

# Revolutionary and evolutionary technology design processes in location-based interactions

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## ABSTRACT

Development and deployment of location based systems is a key consideration in the design of new mobile technologies. Critical to the design process is to understand and manage the expectations of stakeholders (including funders, research partners and end users) for these systems. In particular, the way in which expectations impact upon technology development choices between small-scale, 'high tech' innovations or larger scalable solutions. This paper describes the differences in a revolutionary design process (for 'high tech' prototypes or catwalk technologies) versus an evolutionary design process (for scalable or prêt-à-porter systems), as exemplified in two location-based mobile interaction case studies. One case study exemplifies a revolutionary design process and resultant system, and the other an evolutionary design process and system. The use of these case studies is a clear natural progression from the paper that first described the concept of 'catwalk technologies' (Adams et al, 2013), which itself drew upon research that used mobile devices for outdoor 'in the wild' locations.

This paper presents a set list of fifteen heuristic guidelines based upon an analysis of these case studies. These heuristics present characteristics and key differences between the two types of design process. This paper provides a key reference point for researchers, developers and the academic community as a whole, when defining a project rationale for designing and developing technical systems.

In addition, we refer to the role of the researcher/research team in terms of guiding and managing stakeholder and research team expectations and how this relates to the planning and deployment of catwalk or prêt-à-porter technologies. Lastly, we state how this research has vital implications for planning and enacting interventions and sequences of interactions with stakeholders and, crucially, in the planning of future research projects.

**Keywords:** Catwalk technology; location-based interactions; sense of place; revolutionary and evolutionary design processes; human-computer interaction; ubicomp; heuristics.

## INTRODUCTION

Location-based services and apps are becoming ever more ubiquitous, in parallel to the growth of mobile consumer devices. Many of these location-based technologies tend to be associated

with commercial uses. Location-based systems include marketing and/or advertising, such as showing what shops, cafes, gyms or other facilities are nearby and what offers or discounts may be provided to their clientele. Other location-based services can be used to provide information for visitors about local facilities, such as hotel recommendation sites or tourist information. In contrast, this paper examines the way in which mobile technologies are designed, developed and deployed to support meaningful interactions in outdoor locations. In particular, we focus upon the way in which such technologies are planned and designed and the extent to which they are expected to be scalable solutions as opposed to bespoke, custom systems that do not scale well to mass deployment. In this paper, we expand upon the HCI concept of ‘catwalk technology’ (Adams et al., 2013), a metaphor borrowed from the fashion industry “*whereby innovation leads the development process whilst also providing hooks for some iterative, scalable and sustained technology design processes*”. Adams et al. (2013) analyse ‘in the wild’ research projects from the perspective of both the technology and the role of the researcher. In particular this research highlights the role of the researcher as a boundary creature, similar to a boundary object. As boundary creatures, HCI researchers need to cross between communities and domains and manage different norms in practices and domain languages. Through crossing these boundaries the researcher can be thought of as both horrific, by contradicting the norms within that domain, and insightful, by transporting new ideas into the domain. Within this research the ‘wild’ may mean either the physical terrain (e.g. fieldtrip learning) or an unfamiliar environment in which the researcher finds themselves in (e.g. hospital, school etc.). In all these contexts there is an increased importance for the researcher as a boundary creature to establish a joint understanding of the location based design approach.

Our work here relates to the design processes involved in producing catwalk and prêt-à-porter (ready-to-wear) location based technologies. To understand these design processes in more detail we have used an evolutionary and revolutionary design perspective, whereby a revolutionary design process tend to be, but is not exclusively, linked to a catwalk technology design. In contrast, an evolutionary design process tend to be, but is not exclusively, linked to a prêt-à-porter system. According to Adams et al. (2005), revolutionary design processes are rarer than evolutionary ones and tend to encompass conceptually new designs, new possibilities and may enforce fundamentally different ways of working. In contrast, an evolutionary design process involves small, incremental changes and fairly stable design concepts, with working practices evolving gradually over time in parallel with new products. Evolutionary design processes do not usually result in radical new ways of doing things compared to revolutionary design processes, where this may be a natural consequence of the work.

The main aim of this work is the creation of *development guidelines* or *heuristics* for academics and their collaborators, to inform the design, development and deployment of technologies and systems created by the research community. The production of these guidelines has resulted from the analysis of two case studies, viewed through the lens of revolutionary and evolutionary design processes to produce *catwalk* versus *prêt-à-porter technologies*. Using a grounded design approach, the features of these two types of technical solution can be identified from the case studies and presented as a reference for the community, providing a mechanism by which

researchers can mediate interactions and guide expectations with stakeholders to inform the development and direction of future research projects.

## **ENGAGING IN LOCATION-BASED MEANINGFUL INTERACTIONS**

Technology-mediated location-based experiences are not a new phenomenon. However, it is probably fair to say that with the increasingly pervasive presence of GPS (Global Positioning System) technologies embedded within mobile devices, along with WiFi and mobile operator signal triangulation, such location-based experiences are becoming more widespread than ever before and more socially and culturally ‘normalised’ within our society today. There is a growing breadth of literature around mobile location based literature (Consolvo, 2005) its impacts for navigation (Pritchard et al, 2014; McNamara, 2008) and its privacy implications (Brush et al, 2010; Vasalou, 2012). However the value of location based interactions for educational purposes has been slower to progress.

A number of studies looking at location-based learning interactions emerged between 2000 and 2007 from the MOBILearn<sup>1</sup> and Equator<sup>2</sup> projects. Many of these focused upon environmental education, where users were encouraged to engage with their physical surroundings in order to learn about them. More recent projects such as iSpot (Woods & Scanlon, 2012) , ‘Out There, In Here’ (Coughlan et al., 2011) and GeoSciTeach<sup>3</sup> (Price et al., 2013) have explored the potential of using mobile devices to enable the evolutionary design approach of participatory science data-gathering about our outdoor environment to enable both formal and informal learning.

Theories of location-based meaningful interactions with physical, ‘real world’ spaces encompass research into blended spaces (Benyon, 2012; Benyon et al., 2012), learning spaces (Bligh & Crook, in press) and an increasing amount of HCI research carried out ‘in the wild’ (Rogers, 2011). Research by FitzGerald (2012) suggests that we don’t yet have a universal theory that fully describes how we gain meaningful interactions through engagement with our surroundings, but rather we tend to borrow from a range of existing theories including situated learning (Lave & Wenger, 1991), embodied cognition (Bilandzic & Foth, 2012) and sense of place (Dourish, 2006b; Lim & Calabrese Barton, 2006; Uzzell, 1995). Several projects have shown how to successfully design mobile technologies to support field-based learners, through a process of enriching ‘*situated learning*’ experiences. Practically this can entail support for data collection, information access and sharing (Adams et al., 2011). Students in the field are often highly engrossed in their data collection activities and experiences of the outdoor environment. This highlights the affective value of these experiences, but it can also be to the detriment of performing valuable sense-making and reflection in situ (Rogers et al., 2010). Sense-making has often been related to meaning making and more recently into meaningful experiences. Andre et. al. (2009) talk about meaningful insights that can be obtained from serendipitous discoveries. This has also been related to designing technology that supports our interaction experience in order to socially construct heritage in a meaningful way (Giaccardi, 2011). Meaning making

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<sup>1</sup> <http://www.mobilearn.org>

<sup>2</sup> <http://gow.epsrc.ac.uk/NGBOViewGrant.aspx?GrantRef=GR/N15986/01>

<sup>3</sup> <http://geosciteach.wordpress.com/>

through mobile technologies is therefore tightly intertwined with our relationships with others and with the places in which the interaction occurs. There has been a long history of meaning making research focusing upon social interactions through technology. However, it has only been over recent decades that meaning making has been connected to the experience and sense of place.

A ‘sense of place’ can be broadly defined as “*an overarching impression encompassing the general ways in which people feel about places, senses [them], and assign concepts and values to [them]*” (Najafi & Shariff, 2011, p.187). However, sense of place is a complex multidimensional phenomenon that shifts in emphasis depending on a researcher’s disciplinary area. For example, Dourish (2006b) states that this is a cultural phenomenon (requiring appropriate behavior within a context for engaging in, and interpreting, actions) whilst others consider the socio-economic dimensions, or the physical geography of a place, or the political/historical/spiritual dimensions of a place, or how it shapes their self-identity as an individual or as part of a wider community, possibly related to where someone lives or works (Ardoin, 2006). There are also obvious connections to heritage and a sense of belonging or ancestry (or “rootedness”), associated with an individual’s country of origin, particular cultural background, or how this may have been affected by migration and an increasingly mobile global population. Giaccardi (2011) unpicks how technology interaction, social and physical contexts change our construction and understanding of heritage.

The work presented here has been shaped by the literature relating to sense of place, as we believe that by engaging in active technology-mediated learning within particular environments, we can evolve a sense of place that in turn engenders a deep connection with our surroundings, providing an effective and memorable way of creating meaning and understanding about the places we find ourselves in – a belief also shared by Lim and Calabrese Barton (2006). They examined the role of students’ “lifeworlds” (a set of lived experiences) as a way of creating a sense of place, taking into account the role of place as a situational context and the resultant embodied experiences and relationships occurring in those places. They state how a student’s lifeworld and their resultant sense of place has a fundamental impact on their primary experiential or educational context, in stark contrast to many current educational programmes that focus on standardization and uniformity and are too dismissive of local histories, knowledge and stories that may shape a learner’s outlook or educational development.

Ardoin (2006) states how creating and nurturing a sense of place can promote understanding about real-world conservation issues, community-based conservation and how we can get involved in community action, leading to more environmentally-responsible behavior and a greater desire to care for and protect our environment – sometimes referred to as “environmental stewardship”. Ardoin also suggests that an increased sense of place can also result in a greater psychological, social, and spiritual well-being whilst also raising awareness of human impact upon our environment, and that these consequences are not just at younger ages but also affect older children and adults.

In this paper, we investigate how we can use our outdoor environment as a resource to aid meaning-making in two case studies: “A Conversation Between Trees” (a partnership of artists,

scientists, researchers, to visualize and interpret environmental data and our understandings of climate change by exploring forests on either side of the world) and the “Situ8” project (a tool designed to enable the delivery and creation of geo-located user-created multimedia for use in both formal and informal place-based learning).

## **EVOLUTIONARY AND REVOLUTIONARY DESIGN PROCESSES**

A crucial part of research and design is to understand its rationale, drivers and the expectations of all those stakeholders involved in the work; including researchers, funders, end users, designers, developers, collaborators and communities that play active roles in the research. The researcher /designer has to carefully manage these expectations and act as boundary creature in negotiations with all these interested parties. It is important for this boundary creature to support defining the project rationale which guides the planning and management of the work and supports mediating any tensions (Adams et al., 2013).

An important step in defining the project rationale during the design process for a technology is not only to consider what it needs to do but also how the system is to be developed and deployed. In addition, it is important to consider, whether it is ultimately intended to be a bespoke product and limited in the number of times or places where it is deployed or alternatively if it is intended to be scaled up to a large number of users or uses. There is also the consideration of what happens to the technology (both hardware and software) at the end of the project – something that Taylor et al. (2013) discuss at length in their work concerning community technology handovers. There needs to be careful thought in terms of the *explicit intent* of how the technology is designed with these aspects in mind. For example, is the technology meant to only be a specialist installation, customized to a particular user group or set of requirements? Is the technology expected to have wide scale usage beyond the immediate project, with users that may not yet have been clearly identified or recruited? It is important to note that we are not necessarily advocating only *sustainable* design practices (e.g. Blevis, 2007; DiSalvo et al., 2010), although this may be an important aspect of either revolutionary or evolutionary design processes. Rather, we are looking to review technology design process rationale for scalability and sustainability as part of the overall research project approach or as a follow-on activity after a projects conclusion.

One of the key factors that govern decisions about one-off / temporary versus scalable and sustainable technologies is not only that initial intention, but also the practicality of developing that initial plans and prototypes. If a research project is committed to carrying out true blue-skies innovation then the system itself, or its components, may not currently exist and so may have to be hand-crafted by a team of engineers and developers. Whilst it is relatively rare to construct a completely new piece of equipment, it is quite likely that existing components (e.g. circuit boards, flat screen technologies, sensors etc.) can be combined together to form a product that is new. This is common to research communities, who by their very definition are carrying out original research and so may well have to develop their own bespoke solutions. We would argue that such technical innovation is only truly cutting edge if it had not existed before and needs specialist technical support in order to set it up and maintain it. Also, whilst there is usually a clear purpose behind the creation of such a technology, it may have been designed to

exist as an experiment in development possibilities or as a proof-of-concept to challenge how we currently see the world. In this way, these high-tech *catwalk technologies* may inspire others to re-conceive existing notions about materials, objects or the way in which we interact with them. This may ultimately result in a chain reaction which Gianacchi (2012) notes starts with changed perceptions and leads to changed practices or behaviors. Jenson (2014) highlights how this revolutionary design approach is difficult to initiate as HCI tends towards adapting the familiar and maturing a design through evolutionary design approaches. In particular he has argued for a revolution in the death of the app, in order to completely change our perceptions, practices and current behaviours (Kosner, 2012).

It is important to note that the factors influencing the design for an end system may be pragmatic or intellectual. A systems development may also be guided by the moral or political commitments of the researchers (Dourish, 2006a), the funders and/or the collaborators. These drivers may result in decisions to design, develop and deploy a bespoke catwalk technology to inspire changes in perceptions and behaviours. Conversely the project drivers may seek to develop a more scalable ready-to-wear solution. Whatever the design rationale is, it is important to that it is discussed and a decision agreed upon by all the project stakeholders early on in the design process. A poorly managed project rationale can lead to mismatches and clashes in design expectations. Ultimately, researchers may want to deliver a catwalk solution whilst the end users or collaborators may have very different expectations of what the "end product" of technology will actually be. This is especially likely when working with community groups or other external collaborators, who may have established contrasting perceptions of who will be involved in the technologies deployment and potential ongoing maintenance. The follow case studies are therefore reviewed in light of these potential expectations in two contrasting revolutionary and evolutionary design processes.

## **CASE STUDIES**

Within Jenson's CHI 2014 keynote he focused on the relationship between evolutionary and revolutionary design processes. Building on his previous proposals that mobile apps are over (Kosner, 2012) he argued that mobile apps have matured through evolutionary design and become normalised. They are destined to become dislodged, he suggests, by a new revolution in design towards 'just in time' interactions and discovery services. Whilst this maybe a foretaste of Jenson's concept of the relationship between revolutionary and evolutionary design there is a need to appropriately define these two design approaches within a mobile HCI context. In this section, we examine two contrasting location based projects that exemplify different ways in which we can interact with our environment through the gathering of scientific data related to our local environment. Through collection, analysis and/or visualization of data, end users are expected to improve their knowledge and understanding about their environment. This approach also allows them to put that understanding into a broader national or international picture e.g. climate change.

These case studies were chosen as they illustrate the clear-cut differences in how catwalk and prêt-à-porter technologies can be designed, developed and deployed through a revolutionary and evolutionary design process. The first, “A Conversation Between Trees” (ACBT) was an art installation, created by a team of artists, scientists and researchers, aimed at building public understanding of climate science but in an unusual and unconventional way that was unique and sought to re-conceive the ways in which the public engaged with science. The second, “Situ8” is an ongoing project that we have been developing at the Open University (OU) in the UK. The OU has a strong commitment to supporting both formal and informal learning and also to public engagement. The sheer scale of student numbers at the OU (approximately quarter of a million across the world) means that all resources used to support the OU’s learning and teaching activities must be scalable and although much of our research is classed as innovative and ground-breaking, many of the technologies that we create to support teaching and learning must ultimately have scalability in mind.

### **A Conversation Between Trees: revolutionary design resulting in catwalk technology**

A Conversation Between Trees (ACBT, see <http://hello-tree.com>) was a touring interactive artwork performed at art centres located in three different UK forests, showing how artists could engage the public with scientific climate change data.

#### *Design Approach for ACBT*

Primarily the design approach was driven by a revolutionary artistic vision that was rapidly realised through innovative applications of technologies and interaction experiences for the public. Whilst the artists provided a rationale for the work and thought carefully about their intentions and audience engagement before commencing the work the design process was driven by this artistic vision. This meant that the design cycle was focused on innovative interactions with users aiming to change people’s awareness through establishing a synchronous connection, (or ‘conversation’) between a remote tree in a forest in Brazil and a “local” tree at each venue in the UK (Jacobs et al., 2013). This aimed to change peoples’ concepts of climate change through their interaction with the installation. Benford et al (2014) review this performance-led approach as part of a series of revolutionary design processes resulting in multiple catwalk technology installations.

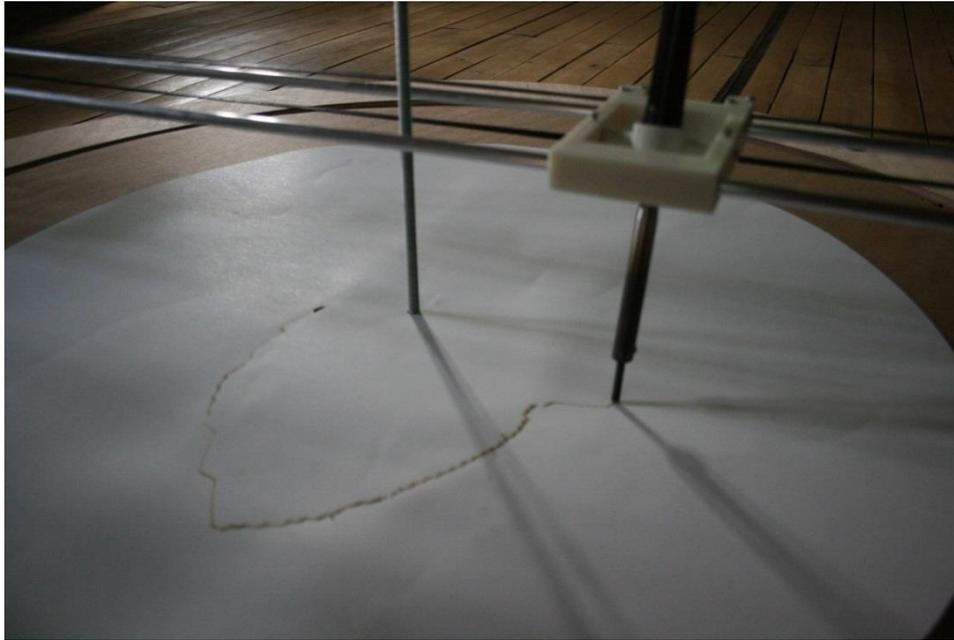


**Figure 1:** A Conversation Between Trees: one of the large screen displays (on wall) and the climate machine (on floor)  
(used with permission © Active Ingredient 2013)

There were three main components to this project's installation that were moved between different locations.

Firstly, sensor data from each tree was collected using bespoke hardware (an Arduino sensor hub connected to an Android phone via USB cable) mounted in waterproof casing on the trees. The sensors captured a range of scientific data (e.g. temperature, humidity, sound, carbon dioxide levels) in addition to a photograph of the tree, once a minute. This data was sent through a 3G connection to a central server in the UK. The data was visualized on two large screen displays (one for each tree – Brazil and UK – see Fig. 1) positioned opposite each other in the installation space or gallery. These visualizations consisted of dynamic star-like shapes, with projections that changed colour, shape and move according to changes in the data received by the server.

Secondly, a custom-made 'climate machine' (see Fig. 2), consisting of a large circular device positioned on the floor between the two large screen displays, created circular graphs of recorded and predicted global CO<sub>2</sub> data, obtained from a freely-available existing scientific dataset dating back to 1959 and containing predictions to the year 2050. Lines were scorched onto the paper by a soldering iron, with each bit of paper representing one year's worth of data. When a year of data had been scorched onto the paper, the paper was removed and then hung by the artists on the walls of the gallery to create an alternative view of an annual data series.



**Figure 2:** A Conversation Between Trees: the climate machine  
(used with permission © Active Ingredient 2013)

Thirdly, visitors to the art installation could choose to go on a walk in one of the forests used in the UK venues, taking with them a mobile phone loaned by the project, which takes photographs of the trees every 10 seconds. The intention was for the visitor to act as an additional ‘sensor’ and the photos collected by them were subsequently combined with data from the local tree and transformed into visualizations on the phone, employing the same approach used to combine and visualize data on the large screen displays back in the gallery space. In addition, visitors could listen to a narrative created by the artists to provide their perspectives on a walk through the forest. Visitors were also asked to estimate and upload environmental levels of sound, humidity, air quality and light on a scale from 1-10 and to also provide three words to describe their feelings at the time, which were all uploaded to the main server.

### *Main findings from ACBT*

The research was evaluated, analysed and presented by the project’s research team from several perspectives: those of the artists’, the visitors, and the climate change scientist that provided professional advice to the project (Jacobs et al., 2013). We will now examine these findings in relation to the design and development of the project and the technologies used, and the way in which these technologies were deployed.

The lead artist for the installation was also the main researcher in the project and so had to juggle the demands and tensions of these two roles. The project required the lead artist to act as a boundary creature between the groups of artists, the other academic researchers and other stakeholders in the project (visitors, climate change scientist etc.). From their published report of the work, it is clear that the project team had clear intentions right from the initial conception of the work. The project aimed to provide a very different way in which visitors could be engaged with climate change data from how it is usually presented (aka the more traditional ‘scientific’ approach common to government, journalism and the scientific community). In the design of this artwork, the project sought to change visitors’ perceptions of data and the way in which it could be collected i.e. practices towards capturing climate data. Instead of providing a scientific

analysis of the data (“telling them what to think”), visitors were instead asked to engage in personal reflection and dialogue around the data. They were supported by the various visualisations of data asking them to report on the emotions they were feeling on the forest walk. The project evaluation (Jacobs et al., 2013; Benford et al., 2013) took a wholly qualitative analysis of different stakeholder perspectives. The analysis of visitor data (mostly semi-structured interviews) suggested that the projects aim, to change visitor perceptions, was successful with many of their interviewees. However, it is important to note that the purpose of the evaluation was not to support iterations for increasing the acceptability or scalability of the system, but to develop a deeper understanding amongst the public and the project team.

As a revolutionary design approach to developing a catwalk system the project sought to change perceptions. Subsequently, the art installation whilst proving popular with many people, had limited appeal with some, indicated by researcher observations of disengagement. They report seeing quite a few visitors enter the gallery space and leave again in a short space of time. Although this may be for a variety of reasons (the project team mention other activities competing for attention or a lack of time), the authors of the paper admitted that this may be because visitors may not find the art installation something that interests them or they may find it difficult to understand. Whilst this may indeed be “something common to contemporary artwork” we also believe that this is a common property of revolutionary design practices resulting in catwalk technologies. This is because it pushes the boundaries of current thinking/practices and therefore will inevitably be unattractive to many people.

### **Situ8: evolutionary design resulting in prêt-à-porter technology**

The Situ8 project (<http://www.situ8.org>) was inspired by and thus adopted an evolutionary design development of the popular mScape (or MediaScape) platform developed by HP Labs Bristol (Stenton et al., 2007). mScape enabled users to attach multimedia content to a map via a desktop authoring environment and subsequently deploy it through a mobile device, with such media being ‘triggered’ by a user’s geographical position, as measured by GPS. Until its demise in 2010, mScape was available for free and was a very popular tool, with an active community numbering many hundreds of ‘mScapers’ who shared their created mScapes through a public website.

The mScape platform both encouraged and supported mass usage and deployment of location-based multimedia and the highly contextualised nature of these media enabled authentic, place-based experiences to take place. However, mScape was very much a one-way delivery of media. We wanted to find a way in which users could actively construct their own observations or experiences and so ‘close the loop’ between passive reception of information and active construction (or co-construction) of information and meaning-making.

#### *Design Approach for Situ8*

Situ8 was driven by the evolutionary design vision of a scalable system that would support current meaningful interactions within a very loose and customisable framework. As an evolution of the mScape platform, this technology would enable a range of geo-located user-generated content to be uploaded, both in terms of media format and in terms of disciplinary, or domain, knowledge. Whilst there exist a large range of products such as Tumblr, Flickr, YouTube and other tools for amassing user-generated content, there are none that currently combine our required range of media types (text, image, video, audio and data) with geo-location data. The system was designed as a broad, ‘activity-agnostic’ tool that could be used for a wide

range of purposes, such as providing historical information about a place or event; creating games or treasure hunts; capturing or browsing stories or experiences; or enabling gathering of citizen science or fieldwork data.

Taking an evolutionary design approach an iterative and user centred set of processes were used. User requirements were gathered from observations of university students carrying out fieldwork, and interviews and workshops with academic colleagues from environmental science, education and learning sciences, geography and computer science. Supporting system scalability meant that the development was to be viewable on a range of devices, including tablets, smartphones or desktop computers.

These requirements were implemented across two different instantiations of Situ8: firstly as a prototype, proof-of-concept Android app (Fig. 3) and secondly as a cross-platform web portal (Fig. 4). Both systems enabled users to upload different media types (text, images, audio and video clips, with data added as a new media type in the web portal). Iterative testing was carried out for both systems throughout the development process and, for the web portal, this included usability/accessibility testing. Interface design, colour schemes and logos/graphics were mostly outsourced to professional contractors.

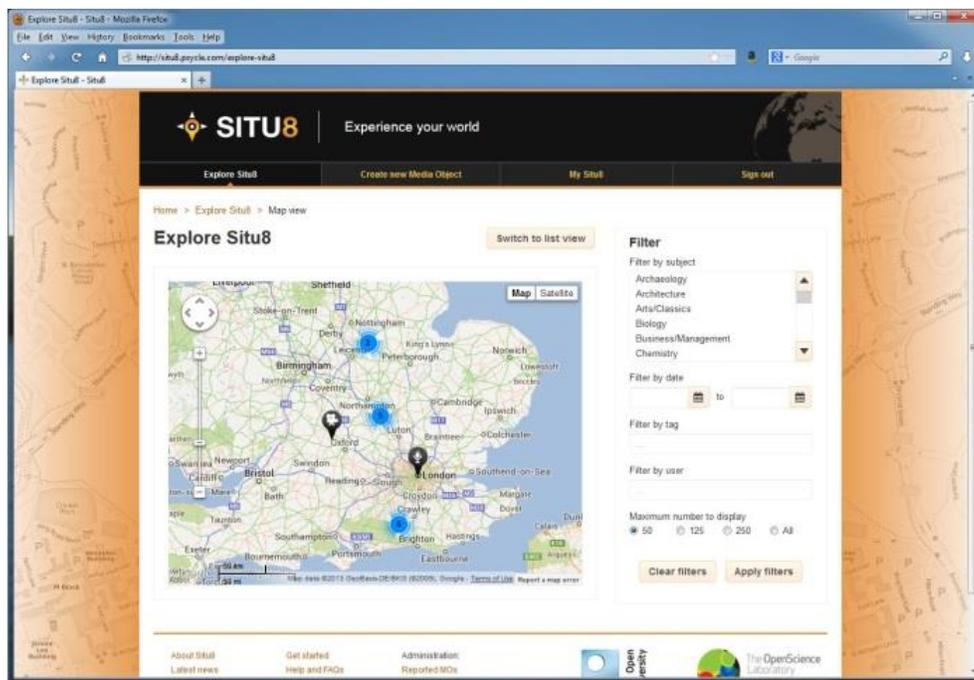
Scalable media hosting and streaming were the main issues emerging from this work. Due to limited funding, a local media server was unable to be set up and maintained, and so we looked to third-party solutions to host and stream the larger media types, namely Flickr (for images), YouTube (video) and Dropbox (audio). Text and data were small enough to be hosted on a local institutional server. An additional benefit of using YouTube was that it overcame the scalability issue of video compatibility across devices; this was eliminated by YouTube's automatic re-encoding as part of the upload process.

Users of the prototype app were asked to record media and data during one day, over the period of a month, when they would use the app to document their daily activities (“A day in the life”). They could document a particular event e.g. their child’s birthday party, a family visit to a park, or capture several separate events, so long as these events had a locational context to them.

For the web portal, users were given a more authentic context and asked to collect environmental data relating to insect pollinators on flowers, to investigate the effect of air temperature and wind speed on pollinator activity. They collected images and/or video relating to different types of insects pollinating flowering plants on a certain area, over a specified time period. They were also asked to record wind speed and air temperature data using basic handheld sensors, along with a number of the different types of insects (e.g. bees, butterflies, hover flies etc.) seen during that time frame.



*Figure 3: The Situ8 Android app*



*Figure 4: The Situ8 web portal*

### *Main findings from Situ8*

Taking an evolutionary design approach the project conducted user evaluations for both the Android proof-of-concept app and the web portal. The evaluation was conducted via a post-usage questionnaire that combined the System Usability Scale (SUS) (Brooke, 1996) and nine further open questions. The questionnaire in its entirety can be viewed at <http://tinyurl.com/situ8-feedback>. To ensure scalability of the system participants recruited to the user trials were able to use their own mobile devices or were loaned equipment if needed.

SUS is a 10-item questionnaire that asks users to score each statement on a 5-point Likert scale. Questions relate to the user experience of the product being evaluated and the scores from each

questionnaire results in a composite SUS score out of 100 that is used to provide an overall measure of a system's usability. SUS is a standardised questionnaire often used for the evaluation of systems for scalability purposes. A SUS score of 68 is rated as average, from its use in 500 studies (Sauro, 2011). The average SUS score for the Android app was 77.5 (minimum=65, maximum=85, n=5) and for the web portal was 67.1 (minimum=32.5, maximum=90, n=7), indicating that both systems had a reasonably good level of usability. The open responses by users to the additional questions added by the research team also indicated respectable levels of acceptance and usability. Users could see a clear purpose for the system and came up with many examples of where and how it could be used, indicating a widespread appeal when deployed at scale. Some minor usability issues were mentioned, including bugs with the location-finding functionality and some problems with file upload limits (both in the web portal) but these could be easily overcome in future iterations.

It is clear that from the very start of the Situ8 project, large scale usage and a sustainable product were at the forefront of the design and development iterations, together with a high-quality end user experience. The project took inspiration from the mScape platform and a range of existing apps used to capture location-based media and as such, did not seek to change people's existing perceptions or practices of engaging with such media. Its rationale was to support both formal and informal learning practices and meaning making. Through the evolutionary design and evaluation process it was identified that this could include an element of fieldwork and support for open learning / public engagement activities.

This evolutionary design approach used iterative user testing procedures that were different to those for the revolutionary case study. For Situ8 the focus was more around the acceptability of the end user experience and therefore used a more formalised method of user feedback (SUS). This reflected the evolutionary design of the Situ8 platform and a desire for it to maintain existing practices. The project aimed to achieve this through a scalable product suitable for mass usage and deployment, rather than changing these practices or the way in which people conceptualise their interactions with location-based media.

## **DESIGN PROCESSES LEADING TO CATWALK AND PRÊT-À-PORTER TECHNOLOGIES**

In this paper, we reported a detailed review of two mobile / touring location-based case studies that exemplify how revolutionary and evolutionary design processes can lead to examples of innovation led catwalk and ready to wear prêt-à-porter technologies. We have described the design processes used, how they were developed, along with their rational / explicit intent and the resultant technologies. These have been used to distil the distinctive aspects from each case study into representative differences between these two examples (see Table 1). This comparative analysis also draws upon the authors own experiences of working across a range of location based research projects (Adams et al, 2005; 2011; 2013; Fitzgerald, 2012; Fitzgerald et al, 2013; 2011) expanding upon points raised in the analysis of these two case studies.

It is vital to note that this list of heuristics is neither prescriptive nor is it a checklist. This is not a traditional HCI usability heuristic. We take the notion of heuristics as 'rules of thumb' rather than presenting a definitive guide. This then presents a starting point for mobile researchers to

guide their location based discussions with stakeholders and support them in formulating an appropriate design rationale. With this in mind we present this as an initial list that can be built upon and evolved through further research within the mobile HCI community. However, these heuristics can act as a useful reference point for assessing the core elements in the design and technical development of a mobile project. They can also act as a tool for guiding design rationale discussions between a research team and other stakeholders in the design and deployment of a particular technology.

### **Design Process Guidance: a list of fifteen heuristics**

A comparative analysis of the two case studies representing a revolutionary and evolutionary design rationale has produced a fifteen heuristics point guidance list for HCI researchers (see summary in Table 1). This heuristic list illustrates the main characteristics of these two design processes and the key differences between them. However, it must be understood that whilst these may guide HCI researchers, no project truly fits within one approach or the other. For example, whilst the Situ8 development had elements of a design process leading to a catwalk technology (especially the app), its strong initial expectation of a scalable, easy-to-use system means it cannot be considered to be truly catwalk.

Below a detailed account of the heuristics from each case study is presented, before summarising the contrasting core elements in Table 1. Several of these heuristics are related, or form a natural consequence resulting from an earlier heuristic. In addition, whilst these heuristics are presented in fairly black-and-white terms, they are, in fact, often at either end of a continuum, or sometimes part way along it. However, for comparative purposes they are presented here as in fairly clear-cut terms.

#### *Expected scale*

Within Situ8 it has been emphasized that there was an ultimate scalable output for the system. Funding was obtained that encouraged the scalable qualities of this system to develop into apps and online systems aimed at large numbers of users. ACBT in comparison was deployed through an art installation at a much smaller scale, at three different venues in the UK, with a correspondingly lower number of prospective end users.

#### *Design process*

ACBT was designed by a collaboration of artists, academic researchers and a climate change scientist to inspire revolutionary, or conceptually new, designs and a radically different way of working/interacting with environmental data through an artistic output. Situ8 on the other hand sought to support current and changing user practices through the researcher incrementally developing existing designs, such as mScape and other related projects/existing technologies, utilising an evolutionary perspective.

#### *Perceptions and practices*

ACBT sought to change the publics' perception of climate change and the way in which we think about and interpret relevant environmental data in innovative ways, through an interactive art installation. Situ8 did not look to change perceptions of how people engage with their environment but rather wanted to support them, alongside existing practices (i.e. using geotagged media) in a more usable way that provided greater functionality than currently available systems.

### *Appeal to users*

From their own visitor evaluations, it was clear that ACBT was not attractive to all those who engaged with the art installations. The research team involved were quite open about a number of visitors who did not stay very long before leaving and reported honestly about this kind of contemporary art not appealing to everyone. Situ8, on the other hand, took great care to ensure widespread appeal and usage, through providing a useful tool that had a good general applicability for many purposes. It can be seen from the open feedback that users of Situ8 could see the relevance, purpose and mass appeal of the technology.

### *Rationale or purpose*

Both case studies had a clear rationale and justification for their creation and deployment; however both contemporary art and blue-skies research can be exemplified by the emergence of a completely new design perspective, approach or output that might not yet have a clear purpose but rather seeks to provide a step-change in innovation.

### *Ease of use and accessibility*

If a technology is being designed with mass usage and scale in mind, it stands to reason that it must be easy to use by the majority of its target audience and should be fairly intuitive to pick up and use. This was a focus of Situ8, through ensuring a high quality look-and-feel through a professionally-designed interface and from extensive iterative testing (including usability testing) throughout the development process. Whilst this is not an explicit aspect of ACBT, it is likely that revolutionary design processes and catwalk technologies may not be easy to engage with or meet accessibility/usability guidelines. By their very nature these approaches seek to change our existing practices and perceptions, and indeed may not exist as scalable developments aimed at mass usage.

### *Iterative development*

Again, the technical development of the Situ8 platforms was planned with iterative development cycles in mind to ensure that functional and usability/accessibility requirements were being met – this was due to the technologies being planned for mass usage and scalability. If a system is not intended for mass usage, or is being created as ‘thought experiment’ with no particular purpose or rationale, it may not require iterative development cycles to be conducted.

### *Hardware or software produced*

Much of the technology used for ACBT was bespoke, from the climate change machine that used a soldering iron to ‘print’ data visualisations onto paper, through to the bespoke system of sensors used to record data from the trees. Conversely, Situ made use of third party services for streaming and hosting media and the platform was deployed through services appropriate for mass usage (smartphone app and web-based system).

### *Deployment*

Due to their bespoke nature, catwalk technologies may need specialist deployment by the researchers, artists or engineers involved in their creation or manufacture, meaning that these experts may need to physically be on-site in order for the technology to be set up for users to engage with. This was the case with ACBT (climate change machine, box of sensors attached to trees) although not so much with Situ8, where users were provided electronically with a brief user guide and instructions for taking part in the relevant scenario.

### *Size of research team or research effort*

ACBT consisted of a collaboration of practicing artists, academic researchers and a climate change scientist, indicating the involvement of several team members, although it is not clear

from their published work how this equated to the amount of full-time effort, amount of funding or the time period over which design, development and deployment occurred. In the Situ8 case study, it has been stated that funds and resources were rather limited and so the team was correspondingly small in terms of equivalent full-time staffing (i.e. two part-time staff, with one being Software Developer). However, as the project aims to produce scalable and sustainable solutions, this would be easier to do with a larger research team. Having a small resource base possibly means being able to fulfil only part of the functional requirement or having to compromise on other aspects of the work, such as usability or accessibility – which may be evidenced from the Situ8 SUS scores. Having a small research effort when attempting to develop a prêt-à-porter solution can also impact on the morale or energy levels of staff involved in the project. This can be especially true of academic staff, as they may be more susceptible to working longer hours on the project than might reasonably be anticipated due to attempting to meet the ‘scalability’ expectations of stakeholders in the project.

### *Extent of development*

As catwalk technologies seek to change our perceptions and our practices and are not expected to be scalable, it stands to reason that they may not progress beyond a proof-of-concept or Wizard-of-Oz stage. However, any system expecting to reach mass deployment and usage must, from its earliest planning stage, be designed to evolve beyond a prototype. The smartphone app in Situ8 was designed as a proof-of-concept and to test user experiences of it, before it was developed for mass usage as a web-based system (<http://www.situ8.org/>).

### *System testing*

This heuristic is a natural consequence of some of the aforementioned characteristics. If a technology is to be iteratively developed and intended for use by a large number of people, it is essential that it is tested as thoroughly as possible, as this will inform usability, functionality and subsequent uptake. Both instances of the Situ8 platform were subject to continuous testing and iteration and future development cycles will include these as a matter of course. In contrast, a system designed to result in a catwalk technology may not need or be suited to iterative testing cycles, nor might it need to be tested with many users – it depends what the nature of the testing is and why it would need to be carried out.

### *Enjoyment for user*

In ACBT the research team found that some people chose not to engage with the art installation and did not find it appealing or of interest to them personally. Taking this to an extreme, it may be that some catwalk technologies resulting from revolutionary designs may be intentionally planned to provide distinctly *unpleasant* experiences for the user. For example, users may be made to experience physical or mental discomfort designed as part of a cultural experience (see e.g. Benford et al., 2012) that aims to challenge our existing practices or perspectives. In contrast, a prêt-à-porter technology aimed at scalability and mass usage will likely be intended as a pleasant experience for the end user, as illustrated by heuristics relating to ease of use.

### *Timescale of implementation*

As a consequence of iterative development/testing cycles and needing to progress beyond a proof-of-concept stage, it is likely that evolutionary designs leading to prêt-à-porter solutions will take longer to reach full implementation than revolutionary designs resulting in catwalk technologies. This is especially true if the catwalk project is a small one, with only a small-scale deployment or pilot study.

### *Size of development*

Our last heuristic relates to the expected size of the development occurring in revolutionary design/catwalk technologies compared to evolutionary design/prêt-à-porter systems. A catwalk technology may only be a prototype and as it not necessarily expected to be scalable, the size of the implementation may be correspondingly small. Conversely, a scalable prêt-à-porter system aimed at mass deployment and usage, possibly over multiple platforms, could be expected to have a respectively larger implementation. This could be measured in terms of number of users, the amount an app has been downloaded, amount of data created/generated by users or uploaded to servers (as for Situ8) or equivalent usage statistics.

These fifteen heuristics described above are now shown Table 1 below, for ease of reference.

**Table 1:** 15 key heuristics of revolutionary and evolutionary design processes leading to catwalk and prêt-à-porter technologies

<i>Heuristic or guideline characteristic</i>	<i>Revolutionary design process to produce catwalk technology</i>	<i>Evolutionary design process to produce prêt-à-porter technology</i>
1. Expected scale	No expectation that end product is scalable.	End product must be scalable.
2. Design process	Design tends to be revolutionary.	Design tends to be evolutionary.
3. Perceptions and practices	Seeks to change both our perceptions and our practices.	Tends to maintain current perceptions and practices.
4. Appeal to users	May have limited appeal or use.	Tends to have widespread appeal or use.
5. Rationale or purpose	Doesn't have to have a reason for its creation – it “just is”.	Created with a specific purpose or rationale in mind.
6. Ease of use and accessibility	Not necessarily easy or intuitive to use and may not meet accessibility guidelines.	Relatively easy and intuitive to use. Must be broadly accessible.
7. Iterative development	Iterative development may be limited.	Iterative development is essential.
8. Hardware or software produced	Tends to be bespoke technology or a “one off”.	Not usually bespoke.
9. Deployment	Specialist deployment usually required. May not be supported by multiple devices and/or platforms.	No specialist deployment needed. Is usually supported by multiple devices and/or platforms.
10. Size of research team/research effort	Can be done with a small team or small number of person-hours.	Hard to do with a small team or limited number of person-hours.

11. Extent of development	Usually only a proof of concept. May not progress beyond rapid prototyping or Wizard of Oz stage.	Must progress beyond proof of concept/prototype stage.
12. System testing	May only have limited testing with small number of users.	Requires more thorough testing or testing cycles with larger number of users.
13. Enjoyment for user	System not necessarily pleasant to use.	System is pleasant to use.
14. Timescale of implementation	Relatively short timescale for implementation.	Longer timescale for implementation.
15. Size of development	Usually small scale development.	Expectations of larger scale development.

## CONCLUSIONS

In this paper, we have reported on the differences between the revolutionary and evolutionary design processes that can produce catwalk and prêt-à-porter (ready-to-wear) technologies. A comparative analysis of two contrasting design process case studies is presented. The conversation between trees and the Situ8 projects, both focus upon outdoor locations as resources to inspire learning and foster meaningful interactions through the use of mobile / touring technologies. A set of heuristic guidelines to support design process was constructed from the case study analysis. These heuristics exemplify the key differences between revolutionary design processes leading to catwalk technologies, and evolutionary design processes that produce prêt-à-porter solutions.

Within this paper we highlight that a revolutionary design process seeks to change our perceptions and practices and naturally leads into developing a catwalk technology. These design processes lead to technologies, curiosity and a means of engagement that are not primarily aimed at being scalable or suitable for mass production or mass usage. Conversely, an evolutionary design process tends to lead towards a prêt-à-porter solution where the central focus is on scalability and providing a sustainable user experience. This design process and resultant technologies do not primarily seek to change our behaviors or perspectives, instead they seek to make current activities more effective and ‘user friendly’.

It is also worth mentioning that in addition to these two case studies many HCI papers contain excellent examples of both catwalk technologies and revolutionary designs. For example, two valuable ‘in the wild’ papers have documented historical accounts that, we suggest, represent these two design approaches. It could be argued that Carroll and Rosson’s (2014) account of research over several decades, using the neighborhood as a location based setting, is an ideal representation of evolutionary design approaches. Using participatory design techniques they review community oriented programmes that have iteratively evolved technical designs. Seok et al. (2014) provide an interesting way to provide insight into evolutionary design through

participatory methods. They propose using an artistic approach to design using ‘non-finito products’ that are developments that are intentionally left unfinished to support and inspire people to engage, acquire and develop the technology for their own purposes. This highlights that evolutionary design can be creatively inspired but is focused on the users evolving the system. In contrast, Benford et al. (2014), reviewing several decades of ‘in the wild’ location based installations, highlights revolutionary design based approaches that take a performance driven rationale ultimately leading to valuing uncomfortable interactions (Benford, 2014). Readers themselves may also be able to come up with their own examples.

One interesting design process issue to consider in this context is to understand the relationship whereby a revolutionary design process has resulted in a prêt-à-porter technology. Alternatively we should also review how an evolutionary design process can result in a catwalk technology. A good example of the former could be Augmented Reality, which was designed in a revolutionary way resulting in catwalk systems. However, through subsequent evolutions, and user-centered adaptations this has now crossed over into the mainstream and has become a prêt-à-porter technology available through numerous different smartphone apps. Although, it is important to note that the cost of the technology or the project’s budget is not an important characteristic of one type of technology or another. A technology can be expensive to create through customised hardware in a revolutionary design processes. However, it can also be costly to produce a scalable, easy-to-use system that is suitable for mass usage.

One fundamental question that should be reviewed is around the relative impact of each design process. It could be argued that blue-skies high-tech innovation surely provides a greater impact upon society in the long run. For without change we stagnate and do not advance technologically or culturally. However, in contrast, some might say that through designing catwalk technologies we have systems that are of limited use unless they can be translated into prêt-à-porter solutions. If we take this premise as true, it is important that we understand how to convert innovations into scalable systems, in the same way that haute couture can filter down to clothing lines found in department stores. It could also be claimed that, from sheer numbers, a prêt-à-porter solution has greater reach and impact than a small bespoke system that only engages a relatively small number of people. However, this argument does not consider the interaction between evolutionary and revolutionary design. As already highlighted, Jenson (2014) argues that there is a distinct relationship between evolutionary and revolutionary design. Technology design, he proposes, starts with the familiar that evolves in its acceptability and matures in its appropriate designs and usability. He argues at this point there is a need for a revolutionary design shift which must then lead to another evolutionary design cycle in which the technologies mature. An example of this can be seen in sensor technologies that were initially presented in revolutionary smart-homes and through evolutionary development have now matured into the standard toilet and hand-washing sensors in many public washrooms around the world. Many similar initial revolutionary developments were not originally intended to be scalable but they inspired an evolutionary process to become scalable and familiar. However, Jenson (2014) argues that it is this familiarity and evolving maturing that makes it harder for the next jolt of revolutionary design to occur.

The best solution seems to be a blend of both – initially a revolutionary design process that leads to a high-tech innovation shown in a catwalk technology. Elements of this can then inspire or cross over into a revolutionary design process that produces a scalable solution that can impact upon the masses. However, the question that remains is how the revolutionary design converts into an evolutionary design and more importantly what remains from a catwalk technology within a prêt-à-porter system. Our next phase of research is to explore exactly how this transition occurs, by developing a ‘Catwalk Design Framework’. The framework will document pathways between innovative proof-of-concept design and scalable design practices. Applying the framework guidance will give those developing research-based prototypes an understanding of how to support innovative artistic design approaches. This will increase the economic value from elements of innovations being scaled, reused and re-purposed as shown in the move from catwalk designs to prêt-à-porter department store versions. However, as Jenson (2014) suggests, designs can then get stuck into a kind of ‘well’ of acceptability, limited by the current design paradigm making it harder for a new wave of revolutionary design to emerge. Both of these design approaches are valuable for mobile HCI and an appropriate approach should be acknowledge, shared and supported through the design process rationale.

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## REFERENCES

- Adams, A., Blandford, A., & Lunt, P. (2005). Social empowerment and exclusion: A case study on digital libraries. *ACM Transactions on Computer-Human Interaction (TOCHI)*, 12(2), 174-200.
- Adams, A., Coughlan, T., Lea, J., Rogers, Y., Davies, S.-J., & Collins, T. (2011). *Designing interconnected distributed resources for collaborative inquiry based science education*. Paper presented at ACM/IEEE Joint Conference on Digital Libraries, Ottawa, Canada.
- Adams, A., FitzGerald, E., & Priestnall, G. (2013). Of Catwalk Technologies and Boundary Creatures. *ACM Transactions of Computer-Human Interaction*, 20(3), Article No. 15.
- André, P., schraefel, m. c., Teevan, J., & Dumais, S. T. (2009). *Discovery is never by chance: designing for (un)serendipity*. Paper presented at the Seventh ACM Conference on Creativity and Cognition (C&C '09).
- Ardoin, N. M. (2006). Toward an Interdisciplinary Understanding of Place: Lessons for Environmental Education. *Canadian Journal of Environmental Education*, 11, 112-126.
- Benford, S., Greenhalgh, C., Crabtree, A., Flintham, M., Walker, B., Marshall, J., Koleva, B., Egglestone, S. R., Giannachi, G., Adams, M., Tandavanitj, N. and Farr, J. R (2013) Performance-led research in the wild. *ACM Transactions of Computer-Human Interaction*, ACM TOCHI, 20(3) article no 14.
- Benford, S., Greenhalgh, C., Giannachi, G., Walker, B., Marshall, J., & Rodden, T. (2012). *Uncomfortable interactions*. Paper presented at the SIGCHI Conference on Human Factors in Computing Systems (CHI '12).

- Benyon, D. (2012). Presence in blended spaces. *Interacting with Computers*, 24(4), 219–226.
- Benyon, D., Mival, O., & Ayan, S. (2012). *Designing Blended Spaces*. Paper presented at the 26th BCS Conference on Human Computer Interaction: People & Computers XXVI, Birmingham, UK.
- Bilandzic, M., & Foth, M. (2012). A review of locative media, mobile and embodied spatial interaction. *International Journal of Human-Computer Studies*, 70(1), 66-71.
- Blevis, E. (2007). *Sustainable interaction design: invention & disposal, renewal & reuse*. Paper presented at the SIGCHI conference on Human factors in computing systems
- Bligh, B., & Crook, C. (in press). Learning Spaces: departure points for a spatial turn in Technology Enhanced Learning. In E. Duval, M. Sharples & R. Sutherland (Eds.), *A Reader in Technology-Enhanced Learning*. Berlin: Springer.
- Brooke, J. (1996). SUS: A “quick and dirty” usability scale. In P. W. Jordan, B. Thomas, B. A. Weerdmeester & A. L. McClelland (Eds.), *Usability Evaluation in Industry* (pp. 189-194). London: Taylor and Francis.
- Brush, A., Krumm, J. and Scott, J. Exploring end user preferences for location obfuscation, location-based services, and the value of location. In *Proc. UbiComp 2010*, ACM Press (2010), 95-104.
- Carroll, J. and Rosson, M. B. (2013) The neighborhood as a living laboratory for HCI. *ACM Transactions of Computer-Human Interaction*, ACM TOCHI, 20(3) article no 16.
- Consolvo, S., Smith, I. E., Matthews, T., LaMarca, A., Tabert, J. and Powlwidge, P. Location disclosure to social relations: why, when, & what people want to share. In *Proc. CHI 2005*, ACM Press (2005), 81-90.
- Coughlan, T., Adams, A., Rogers, Y., & Davies, S.-J. (2011). *Enabling live dialogic and collaborative learning between field and indoor contexts*. Paper presented at the 25th BCS Conference on Human Computer Interaction (BCS-HCI'11).
- DiSalvo, C., Sengers, P., & Brynjarsdóttir, H. (2010). *Mapping the Landscape of Sustainable HCI*. Paper presented at the SIGCHI Conference on Human Factors in Computing Systems (CHI 2010).
- Dourish, P. (2006a). *Implications for design*. Paper presented at the SIGCHI Conference on Human Factors in Computing Systems (CHI '06).
- Dourish, P. (2006b). *Re-Space-ing Place: “Place” and “Space” Ten Years On*. Paper presented at the 20th Anniversary Conference on Computer Supported Cooperative Work (CSCW '06), Banff, Alberta, Canada.
- FitzGerald, E. (2012). Towards a theory of augmented place. *Bulletin of the Technical Committee on Learning Technology*, 14(4), 43–45.
- FitzGerald, Elizabeth; Ferguson, Rebecca; Adams, Anne; Gaved, Mark; Mor, Yishay and Thomas, Rhodri (2013). Augmented reality and mobile learning: the state of the art. *International Journal of Mobile and Blended Learning*, 5(4)
- FitzGerald, Elizabeth; Sharples, Mike; Jones, Robert and Priestnall, Gary (2011). Guidelines for the design of location-based audio for mobile learning. *International Journal of Mobile and Blended Learning*, 3(4) pp. 70–85.
- Giaccardi, E. (2011). *On pause and duration, or: the design of heritage experience*. Paper presented at the 25th BCS Conference on Human-Computer Interaction (BCS-HCI '11).
- Giannachi, G. (2012). Representing, Performing and Mitigating Climate Change in Contemporary Art Practice. *Leonardo*, 45(2), 124-131.
- Jacobs, R., Benford, S., Selby, M., Golembewski, M., Price, D., & Giannachi, G. (2013). *A Conversation Between Trees: What Data Feels Like In The Forest*. Paper presented at the SIGCHI Conference on Human Factors in Computing Systems (CHI 2013).
- Jenson, S (2014) The physical web. Closing Keynote at ACM CHI 2014, Toronto.

- Kosner, A. W. (2012) Apps are over: frog design's Scott Jenson want to overthrow the desktop paradigm. accessed from: [forbes.com/sites/anthonykosner/2012/04/01apps-are-over-frog-designs-scott-jenson-thinks-they-should-discoverable-in-real-time/](http://forbes.com/sites/anthonykosner/2012/04/01apps-are-over-frog-designs-scott-jenson-thinks-they-should-discoverable-in-real-time/) (30/04/2014)
- Lave, J., & Wenger, E. (1991). *Situated Learning - Legitimate Peripheral Participation*. Cambridge: Cambridge University Press.
- Lim, M., & Calabrese Barton, A. (2006). Science learning and a sense of place in a urban middle school. *Cultural Studies of Science Education*, 1(1), 107-142.
- McNamara, L., Mascolo, C. and Capra, L. Media sharing based on colocation prediction in urban transport. In Proc. MobiCom 2008, ACM Press (2008), 58-69.
- Najafi, M., & Shariff, M. K. B. M. (2011). The Concept of Place and Sense of Place In Architectural Studies. *International Journal of Human and Social Sciences*, 6(3), 187-193.
- Price, S., Davies, P., & Farr, W. (2013). Teachers' tools: Designing customizable applications for mlearning activities. In Z. L. Berge & L. Muilenburg (Eds.), *Routledge Handbook of Mobile Learning*.
- Pritchard, G., Vines, J., Briggs, P., Thomas, L., Oliver, P., (2014) "Digitally Driven: How location based services impact on the work practices of London Bus Drivers." presented in Chi 2014, Toronto. p.3617
- Rogers, Y. (2011). Interaction design gone wild: striving for wild theory. *Interactions*, 18(4), 58-62.
- Rogers, Y., Connelly, K., Hazlewood, W., & Tedesco, L. (2010). Enhancing learning: a study of how mobile devices can facilitate sensemaking. *Personal and Ubiquitous Computing*, 14, 111-124.
- Sauro, J. (2011). Measuring Usability with the System Usability Scale (SUS). Retrieved 26 November 2013 from <http://www.measuringusability.com/sus.php>
- Seok, J.M., Woo, J.B., and Lim, Y. K (2014) Non-finito products: a new design space fo user creativity for personal user experience. presented at CHI 2014, Toronto. p.693.
- Stenton, S. P., Hull, R., Goddi, P. M., Reid, J. E., Clayton, B. J., Melamed, T. J., & Wee, S. (2007). Mediascapes: Context-Aware Multimedia Experiences. *IEEE Multimedia*, 14(3), 98-105.
- Taylor, N., Cheverst, K., Wright, P., & Olivier, P. (2013). *Leaving the Wild: Lessons from Community Technology Handovers*. Paper presented at the SIGCHI Conference on Human Factors in Computing Systems (CHI '13).
- Uzzell, D. L. (1995). Creating place identity through heritage interpretation. *The International Journal of Heritage Studies*, 1(4), 219-228.
- Vasalou, A., Oostveen, A. and Joinson, A. N. A case study of non-adoption: the value of location tracking in the family. In Proc. CSCW 2012, ACM Press (2012), 779-788.
- Woods, W., & Scanlon, E. (2012). *iSpot Mobile - A Natural History Participatory Science Application*. Paper presented at the 11th World Conference on Mobile and Contextual Learning (mLearn 2012), 16-18 October 2012. from [http://ceur-ws.org/Vol-955/papers/paper\\_9.pdf](http://ceur-ws.org/Vol-955/papers/paper_9.pdf).