

A Novel Methodology for the Design and Evaluation of Pervasive Systems

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The Cityware project is a research collaboration between the University of Bath, Imperial College, The Bartlett at University College London, Vodafone, Nokia and Hewlett-Packard (<http://www.cityware.org.uk>). The main goal of the project is to increase our knowledge and understanding of people's relationships with urban spaces and with pervasive technologies in order to enable the development of tools and techniques for the implementation of long-term, city-scale pervasive systems. Evaluation is a core component of Cityware. The scope of the project is such that longitudinal evaluation is desired in addition to discrete, one-off studies. The longitudinal work focuses on how people perceive the city, how people use pervasive systems and how perceptions of the city and uses of pervasive systems interact with one another.

There are a number of serious shortcomings in current HCI evaluation. There is often a bias towards the use of laboratory testing of systems and applications. Laboratory evaluation typically involves technologically literate participants in controlled conditions, limiting the realism and generalisability of findings. These problems are emphasised where there is no clear boundary between the system being evaluated and the context in which it is situated. Where methods outside the laboratory are employed, participants still often have high levels of technological ability, diminishing ecological validity. Mobile and pervasive systems are both, by their nature, difficult to separate from the contexts in which they operate. They are also generally designed for the general public – not necessarily technologically able – to use, at least in the long term.

Recent projects have explored the relationship of pervasive systems and urban environments (e.g. the Equator IRC, Mobile Bristol, Urban Tapestries, Intel's Urban Atmospheres) and have conducted their research largely through 'experiences' or 'performances' that in many cases cover relatively small physical areas and in almost all cases are held over short timescales. While previous studies have explored people's social behaviour and relationships with urban space and pervasive technologies and have provided useful findings on which we can build, they have not addressed the methodological challenges of longitudinal, city-scale studies.

An alternative approach is to recruit a cohort of participants from the general public, with varying degrees of technological familiarity and ability, for the duration of a large-scale project. This cohort is involved in the design and evaluation of systems and applications using both qualitative and quantitative methods. While it may seem that the recruitment and maintenance of such a cohort could be a difficult or expensive operation, we aim to show that, especially in the case of a long-term, multi-faceted project,

that the benefits in terms of validity and reliability of results far outweigh any costs.

Our work can be situated within a cooperative design framework which originated in Scandinavia involving adults in co-design techniques. This approach was adapted for technology design with children and fuelled debate around engaging children as full design partnerships or just engaging them in parts of the process. Our approach is taking this design methodology with both adults and children and extending it for the design of pervasive technologies with a group of residents of the city.

Recruitment of the Cohort

It was important to consider, before advertising for participants, how the cohort should be made up. The first of our considerations had to do with the size of the cohort. The cohort consists of thirty participants – as many as possible within certain constraints, having to do with the manageability of data produced and the availability and cost of necessary equipment. We aim to maintain engagement amongst this group for the three year duration of the project. A representative sample was deemed unnecessary, but it was desirable that the cohort should offer opportunities to explore group and individual differences in behaviour. The main factors we considered in determining the makeup of the cohort, given its size, in order to maximize these opportunities, were age and gender, occupation and home/work location.

Age diversity within the cohort is important as we expect younger people to interact with both the city and with technology in different ways to older adults. Usage of a mobile device is likely to be substantially different between younger and older adults.

Gender differences are also well represented in the literature. For this reason, we aimed to have a mix of male and female participants in the cohort.

We endeavoured to include people with a range of occupations. Other population variables, such as ethnicity and economic status were considered but were not manipulated in the make up of the cohort. Additionally the proximity of participants' homes to the city centre was also considered, the aim being that the systems developed should be usable by both regular and infrequent visitors to Bath, and we therefore wanted the cohort to represent a range of familiarity with the city. (While we do not report on this within this paper it is worth noting that we are also carrying out studies with tourists to Bath).

In order to recruit the cohort in February 2006 a local press release was designed asking for participants to take part in the project. There was a high response rate with 200 respondents within a week. A high proportion of these respondents were male (80%) and the majority fell between 25-55 years of age. They

responded from a variety of sources including The Bath Chronicle, The Register, IT Weekly and the University home Page. In order to gain a more diverse age range the Bath Chronicle ran a follow up piece encouraging the older and younger participants to apply. Unfortunately 'Cyber Guinea Pigs Still Needed' was not our choice of title! However it was successful. In order to sift through the 200 plus applications we sent out a questionnaire on use of technology in order to gain a feel for enthusiasm, with a strong caveat that we were not selecting based on technology expertise. We then shortlisted on our criteria age, gender, occupation and home/work location. Our final 30 cohort members included 10 females and 20 males. Occupations were varied including a foster carer, a magician, a fireman, golf course manager, pensions analyst, a pilot and a potter. Three of the cohort are under 18 years of old and needed parental and school consent. We also created a reserve cohort consisting of 30 people who receive regular newsletters about the project and all the other respondents are kept on file as potential participants.

All of the cohort were visited individually in order to discuss the project and were required to sign an IP disclaimer. The cohort is now an integral part of our team and have taken part in six workshops, an experimental study and also undertaken a number of challenges.

The primary purpose of the cohort is to participate in the iterative design and evaluation of applications and systems developed in Cityware. As the cohort will therefore be familiar with applications and systems developed in Cityware the role of the reserve cohort will be to take part in evaluation studies towards the end of the project where it may be important that participants are new to the application or system under investigation. Members of the reserve cohort can also be called upon to replace drop-outs from the main cohort.

There are some incentives for members of the cohort. We aim to make events involving the cohort as interesting and engaging as possible. We are also providing each member of the cohort with a mobile phone (currently a Nokia N70) and a Vodafone SIM that allows free unlimited voice, SMS and data transmission.

Data and Methods

Our cohort is providing baseline data and engaging in usability testing and trials. We are carrying out a rolling analysis which regularly integrates data collected through interaction with the cohort. Our method is evolving according to the contingencies of long-term field research, but we are drawing on existing participatory methods that we have developed in previous work. This longitudinal work is also complemented by the space syntax analysis carried out at the Bartlett and statistical data from Vodafone on user volume and movement in Bath.

Initially, we gathered information on the cohort's lifestyle, perceptions of the city, technology use and trust in, using workshops, questionnaires and interviews. We have also collected personality questionnaires, including the Eysenck Personality Inventory, measuring levels of extraversion and neuroticism, for later comparison with experimental data.

There are three main areas of people's behaviour that we are interested in. These relate to relationships with the city, relationships with technology and associations between technology and the city.

A variety of methods have been employed during the project in order to gather data. Amongst these have been questionnaires, interviews and focus group work. We have also been using map-sketching and moblogging in order to learn about participants' perceptions of their neighbourhoods. A significant advantage of maintaining a cohort of participants is the ability to revisit questions at a later date in order to explore issues further on the basis of initial analysis. This makes it easier to triangulate data in order to address a problem from multiple perspectives.

At the same time as participating in discrete design and evaluation studies, the cohort will be generating long-term datasets describing their use and experience of the Nokia N70 and the city of Bath. This is achieved through use of an application developed at Imperial College – the context logger. This logs and transmits data about phone use to a remote server –including location, voice call/SMS information, nearby Bluetooth devices, battery level and photos taken. We anticipate that this will add a new level to our understanding of participants' behaviour.

Summary

There are some high costs involved in working with a cohort of participants for the duration of a project like Cityware, but there are also some more than worthwhile benefits. The main costs are the time and effort required to recruit and retain the right kinds of participants for the project. There has also been the need to develop novel methods of data transmission between cohort and researchers. The benefits, from our point of view, outweigh these costs. These consist in the ability to generate large quantities of focused data regarding the behaviours of the cohort in relation to both the city and in their use of technology. The cohort has a role in both the evolution (through iterative design processes) and evaluation of systems that we develop.

The main advantage of maintaining the cohort has been that we are able to reduce problems of generalizability associated with laboratory studies. Realism is maximized by selecting a group of participants in order to ensure a range of ages and technological abilities. The cohort is not intended to be a genuinely representative sample of the population, but to give us opportunities to explore individual differences in behaviours that we are interested in.