

Experience Design for Pervasive Computing

Richard Hull & Josephine Reid
Hewlett-Packard Laboratories, Bristol, UK
E-mail: {richard_hull | josephine_reid}@hp.com

Abstract

The experience provided by a product (or service) is one of the major factors in a consumer's choice of that product. As the long-expected era of pervasive mobile computing becomes reality, it will continue to be essential that Hewlett-Packard is able to deliver products and services that indirectly enable or directly deliver compelling experiences. The 4D experience project in HPLabs, Bristol is exploring both what constitutes a compelling experience and how they might be delivered through the emerging technologies. In this non-technical introduction to our work, we outline our motivation and approach, and briefly describe two case studies, the Zap Scan exhibit at Explore@Bristol and a photographic exhibition augmented with a context-sensitive digital soundscape.

1 Experience matters

Why do we buy some things and not others? At first sight, this seems like a straightforward question: We buy those things that do what we need to have done. So, we buy food to eat, clothes to keep us warm (and decent), and cars to get us from A to B. However, a moment's reflection reveals that the situation is not really so simple. There are a multitude of food choices in our supermarkets, our clothes show both conformity and wild diversity, and few car adverts bother to tell us that their product will indeed transport us to our intended destinations. Obviously, other factors also influence our purchasing decisions.

In general, we can consider consumer choices to be driven by four main factors:

- Utility *What the product (or service) does*
- Symbolism *What the product says about you*
- Experience *What it feels like to use the product*
- Cost *What it takes to acquire and use the product*

In many consumer markets, neither utility nor cost are major factors in choosing between one product and another. Most, if not all, consumer products perform their basic functions satisfactorily and similar products normally demand similar prices. Of course, this generalization is not always true, with price-competitive food retailing, for example, providing one exception. But it remains a reasonable rule of thumb for consumer electronics, computing and appliance markets, where brands and perceived user experience dominate.

At Hewlett-Packard Laboratories, we have been exploring the nature of consumer choices. While we retain an interest in the construction and interpretation of the symbolic meaning attached to particular products, we have chosen to focus on two dimensions of user experience:

- Experience *of* the product, i.e. what it feels like to use
- Experience enabled *by* the product, i.e. the things it allows you to do

Of course, over the last few decades there has been much work throughout the computing industry on optimising the user's experience of products, with a strong emphasis on ease of use that has led in part to the emergence of the appliance product model. One lesson from this work has been that the packaging and presentation of a product's functionality matters. Consider the three pictures below.



Each picture shows a device with the same functionality; the ability to display text and graphical information. However, the packaging of this functionality in the three devices generates different expectations in the user and leads to different experiences. The monitor on the left is evidently a serious tool and engenders a productivity-oriented approach to its use and evaluation. The digital picture frame prototype in the centre is much more domestic and might generate the same response as a fine painting or a favourite piece of music. Finally, the embroidered pillow with an embedded display shown on the right, created for us in a collaborative project by a local artist, Annie Lovejoy, generally invokes surprise and delight. The devices have similar utility but quite different meanings.

We continue to endorse attempts to enhance the user's experience of products through functional, presentation, and interaction design. However, our research is increasingly focused on the second dimension mentioned above; experiences that are enabled *by* consumer products. In other words, the question is not now so much, "What does this product feel like?", but, "Where does it take me?". As an example, think about your favourite hobby and the things that it has led you to buy. Maybe you are a musician. If so, then you probably cherish your instrument and like the way it looks and feels. But, the real thrill comes not from owning the instrument but from playing it, from the challenge of trying to master its subtleties and the sheer fun of playing with other people. In a sense, the instrument is merely the entry ticket to the real experience that you sought through its purchase.

Our interest here has led us into the emerging field of *Experience Design* where the emphasis is precisely on the design of products and services that generate compelling experiences for their users. This new field draws on a number of traditional disciplines such as architecture and graphics design, but is increasingly beginning to engage with emerging digital technologies. This trend is well illustrated by Nathan Shedroff's recent book on Experience Design (<http://www.experiencedesignbooks.com>) and the establishment of the Experience Design Group at the American Institute of Graphic Arts (see <http://www.aiga.org/content.cfm?Alias=fourthadvancefordesignsummit>).

Our contribution to this new field is to explore how compelling experiences can be delivered via new digital technologies, and particularly through pervasive mobile technology and context-aware services. We are working with designers, artists, musicians and other creatives to develop - and evaluate - prototype experiences in and around the city of Bristol. In the rest of this article, we will look at two case studies. Later, we will describe an art installation in which the physical exhibition space has been augmented with a location-sensitive digital soundscape. But first, we will look at Zap Scan, an exhibit at a local science museum designed to compete with virtual volleyball and Bernoulli blowers!

2 Making an experience: Zap Scan

Zap Scan was an experiment with two objectives. First, we wanted to see if we could turn mainstream computing products into an engaging, hands-on experience that was viewed as a fun exhibit rather than as utilitarian office equipment. Second, we wanted to use the exhibit as a real world probe to begin to understand what constitutes a compelling experience.

Zap Scan incorporates a standard scanner, flat panel monitors, PC's and an Inkjet printer. The inventiveness in Zap Scan lies in the way that these products are packaged into an interactive

exhibit with a custom application designed to make the user actions as simple and intuitive as possible. It shows how technologies that are often considered to be rather dull can be transformed into what children call “the cool card maker” or the “magic screen scanning machine”. One lesson is that when people use technology to enhance their own creativity and inventiveness they project attributes of creativeness and inventiveness onto the products themselves.



The Zap Scan system is situated on the first floor of the Explore-At-Bristol science museum (see <http://www.at-bristol.org.uk>). Visitors walking up the main stairs are met by a picture wall with framed prints. There is also a digital picture frame showing images that have just been created on the other side of the wall.



Walking around the wall the visitor finds a drawing area with paper and crayons available so that they can sit and create their own work of art. At the end of this area there is an embedded scanner. By lifting the lid, placing the drawing and pushing a button the user causes their image to appear on the screen above the scanner as well as on the picture wall. Signs on the exhibit inform the user that their drawing will also be available on the Web (follow the Zap Scan link from <http://www.at-bristol.org.uk/explore/default.htm>).



The Zap Scan card printer is a physically separate unit that has a touch screen, coin slot and printer. The touch screen always displays the last ten scanned images. The user touches their picture, enters their name, inserts a pound coin and a glossy card of the picture is printed with their name on the back.



Response to Zap Scan

So in summary, Zap Scan enables visitors at the science centre to draw a picture and scan it for display on a digital picture frame. The user can then opt to print a glossy greeting card of their image using the Zap Scan card maker. The scanned image can also be accessed anywhere in the world via the web.

In terms of functionality, Zap Scan does not do anything that most people cannot already do with a PC, scanner and printer at home. However it is clear from the response to the system that:

- Zap Scan is popular. Between April 2001 and October 2001 there were 29551 scans, 10670 pictures uploaded to the web site, and 1918 cards printed. Throughout the summer holidays the number of cards printed per day ranged between 17 and 37.
- It is not seen as being the same as a computer system. Interviews with users and observational study confirm that it is considered a positive hands-on experience just like others at Explore. Whilst most of the people interviewed had a scanner and printer at home they would still use Zap Scan because it was easy to use, fun and they really liked the cards.
- The staff like it. Zap Scan easily justifies its presence as a visitor attraction. Some visitors will spend a long time working on their drawings. Parents will sit beside their children watching them draw or joining in themselves. Friends will sit together and share in the excitement of seeing each other's drawing on the digital frame.
- It is compelling. The ability to see your own creations immediately on screen and in the public eye is exciting. Young children nudge their friends and point excitedly at the screen when their own or their friend's picture appears. Similarly, the moment that a card drops out of the shoot from the printer is also exciting. Children will gaze in anticipation into the printer watching the card appear little by little.

3 Unpacking the experience

The response to Zap Scan suggests that we were successful in the first of our objectives for the project. Anecdotal feedback is very positive, but exactly why is that? What is it about Zap Scan that makes it fun? This question is at the heart of the second objective for the project: to begin to understand more formally what constitutes a compelling experience. This part of the project involved three analytical methods:

- **Observational study.** Six exhibits were selected as: representative of some of the most popular exhibits, offering a variety of experiences and relatively easy to observe inconspicuously. We used informal pilot research to generate a set of 17 categories of behaviour commonly observed around these exhibits. These were used to construct a check sheet that observers filled in during set periods of observation. Whenever a behaviour was observed it was marked appropriately on the check sheet.
- **Discussion Groups.** Over a 2 day period, we recruited 78 Explore-at-Bristol visitors to attend a 15 minute discussion group and complete a questionnaire. We encouraged the groups to talk about which exhibits they most and least enjoyed and why, what they felt makes a good or bad exhibit, How they thought about the value of the Explore-at-Bristol experience and what kinds of things they compared its value with.

- **On the spot interviews.** A further day was spent observing people using Zap Scan and asking them for feedback on how they enjoyed the it and how it compared with other exhibits.

Based on analysis of the data gathered from these studies we have developed an initial model of what we believe are the main dimensions of experience. These are:

- **Challenge and self expression**
Many compelling experiences, particularly at an interactive science museum such as Explore, have an element of challenge and self expression, for example, the way in which an experience stretches the user's physical or mental skills or enables her to express or create something.
- **Social.**
Similarly, many enjoyable experiences have a strong social dimension, which might include both the ability to compete against others and to bond with other people.
- **Drama and sensation**
Finally, many experiences are compelling because they provide stimulating sights, smells and sounds, or include narratives and other cues that trigger flights of imagination.

Of course, most experiences will have a mixture of these dimensions. Our ongoing research is largely concerned with understanding better how these elements relate to an overall experience, and with refining and validating the model through active experimentation.

4 Digital: The 4th dimension

Mobile technologies are becoming increasingly pervasive in developed economies. Mobile phones are already ubiquitous, laptop computers are widely used in business and academia, and handheld devices are beginning to gain a foothold in the market. As computers increase in power and memory size, while size, power consumption and cost all fall, we can expect to see the advent of two related phenomena

- *Wearable computing*, in which users increasingly carry (wear) powerful, context-aware devices that aim to do the right thing for the user, at the right time and in the right place
- *Ubiquitous computing*, in which functionality migrates from distinct computing devices into the fabric of everyday life

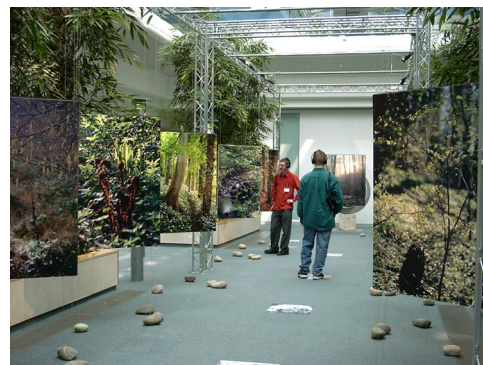
The significant change that will trigger the emergence of these long-predicted phenomena from research laboratories into the real world is likely to be the arrival of low-cost wireless connectivity. Mobile phone operators around the world are investing billions of dollars in third generation (3G) networks that promise to deliver low latency and high bandwidth data channels over the next few years. In the meantime, free 802.11b wireless LAN access is spreading rapidly as companies and individuals deploy base stations open to all comers.

One way of thinking about these developments is to imagine the emergence of a new, digital dimension overlaying the physical world. This new dimension will be mediated in part by a user's personal devices and in part by the intelligent signposts, bus stops, shop fronts etc now

populating the urban landscape. The question is: What will we find in the digital dimension and why will users value it?

Not surprisingly, our belief is that one valuable use of the digital dimension will be to enable compelling consumer experiences. In particular, we expect the emergence of what we have termed *Situated Digital Experiences* in which the experiences reflect and enhance their physical locations. Examples include digital art interventions, virtual games played out in the city streets, and context-sensitive tourist and local history guides. Consequently, we are now applying the approach developed in the Zap Scan project to prototyping, deploying and evaluating such experiences.

5 A walk in the wired woods



Our first experiment in this area is an art installation developed in collaboration with a local artist, Liz Milner, and musician, Armin Elsaesser, entitled *A Year and A Day*. The installation builds upon an existing exhibition of woodland photographs made by Liz over the course of a year in a nearby wood. We recreated the exhibition in the atrium of our building at the Hewlett-Packard site in Bristol and augmented it with a digital soundscape.



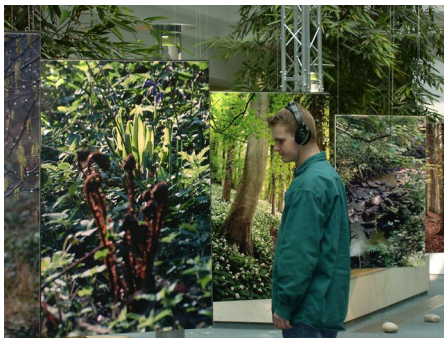
Visitors to the exhibition are invited to wear headphones with an integral ultrasonic sensor and a small shoulder bag while viewing the photographs. The leads from the sensor and headphones both make their way into the shoulder bag. Inside is a HP Jornada 568 handheld computer with 802.11b wireless network connectivity and an extension board handling the output from the sensor.

Equipped with this "wearable client", the visitor typically spends around twenty minutes wandering around the exhibition, viewing the photographs and hearing music, woodland sounds and speech chosen to enhance their content. The particular sounds heard by the visitor at any point are determined automatically by the system according to her location within the exhibition space. For example, as the visitor approaches certain photographs, she might begin to hear atmospheric music appropriate to the scenes depicted. As she moves on to other images, the music might be replaced by natural woodland sounds, or by a spoken fragment of woodland mythology.

The wearable client achieves this effect through its ability to:

- detect its location within the exhibition space using an ultrasonic positioning system developed by our partners at the University of Bristol (see <http://wearables.cs.bris.ac.uk>)
- interpret its location with respect to a map of the physical and digital exhibition space
- fetch audio data (and other information) on demand from servers over the wireless network
- mix and play multiple stereo audio streams via the headphones

The association of particular sounds with locations was determined by the artists responsible for the exhibition. There are around thirty audio "auras" in the central exhibition space, with another dozen auras ring-fencing the space. A circular area of applicability, one to two metres across, is defined for each aura centred on its specified location.



The client's behaviour on detecting that it has entered an aura depends on the "channel" label for that aura. For the majority music and natural sound channels, the client simply (fetches and) plays the associated audio. Where auras overlap, the client plays the audio associated with the aura whose centre was nearest. The behaviour for the speech channel is a little more complicated and depends upon the client's history. In particular, all of the speech auras are associated with the same set of audios. The audio actually played in a

speech aura is chosen to maintain a sequence of spoken descriptions regardless of the order in which these auras are encountered. Although simple, this example illustrates how context-sensitive applications can tune experiences to reflect both the user's actions and the creator's intentions. A feel for the exhibition can be obtained from a website documenting an open day we held at the end of January 2002 (see <http://www.hpl.hp.com/hosted/mbristol>).

The response of visitors to the augmented exhibition is overwhelmingly positive. Of course, the high quality of the photographs and music contributes significantly to this outcome. However, most visitors report that the extra dimension added by the contextual juxtaposition of the two media adds even more value. A simple ranking exercise undertaken by a colleague, Erik Geelhoed, revealed that more visitors likened the exhibition to a walk in the woods (something that it attempts to invoke but really is not) than to a museum tour (something that it really is). This reinforces our belief that it is possible to create a convincing and compelling experience with the kind of mobile technology that we can expect to become pervasive over the next ten years. The challenges now are to refine our ability to create a range of compelling experiences reliably and effectively, to influence the development of the emerging technologies to better support such experiences, and to establish appropriate business models for their delivery.

6 Into the streets

Which brings us on to future plans. Our research is being undertaken in the context of a larger collaboration between Hewlett-Packard Laboratories and the University of Bristol, known as Mobile Bristol, which aims to equip the centre of Bristol as a living testbed for wearable and ubiquitous computing. This involves the deployment of 802.11b base stations around the city,

the development of prototype client devices capable of sensing the user's context, the development of prototype context-aware services, and the subsequent studies of what users make of it all.

As this year progresses, we will start to move our experimental experiences out of the protected environment of the Hewlett-Packard Laboratories and into the city streets. Using our provisional model of experience as a guide, we will attempt to deploy and evaluate applications that emphasize social, achievement and/or sensation oriented dimensions of experience, and use the feedback from those experiments in turn to refine and extend the model. In doing so, we hope to develop our expertise in experience design for pervasive mobile technologies, and help determine the future of the digital fourth dimension.

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