours by making desired outcomes easier to achieve"
Designers from one culture designing for another sometimes fail to understand these cultural differences and assume certain consumer knowledge, taste or habits are universal. When this turns out not to be the case products can fail (as in the case of iMode in Europe). “What makes it doubly hard to differentiate the innate from the acquired is the fact that, as people grow up, everyone around them shares the same patterns” (Hall 1976).

The differences in the way different cultures perceive products and technology has been well understood for some time and so large companies often have design offices in different parts of the world as a means of accounting for these factors (Trompenaars, 1997). In theory, this should deal with the problem, but in fact these arrangements can fall foul of the very cultural differences they set out to address. PDR commissioned an ethnographic research company to investigate issues facing design teams dealing with information appliances. The study was commissioned to develop improved approaches to the issue including new tools. Some of the case studies uncovered by the research are used here to illustrate six of the challenges faced by the design industry. The following is an excerpt from one of the interviews. Companies’ and employees’ names have been replaced by the titles “A”, “B”, “C” etc. to protect their identity (individuals have agreed to their inclusion in this paper on that basis). Mr X, is a designer in Company A which is a well known multinational concern with a design office in Europe to create products for that market. Mr X: “we spend months working on a design that has been painstakingly researched and developed for European tastes, when the final proposal is sent to Company A headquarters they make arbitrary changes and launch it in another market altogether”. In other words, although the design office has been set up in order to advise HQ on European tastes, they are not allowed to make the final decisions. These decisions, including those on culturally biased tastes, are made by senior managers from a different culture from the intended users of the appliance. The situation is compounded by a culture within the home company of deference to seniority, even when those in more junior posts are better placed to make decisions.

3.2 Challenge 2: Breaking with convention

“Interaction requires two key components. One is the controls, through which people can manipulate access to digital information and computations. Also it’s very important to have external representations that people can perceive, to understand the results of the computations.” – Hiroshi Ishii in Designing Interactions (Moggridge 2006)

There are many conventions that users rely on to help them “navigate” products (what Norman refers to as “natural mapping” (Norman 1998)). The semantics and grammar of many signs have become ingrained with associations only partially based on their original meanings. One example is the triangular symbol found on audio and video devices, the history of which can be traced to the reel to reel tape recorder where it denoted the direction of the tape’s travel. Today it has
come to mean Play on a wide variety of devices from DVD players to solid state MP3 devices. Its original meaning has been lost, but by convention it has acquired a powerful and ubiquitous communicative ability. Designers working towards the right solution for an individual product sometimes fail to understand the significance of conventions such as these, particularly when they are in the process of evolving.

As we grow up, we associate certain shapes, symbols, colours, textures, materials and sounds with given functions, so much so that when we interact with a well-designed product we speak about having a “natural” sense of how it should be used. If there was such a natural sense, and we had been brought up isolated from the industrialised world we would be as able to use it as someone who had used this type of object all his or her life. There is nothing natural about it however. Rather there is a direct link between cognition and culture (Hollan et al, 2000 and Gill, G. 1993) and by understanding us as users, the designer has made use of accepted metaphors and norms, borrowing imagery, shapes, textures, symbols etc. to help us interact using pre-learned knowledge. Goldstein et al (2003) argue that complex devices with multi function devices prevent the use of previously acquired source metaphors (in other words conventions). They note that “a novice users’ previous knowledge plays a major role when interacting with a new multipurpose device for the first time. In order to bridge the gap between the known and the unknown context, the use of metaphors as knowledge carriers have been frequently employed by human computer interaction (HCI) designers.” They go on to discuss how, for example, a digital camera function in a PDA forces the user to use computer conventions to interact with the camera, breaking the contextual link with the user’s source metaphors. For more on the methods used to design exactly this type of product see Fernandez (2004). This paper spells out some of the problems, amongst them the isolation of the industrial design and software design teams (see below). What really adds complexity to the issue of conventions however (as briefly touched on by Goldstein above) is the issue of context.

Fifteen years ago Robinson (1993) noted that “Computer systems and applications that mediate work between people are increasingly discovered to be used in ways that were not anticipated by their designers.” He goes on to note a simple illustration of a hotel key rack that incidentally to its original purpose serves as an indicator of which guests are currently in residence. While a key rack could be misused, it was predictable for designers and users. Furthermore, its potential uses were dependant on its “physical properties, local conventions and rules, and situated activities.” Robinson proposed that this was a model on which computer based interactions ought to be based. Vyas and Dix (2007) argue that as well as previously understood issues such as distributed cognition affecting product users, the materiality and embodiment of their context are equally important factors. Introducing the concept of “Artefact Ecologies”, they note: “One of the central aims behind designing tangible and embedded interfaces is to allow users to interact with them in a natural way that is grounded in everyday mundane experiences. This poses two main
challenges for designers. First is to understand what ways the users naturally interact in their mundane experiences. And the second is to introduce a technology that supports (or improves) their experience.” Dix (2006) discusses the impact of physicality on users and, in some ways Magnasson (2006) continues the theme of physicality, discussing the affordances required of computer screen based musical instruments for use by musicians whose understanding of their instrument lies partly in embodied action. He also notes that one of the potential problems with computing based musical instruments (as with information appliances) is “unnatural mappings”. He notes: “the control device and the sound source are arbitrarily related, unlike in acoustic instruments.”

This lack of any physical link between action and response is one of the reasons such care needs to be taken with information appliances since the user is all the more dependent on the informed and careful use of conventions by the designer. Some of the problems of convention and context became apparent recently when researchers from PDR conducted tests on a BT Equinox. The Equinox is a landline phone with some of the same functionality (e.g. colour screen, texting) as a mobile phone. Although the red and green phone button convention has been “borrowed” from mobile phones for answering and ending a call, the Power control has been placed at the top left of the product. There are three immediate and contradictory issues of convention here.

1. It is a common convention on products to have the power switch on the left hand side, often away from other control inputs (Hi Fi separates, DVD players, washing machines)
2. It is common for mobile phones to have a power switch. There is no absolutely established convention but many phones (Nokias for example) use the red phone key for the Power control.
3. Conventional landline phones do not usually have a Power control at all.

PDR conducted a series of empirical tests on the Equinox based on a methodology developed by Nielsen and Molich, (1990). Tasks were chosen to include common functions including Power On and Power Off. The programme was critically trialled on six participants to check for errors before implementing the main body of tests. Modifications were made to the software, hardware and methods of testing and recording data as a consequence of these. A total of 80 participants from the University of Wales, Institute Cardiff (UWIC) took part (62% female), ranging in age from 18 to 30 years. They all had at least 1 year experience using mobile phones with an average experience of 7 years. They sent an average of 6 text messages a day, suggesting good familiarity with ‘typical’ phone interfaces. Each participant was given an instruction sheet to read and they were allowed to ask questions if they were unsure of the procedure. They were then given one minute to familiarise themselves with the interface before the tasks commenced. The trials were also videoed with sound (see Figure 2) and users were encouraged to ‘think aloud’ if they wished. Comments were noted as were actions or errors of specific interest.
One of the most notable issues that users had was that they were repeatedly confused by the placing of the power switch. This was because although the designers had made a series of choices that followed convention, the context in which they had used them (a landline phone with the functionality of a mobile) was confusing because the predominant characteristics of the phone as perceived by users were that of a mobile. Consequently they tried to implement the wrong source metaphors and when asked to switch the phone on they automatically pressed the red phone button without looking for the Power symbol. Many of them tried the same thing repeatedly and some failed to switch the phone on at all.

The development of designs which successfully employ “natural mapping” require designers to be fully cognoscente of which conventions should be employed where. Tests need to take place at an early stage in a product’s development to determine how the user views the product. It is not enough to follow a series of conventions, rather the designer needs to know (and know early) which conventions users expecting to follow. As mentioned elsewhere in this paper the tools to allow designers to very rapidly explore these issues at an early point in the design process do not exist in a satisfactory form.

3.3 Challenge 3: Social Context

"In attempting to design a system to "fit" the end user, behavioural issues must be considered and understood. Given the limitations of the analytical tools available, and our inability to adequately predict system performance in "real-world" situations, it is unlikely that the first implementation of any user interface is going to function as well as it could or should. Under these circumstances, an alternative is to take an iterative approach to design: keep trying until you get it right" (for more see Schrage, 2000). “However, two problems become immediately obvious. First, how do you know when you have got it "right", and why it is "right". Second, how can such an iterative approach be made practically and economically feasible?” (Buxton & Sniderman, 1980)
When 3G phones were first launched one of their key Unique Selling Points (USP's) was that they had cameras. The cameras were mounted on the same side as the screen to allow video conferencing. Later ethnographic research (Loudon et al 2002) showed that users wanted cameras to take photos of other people and objects and so later models, (many of them not 3G) place the camera on the other face of the product. Manufacturers had failed to understand the social context of phone camera use.

Most commercial design tends to be carried out in a studio or office environment. There are a number of reasons why this is the case, not least among them confidentiality issues and the fact that the environment is equipped for that purpose. Nevertheless, products are frequently designed and tested well outside their context of use and as the example of the camera phone illustrates, this can lead to problems once they are in production. Experience Prototyping (see 2.3) is one way to tackle the problem of simulating the context of use environment without leaving the office or design studio. Augmented Reality (for testing rather than prototyping as described in 2.5) is another, as are the techniques used in Project Maypole (Kankainen, 2003) where end users (children in this case) were brought into the design environment and involved in the product development process. A third method is the use of video collages, sound, pictures etc. gathered, filtered, edited and presented by ethnographers to help the design team understand a product’s Context of Use (Keller & Stappers, 2001).

Unfortunately, design teams are frequently not in a position to undertake Context of Use testing or simulation either because of company structures or financial and time pressures (see Issues 5a & 5b below), so are forced instead to work in isolation from either the end user, other parties involved in the design or both. The result is that designs are frequently conceived, designed, developed and launched with no real understanding of the users’ requirements.

3.4 Challenge 4: Ingrained Thinking

“Just a few years ago, a camera was a mechanical and optical instrument with a chemical film. Little by little the computer chips invaded. First it was automatic exposure, then auto-focus and red-eye removal; now digital memory is replacing film. We still think of it as a camera, though, dedicated simply to the task of capturing images, but it is not just a camera anymore. It’s a camera, an album, and a way of editing and choosing. Somehow the design expression has to support all of these things.” (Moggridge 1999)

From early on in their history cameras have had viewfinders that necessitate the user placing their eye to them. As the digital camera came of age it became apparent that users frequently ignored the viewfinders and used the screen. Ingrained thinking by designers, manufacturers and users led to a slow transition from optical to digital viewfinder/viewing screens that allow more
camera angles and facilitate effective picture browsing. Tripsas and Gavetti (2000) describes a case study of Polaroid’s response to the problems of digital technology dominance, citing the mindset of managers who, since they “are boundedly rational, must rely on simplified representations of the world in order to process information (Simon, 1955). These imperfect representations form the basis for the development of the mental models and strategic beliefs that drive managerial decisions. They influence the manner in which managers frame problems and thus how they search for solutions.” What they found was that while Polaroid had the technology and the personnel to make the changes required, their view of the photography market was too ingrained to allow their products to flourish. Kodak took a different approach, asking IDEO to “make sense of digital camera interactions” for them. IDEO were early pioneers of a change in traditional design methodologies. They recognised that designers of information appliances should start by “designing interactions” rather than products or interfaces. In an interview with Bill Moggridge (Moggridge 2006) Matt Hunter describes how the brief from Kodak led them to re-look at the possibilities offered by the technologies and conduct ethnographic research in order to point at the types of functionality required. The output was an oversized interactive prototype which embodied a number of suggested interactive possibilities for Kodak to utilise in future products. Kodak quickly developed a strong market position on the back of this work which was carried out by a multidisciplinary team looking at an issue laterally.

**Figure 3:** Camera on the left retains standard viewfinder (image source: zdnet.com.au). Model on the right uses the increasingly popular large screen format with no conventional viewfinder. (image source: Kodak.com)

Designers are trained to think laterally. Methods such as *Six Thinking Hats* (De Bono 1990) and *Techniques of structured problem solving* (Van Gundy 1988) are commonly taught in universities. There are many examples of designers displaying this ability to “think out of the box” (e.g. Gaver and Martin 2000). Unfortunately the realities of design as a commercial practice are that there is frequently not enough value placed on innovation in any fundamental sense (i.e. not a willingness to pay or to wait for it). Thus, early on in the evolution of the digital camera, standards were borrowed from chemical film cameras without fully understanding the change in its function brought about by the technology that enabled it to exist (hence Kodak hiring IDEO).
Again, this situation is exacerbated by the lack of prototyping tools available to designers without access to multi disciplinary skills and further still by ingrained thinking within their immediate environment. Even now, the designers interviewed by PDR did not have access to the skills required to output prototypes of the type IDEO produced for Kodak in 1995.

A researcher commissioned by the PDR interviewed Mr Y, also a designer within Company A. Mr Y was asked about his views on usability testing. He stated: “Usability testing should provide validation, as designers should be able to know what a user wants”. Dr Z noted a similar trend in Company B (another multinational brand): “The New Product Manager called us in and told us that he wanted us to conduct user research into the design of a new product. However he already had strong views on the design including the type of screen, its input devices, its capabilities and so on and insisted on us using his ideas. When we did the research we found that the needs of the target users didn't really match the design ideas of the New Product Manager”.

4.0 Challenges 5 & 6 (Commercial Organisations)

Design is a commercial activity and design departments don’t exist in isolation, even in design consultancies. The structure of an organisation has the potential to greatly influence design output. This issue isn’t unique to information appliances, but given their complex nature and need for effective cross-disciplinary cooperation, they are particularly vulnerable to issues of organisation.

4.1 Challenge 5: Company size and structure

There are three main sectors within which information appliances are generally designed: design consultancies, Small to Medium-sized Enterprises (SME’s) within the manufacturing sector and multinational companies. The opportunities and the challenges facing each of these will be discussed and illustrated through case studies.

Issue 5a: The company is too small

Researchers working for PDR spoke to the design & development employees of six UK-based companies. All agreed that the ideal way to approach the design of a product is to get in-depth market and user analysis before proceeding towards concept generation. Unfortunately, in the case of small companies, they faced growing pressures to get products to market within very

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2 To contextualised this remark, he was expressing the opinion that ideally, a designer should make it their business to become an expert in their given field, to the extent that most parameters of the design are understood. In this scenario, user testing ought to validate the design although it may raise minor modification issues.

3 2005 confidential report commissioned by PDR, carried out by Lightminds and funded via the Knowledge Exploitation Fund exploring industry practice on the design development of Information Appliances.
tight time and cost constraints. In general terms, the smaller the company, the less able it is to turn work away and the less able also to influence a client’s decisions. In the words of a senior manager of Company C, a medium-sized design consultancy: “The problem with Market Research is delay”. The biggest design consultancies like IDEO and Pankhurst Design & Development (PDD) are in a stronger position to dictate to clients the type of design process which should be undertaken because they have multidisciplinary teams making them able to deal with large and complex projects in their entirety. In the short term this process costs the client more money and time but in the long term they see the benefit from a product which is able to capture a greater market share. Smaller consultancies are faced with a stark choice: Accept the terms the client offers: i.e. short time-to-market and low cost, or see the work go elsewhere. In short, their work is cost-based and other considerations must often be given less priority. Consider the example below:

Company D is a medium-sized company who specialize in industrial design. An employee of Company D and who had worked on the design of an information appliance was asked; “How did you design it?”

Answer: “I produced templates in Photoshop for design critique and then we developed those into fully working interfaces on screen in Director or Flash and when the basic structure was approved we employed a technology company to develop a test rig, it was programmed and Company D built a full working prototype”.

Question: “Did users test these? Or a designer (like yourself)?”

Answer: “Well it starts off just internal testing but eventually the client takes it away and goes around the globe presenting it to investors and panels for review, so we have phases and they come back and we get feedback and work from there - depends on cost, schedule, and whether you have time for all of that”.

Question: “Ok, tell me, when is the actually 'user' involved for testing the interface, at the end? e.g. You guys create what you can from your experiences, and then is there an actual "end user" testing, to test the interface, or do you rely on the designers’ knowledge?”

Answer: “It’s up to the client how they want to manage that. To be honest, the Company D interface was poorly conceived and I tried to warn them, but time doesn’t allow it, it just gets done and you go with it. It was more design led than usability. A senior worked on the ID, and I worked on the screen interface when really we should have worked TOGETHER and I keep asking him about the locations of buttons and things, because the interface should reflect that but there
was no time, he just gets on with it, and I just have to do it, with or without knowledge of what he is doing!“.

In addition to the factors mentioned above, designers in smaller companies are frequently presented with an electronics "package" complete with control inputs (often with the interfaces fully designed) and then simply told to "box" them. PDR’s design department for example received a total of 20 design jobs related to information appliances between December 2003 and February 2007. Of these two were developed only to concept level and one involved the development of CAD data to output rapid prototypes. Of the remaining 17, 10 involved “boxing” an existing electronic package. Because most small to medium sized consultancies do not have teams of designers and engineers working together the designer becomes disempowered because he or she has no way to properly test ideas in three dimensions. All of the methods mentioned in the introduction, including the current IE System (Gill, S. 2003) require levels of time commitment that are frequently too high for many small and medium sized consultancies.

Issue 5b: The company is too big

Surprisingly, multinationals designing information appliances can suffer from many of the same problems as SMEs. Their very size means that they can only be effectively managed if they are split into smaller components. Sachs (1995) noted that the way these components are organised is often influenced by an organizational view which defines structure by sets of defined tasks and operations. She argues that organising companies by activity is a better strategy; “An activity orientation draws on insights about work practice from several disciplines, including anthropology, history, and psychology, and in so doing provides a holistic approach to the analysis of work.”

One of the consequences for task structured companies (which include Company A and Company B) is that many of these smaller components are the size of SMEs and, being structured by task (e.g. software interface) rather than by activity (e.g. appliance design) don’t have very diversified facilities or skill sets.

Iansiti and West (1999) note an additional problem for companies who wish to efficiently employ new technologies and must therefore integrate their Research & Development activities into their design departments; “if a company selects technologies that don’t work well together, it can end up with a product that is hard to manufacture, is late getting to market, and does not fulfill its envisioned purpose”

The problem in this case is often not limited resource but limited organisational remit. As the various components of the design are processed (user interface, electronics, programming, graphical layout, product design etc.) it is almost inevitable that important aspects are left out because they become apparent “too late” in the development cycle to influence product architecture, in other words, when too many factors are already defined or determined. This
problem is exacerbated by communication problems between the various task-oriented departments. Multinationals may have design departments, research & development labs, market research units and so on but because of the size of their operations these tend to be placed in separate units, sometimes in different countries or even continents. Each of these units is frequently reliant on the work of another, so a unit working on usability cannot start to integrate product design within their own remit since this work is carried out elsewhere. Fernandez (2004) describes working out the entire camera interaction software for the Palm Zire without having any knowledge of the product form. In certain cases much of the work that takes place in one department is also confidential from another and so the job of effectively coordinating the various skillsets in the company as a whole is very problematic. The result is that, like in an SME, each unit in a multinational frequently finds that it is unable to work in a fashion best suited to producing effective information appliances. As with the SME, the design department may be told to “box” electronics designed by the engineering lab and the usability experts told to work with the layout that product design have selected for them. Some of the problems related with this type of company structure are related in Buchanan & Huczynski (1997).

4.2 Challenge 6: Company politics

Companies are frequently described as being "design led“ (Apple) or “technology led“ (IBM) and this is a direct reflection of their ethos. The differences are summarised by Hagedoorn et al (2001): “The IBM approach to personal computing as found in the PC, introduced in 1981……was designed by technologists for use by technologists. Users with some technical ability could open the computer, add and remove components, and otherwise modify the system, but such activities required an understanding of the technical principles.” “In contrast” (they continue): “The ‘philosophy’ behind the introduction of the Macintosh computer to the mass market in 1984 represented a change within the existing technological paradigm. First, the Macintosh approach introduced the concept of ‘user-friendliness’ with the graphical user interface (GUI) using icons on a desktop to represent programs and files. Second, the overall architecture of the Macintosh was conceived as a single integrated unit, ..........Third, and most important, the Macintosh was developed as an integrated system which made the technical aspects of the computer opaque to the user.” By and large both companies have the same ethos today.

When companies change ethos however, new management structures alter the “balance of power” and the product design process can be altered according to which discipline is dominant. Dr Z was previously a manager charged with overseeing usability issues of new products at Company B (mentioned above, a well known multinational company who produce mobile phones). Interviewed on behalf of PDR, he said: “Company B was traditionally engineering led. In that climate the industrial design department did as the engineers told them and were not consulted on many aspects of the design. Following a change in strategic direction the industrial
5.0 Overcoming the Six Challenges

The six issues outlined above amount to a small proportion of the problems faced by design teams. Nevertheless, it is quite possible to overcome them and successful design approaches certainly exist, the Steelcase Roombooker for example (O’Hara et al 2003). The case study below also illustrates a methodology and team structure that seeks to overcome the barriers to the creation of successful information appliances.

Company X specialise in designing information appliances. Their size, mix of expertise and approach address each of the six issues outlined in this paper as illustrated by an information appliance designed by them, the Navitile:

5.1 Case Study: The Navitile

The Navitile is a good example of Company X’s methods. In approaching the problem of route finding within large buildings they used ethnographic research techniques to look at conventional methods before proposing a solution. Sharpe & Stenton (2002) note: “Humans tend to build up very rich physical environments that help reduce the load on our cognitive functions. A classic example is wayfinding. The rich variety of mechanisms we use to guide us around the environment offer and reduce choices in ways that we can deal with as we move around”.

There are two common methods of helping users navigate a building: Maps and signs. Company X considered that maps provide a “big picture” view with huge amounts of information that users are required to sift. Signage on the other hand, while requiring less sifting, only works on a localised level, expressing the choices of route faced by a traveller at any given junction.

Figure 4: The Navitile. Source: Modulex.com (2005)
The *Navitile* system consists of a series of networked Radio Frequency Identification (RFID)-enabled floor tiles. On their surface is a series of arrows arrayed on the 8 main points of the compass. It is designed for large public buildings such as hospitals where people not familiar with the building are frequently asked to navigate their way through it.

The concept is very simple. At reception the visitor is given an object such as a name badge, a brochure, card etc. that has an RFID tag attached to it on which is encoded the visitor’s destination. *Navitiles* are placed on every corridor junction in the building so that every time he or she reaches a junction they simply stand on the tile. The tile senses the weight of the person on it then reads the RFID tag and points the visitor in the right direction by illuminating the appropriate arrow.

So, why is it an example of good practice?

- The system seeks to perform only one task. This means that fewer compromises have had to be made. If it was designed to perform two tasks it might perform both less well.

- Visitors can take detours and still find their way to their destination. So if they have arrived early and decide to go get a coffee before their appointment they can still find their way, even from a different point in the building.

- Unlike a map, it only gives you specific information about a single destination. So although the system covers all locations, it only shows a user the information they require.

- It breaks with convention (using maps or diagrams to navigate), an issue well understood by designers. Breaking convention is often achieved by using a series of techniques (mind mapping, group discussion, direct observation) to suppress prejudices and pre-conceptions. The problem achieving it tends to make itself felt when other factors such as social context, company politics or company size/structure come into play (see *Challenges 3, 5 and 6*) preventing the full design process coming to bear on a design problem. Company X have been careful to create conditions whereby they are free to operate outwith those constraints. Key to this approach is the use of ethnographic research techniques.

- Creative stimulation study techniques were employed to look for latent consumer need by looking at the ways in which products or artefacts are converted or subverted for uses other than those for which they are designed. (See Figure 4). The
process involves viewing users in their social context, observing conscious and unconscious interactions with products, people and the environment.

Figure 5: Creative Stimulation (for Suri, J.F. + IDEO, 2005)

Again, this method of gathering information is not new, it is an established design technique, widely taught in universities and used at the highest levels by the likes of IDEO and PDD. Unfortunately, however, for the reasons mentioned above and others, the technique is frequently not applied to information appliances. Because they have both technological and usability expertise “in house”, Company X is able to construct working prototypes and test products in their “natural” environment, thus it is able to benefit from unexpected “windfalls” such as the one in Figure 4.

6.0 Conclusions

The context of a designer’s day to day work can have a dramatic impact on their effectiveness. This paper has argued that there are six major challenges that most affect designers of information appliances:

- Unwitting cultural bias
- inappropriate breaking of conventions (caused by lack of support in training, time or tools to carry out the job),
- designing without reference to social context because of time, cost and/or IPR issues,
- ingrained thinking, (creativity suppressed by commercial and time pressure realities and compounded by a lack of fast, easy to use tools for the iterative design development of information appliances)
- issues with company size / structure (either too small to drive the design agenda or too large so that expertise exists across different departments, countries or even continents)
- company politics (one part of a team has dominance over another with negative results)
As Figure 6 illustrates, each of the six issues has potential consequences to the success of a product.

### 6.1 Dealing with the Six Challenges

While the Company X case study above demonstrates that all of these challenges are surmountable, the fact remains that there are significant barriers to overcoming them in anything less than ideal design set ups:

6.1.1 PDR’s research found that companies like Company A understand the problem of Cultural bias and have put experts in place to deal with it. The real issue is that they are not yet making full and proper use of that expertise by devolving decision making powers to those on the ground.

6.1.2 Iterative product development is not a new concept and proper rig testing and user involvement have been picking up issues such as the inappropriate breaking of conventions, for many years. Given the time and opportunity any designer ought to know how to develop a product this way. The issue for a designer developing an information appliance is that they frequently don’t have the training, skills or appropriate range of tools necessary for the effective development of that type of product. This issue is particularly critical at the fast and fluid low to medium fidelity development stage of a project when most of the key decisions are made.
6.1.3 Companies need to understand the commercial value of products that are appropriately designed for their social context and realise that time and cost can be re-cooped from a design that gives a market what it wants, be it explicitly or implicitly. Where IPR issues are particularly sensitive, techniques already exist to give designers detailed information about the user and offer ways to simulate context of use, these need to be implemented more widely than they already are but that implementation is dependent on recognition of their value at all levels.

6.1.4 Ingrained thinking can also be tackled by persuading companies to release their designers’ skills for innovation at a fundamental level using some of the standard techniques mentioned above. Unfortunately, this will again be hampered by the lack of training, skills or a complete range of tools (to supplement the likes of Experience and Paper Prototyping) specifically to empower designers to develop ideas for information appliances in a fast and fluid fashion early in the design process.

6.1.5 Company size/structure: Companies approaching design consultancies need to understand that they frequently undermine their own interests by restricting briefs and failing to allow designers to use their training to approach a project from a fresh perspective. Large consultancies such as PDD and IDEO have, in part, become large precisely because they have been able to persuade clients of sense in this approach. It must be recognised however that small consultancies often simply don’t have the resources to undertake information appliance development work in this manner because, at present, a lot of very specialist knowledge is required to prototype them and it takes a long time, thus we return to the issue of providing designers with appropriate tools. As discussed above, large companies have all the expertise required but it tends to be compartmentalised so that employees in one department find it difficult to effectively access the skills available in another for political, geographical and confidentiality reasons. These issues are complex simply because the scale of operations in a large multinational mean that teams have to be very large. It is clearly in accord with the best commercial interests of a company of whatever size to operate a sensible, well structured approach to information appliance development. To that end, and in the context of information appliances it would make sense to implement Sach’s concepts of company structure based upon activity rather than tasks. Failing that, improved communication between departments might make a significant difference. Protocols for the treatment of IPR sensitive data would keep the risk to sensitive data at a minimum, and the use of secure links for the electronic transfer of CAD and other design data wedded to the appropriate implementation of products such as the Virtual Desk (Ashdown & Robinson 2005) that
allow for collaborative work practices regardless of geographical remoteness would further ease the communication and organisational issues.

6.1.6 **Company politics** causing one part of what should be a team of equals to have dominance over another is a perennial issue not restricted to information appliances. The growing consumer pressure to produce usable products is likely to aid the resolution of this issue but again, giving designers the tools to make low, medium and high fidelity prototypes would make a significant difference, returning rig development to its rightful place in the development process and removing the skills bottleneck that frequently exists, especially when dominance issues come into play.

### 6.2 Possible Solutions

The issues summarised in 6.1 can be grouped into two areas: Company Management and Design Tools:

#### 6.2.1 Company Management

Cultural bias, company size/structure and company politics might all be combated by the implementation of team structures that:

- allow the views of those best placed to judge specialist issues the power to make decisions related to that specialism;
- recognise the commercial value of innovative design that breaks boundaries and invest accordingly;
- give equal weight to the views and skills of all major contributors to the design and development process

#### 6.3.1 Design Tools

Inappropriate breaking of conventions, design for social context and ingrained thinking can all be tackled by new techniques and tools that facilitate a return to basics, ensuring that an iterative design process is implemented for information appliances as much as for any other. Such tools need to be fast & flexible, allowing the rapid exploration and testing of design concepts at a very early stage. They will have to be a good fit with designer’s existing working habits and capable of working with ethnographic methods such as *Experience Prototyping* and *Paper Prototyping*. Like *Experience Prototyping* and *Paper Prototyping* they will also need to be capable of different fidelity levels, and no complex electronics or programming should be required. One last issue not addressed so far: universities need to engage more with this subject. Design undergraduates need to be taught new techniques as they evolve, so that each new generation of designers brings to the market up to date skills that improve the profession’s grasp of the issue.
REFERENCES


