The Port of Sheffield: Co-creation in Mobile Application Development for Place-Based Interaction with Large-Scale Urban Heritage Sites

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Abstract

Constructed in 1819, the Sheffield and Tinsley Canal linked the City of Sheffield with the rest of the British waterway system and brought ships into the canal basin in the city centre for the first time. Eroded by periods of rapid social, economic and technological change, the three-mile stretch of the canal site has today become a 'forgotten' space, hidden behind surviving industrial sheds and derelict warehouses. The city council's regeneration plans of new waterfront housing along the canal have been held up by the complexities over land ownership, use patterns and brownfield contamination. It has been suggested that the 'sense of possibility' of neglected sites such as the Sheffield and Tinsley Canal is what gives the urban landscape of Sheffield its unique character. This article presents our research on the development of a location-aware mobile application through a community-oriented process to deliver 'place-based' interaction with the Sheffield and Tinsley Canal as a large-scale urban heritage site. In collaboration with local creative practitioners, we piloted 'The Port of Sheffield' a mobile application that enables oral histories and memories to be overlaid onto specific geolocations along the Sheffield and Tinsley Canal. Through the data collected from public use of the application, we reflect on the effectiveness and limitation of co-creation as a methodological framework and discuss the implications of place-based mobile interaction for initiating and sustaining citizens' engagement and interpretations of the past and future of large-scale complex urban heritage sites.

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Introduction

In recent years, new methods and tools for interacting with built heritage sites have emerged from a diverse range of fields including museology, sound and environmental art, architecture, theatre and performance, and human-computer interaction (Butler 2006). While many of these new approaches build upon types of established forms of audio-visual guide or signage, the rapid spread of mobile and smartphone technologies has opened up new possibilities for interaction with heritage sites. A real-world heritage site can become 'interactive' in the sense that digital content is seen and heard by visitors through digital devices in the form of audio-visual overlays onto various locations of the site, which may be a building or a large-scale historic urban space.

The use of location-based mobile apps has become commonplace in architectural, cultural and heritage sites across the world (McGarrigle 2012: 88). A distinctive feature of them is the need for the user to be both physically present and mobile within the site in order to activate the specific pieces of audio-visual information, which are typically experienced individually through headphones and a smartphone display. Recent examples from the UK allow participants to use their smartphones to: compare historical photographs with present-day locations across a region (e.g. 'Wild Wales app' DOC nd-f); experience historical video footage in the specific urban location that it was filmed (e.g. 'Manchester Time Machine' DOC nd-d); or listen to archived stories and music that relate to specific locations in a neighbourhood whilst walking through that urban space (e.g. 'Hackney Hear' DOC nd-b). These examples demonstrate the ability of heritage organisations, creative practitioners, and community groups

to deploy location-based visitor interpretation over much larger-scale outdoor spaces than would have been previously feasible.

In the hands of creative practitioners, often working alongside local communities and heritage organisations, mobile interactions can enable participants to experience intimate locations, encounters, or stories in a way that would have traditionally required a live tour guide or performer (Harvie & Etchells 2009; Montola et al. 2009). This potential has been recognised in the field of 'site-specific' art and performance, and location-based mobile technologies have become widely recognised within contemporary performance theory and practice (Benford & Giannachi 2012). Performance theorist Alison Oddey has described how location-based audio in particular can open up the 'autobiographical space' of the participant for them to 'imbibe' the 'history, memories, imagery and soundscape of the site', evoking past associations, present existence and future imaginations (Oddey 2006). These types of experiences are often designed to encourage participants to 'touch, smell, listen and look', 'challenging the way people perceive places' (Pearson 2010).

This article reports the design and public use of a prototype mobile storytelling app that enables local histories and memories to be overlaid onto specific locations along the Sheffield and Tinsley Canal, the waterway and towpath that cut through the industrial Lower Don Valley in north-east Sheffield. The 'Port of Sheffield' mobile app was developed out of a collaborative inquiry between Sheffield-based theatre producers The Blue Shed, researchers from the RECITE Network at the University of Sheffield, and communities who have lived and worked on and around the canal site. The aim of the project was to bring together local storytellers, other canal users, and the wider public to interact within the industrial and post-industrial heritage of the canal and the wider Lower Don Valley. Drawing upon oral histories, stories,

memories, and music produced by local people, the project aimed to articulate the hidden stories and memories of this place – perspectives that are perhaps overshadowed by the dominant local narratives of de-industrialisation, dereliction, and stalled regeneration plans within the area. The work described in this article contributes to research on co-creation in mobile app development for public engagement with the past and future of urban heritage sites.

The Port of Sheffield project was initiated with a set of broadly defined questions. Can the design and production of a location-based audio-walk app encourage people to discover and walk the route of the canal for the first time? Can the audio-walk change existing perceptions of the canal and its environs? Can participation in the audio-walk provoke ideas about the future of the canal, or engender a greater sense of place? And, what is the most appropriate platform and interface for encouraging public engagement with the audio-walk?

To better organise the social and programmatic cycles of the app development process, a methodology of 'co-creation' was employed consisting of four main elements:
(1) *Gathering* – identifying, meeting and working with a range of local participants to research the history of the canal and gather a combination of stories, memories, and provocations; (2) *Curating* – recording, editing and cataloguing the original audio contributions gathered; (3) *Spatial Negotiation* – designing, coding and testing the extent of the walking route and mapping the narrative and musical audio content onto a series of listening locations; and (4) *Engagement* – building and launching the Port of Sheffield website (http://mapcodebuild.co.uk/pos/), publicising the walk through traditional and social media channels, and collecting data from public participants who had undertaken the walk.

As a piece of practice-based research, the Port of Sheffield project involved researchers working in collaboration with a creative producer, 'The Blue Shed', who specialises in increasing participation in the arts by making work for 'non-theatre' audiences across a range of art forms. This collaboration enabled the researchers to be involved over the course of the community engagement, story-gathering, and curatorial processes, as well as the design and development of the app itself. The public experience of, and response to, the Port of Sheffield app was recorded using a participant feedback survey, the data from which was analysed alongside interviews with individuals and organisations involved in the creation of the project. We examine how mobile apps can become 'place-based' by connecting reflections and memories of local communities to other visitors and users of the canal. The following account reflects on the potential of this form of place-based practice to encourage greater exploration of 'forgotten' places, while also stimulating new interpretation and (re)imagination of a complex and multi-layered heritage site.

The heritage context of the Sheffield & Tinsley Canal

The site for the Port of Sheffield app is defined by a three-mile stretch of the Sheffield and Tinsley Canal. The construction of the canal was completed in 1819, when its opening linked the city with the rest of the British waterway system and brought ships into the canal basin in the city centre for the first time. Plans for a canal had been proposed some 120 years previously, but attempts to construct a waterway were opposed by mill operators on the River Don, as well as the landowning Dukes of Norfolk, who managed to prevent construction until the early 1800s (Hey 1997).

Figure 1. Sheffield canal basin, also referred to as 'Victoria Quays', looking towards the Straddle Warehouse.

Sheffield Canal Basin marks the terminus of the canal as it reaches the city centre adjacent to the former site of the Sheffield markets and castle. Rebranded as ‘Victoria Quays’ as part of a programme of investment in the early 1990s, the canal basin has become a hub for commercial activity and leisure boats (Figure 1). Alongside the new-build offices and hotels, the site is also notable for the residential conversions of the Listed Terminal and Straddle Warehouses, which sit alongside a series of small retail units inserted into the former railway arches, restored dock, and a ‘swing bridge’ over the canal. A few hundred metres further along towpath, walkers, cyclists, and boaters encounter the first in a series of original structures and buildings, including the Cadman Street Bridge (see Figure 2) and canal-side warehouses of GS Dilley and Sons. Beyond this, the canal passes under the restored Bacon Lane Bridge and over the original Darnall aqueduct, which carries the canal over the old Worksop Road. The urban landscape in

between these original examples of canal infrastructure is markedly different, with a series of scrapyards, semi-derelict works, and light industrial warehouses. Since the regeneration of the canal basin, the Sheffield City Council have had long-term ambitions to redevelop a number of sites along the canal for new waterfront housing, but the complexities over land ownership, existing use patterns and brownfield contamination have held up plans for further regeneration (Interview with Sheffield City Council City Development Manager, 2013).

Figure 2. The Sheffield & Tinsley Canal looking towards Cadman Street Bridge.

The present state of semi-dereliction along the canal can be linked back to 1845, when the first big railway company took control of the Sheffield Canal Company and the expansion of rail transit resulted in the water traffic becoming increasingly overshadowed. Trade did continue along the canal up until middle of the 20th century, but following years of neglect it was effectively derelict by the late 1970s and designated as a 'remainder waterway' (Hey 1997).

Much of this dereliction, which was accompanied by the wider decline of industrial activity in the Lower Don Valley, is still apparent today (Figure 3). The majority of the canal and its towpath remained relatively undisturbed by the regeneration of the Don Valley in the late 1980s and early 1990s, when the Sheffield Development Corporation transformed the area into a leisure and retail destination (Dabinett 1991). Despite the construction of the nearby Meadowhall shopping centre, Sheffield Arena, 'Valley Centertainment' and the Don Valley Stadium (now demolished), the canal has remained more or less hidden behind its screen of surviving industrial sheds and derelict warehouses.

Figure 3. A Port of Sheffield participant walking alongside one of the derelict former Works buildings.

Sociologist Stephen Spencer has portrayed the Sheffield and Tinsley Canal as an environment where industrial ruins, albeit interspersed with surviving light industry, are being slowly reclaimed by nature. As part of this process, Spencer argues that the landscape of the Lower Don Valley is revealing layers of 'dialectic change' (Spencer 2011: 80). Echoing Solà-Morales' notion of 'terrain vague', this dialectic change describes how the melancholy of a lost industrial era merges with opportunities for new forms of inhabitation and use (Solà-Morales, 1995). Similarly, architectural critic Owen Hatherley has suggested that the particular qualities of neglected sites, such as the Sheffield and Tinsley Canal, and their 'sense of possibility' is what gives the urban landscape of Sheffield its unique character (Hatherley 2010). While the economic promise offered by the regenerated Victoria Quays and proposed waterfront developments still appear to be some way off, the experience of walking along the canal still feels like the discovery of secret space in the city – one that is being slowly reclaimed as a natural environment. Taking this patched-up landscape as its context, the Port of Sheffield project sought to understand the human dimensions of this place, epitomised by the local fishermen, ramblers, boaters, birdwatchers, and others who use the canal as a place to 'escape' from the nearby leisure and retail destinations.

The scale and complexity of the canal site emerged as a key driver behind the decision to develop the Port of Sheffield as a location-based app for mobile interaction (Figure 4). The lack of formal visitor hub on the site pointed towards an experience that needed to be self-directed, undertaken at any time, and started at any point along the canal. The linear nature of the canal site evoked a strong sense of movement, which supported the idea that pedestrians, cyclists, or boaters might encounter a series of 'nodes' – locations or buildings on the route that were associated with particular memories and stories. The use of the canal by different communities or groups also suggested a form of interaction that could be made up of several

layers of different voices or perspectives by overlaying the canal trail with local music, verbatim memories and stories of the diverse communities and local heritage. And finally, the external view of the site as a 'forgotten' space, or escape from the busy city, leant itself to a storytelling project as a way of engaging with those communities and their personal memories of the canal and its history.

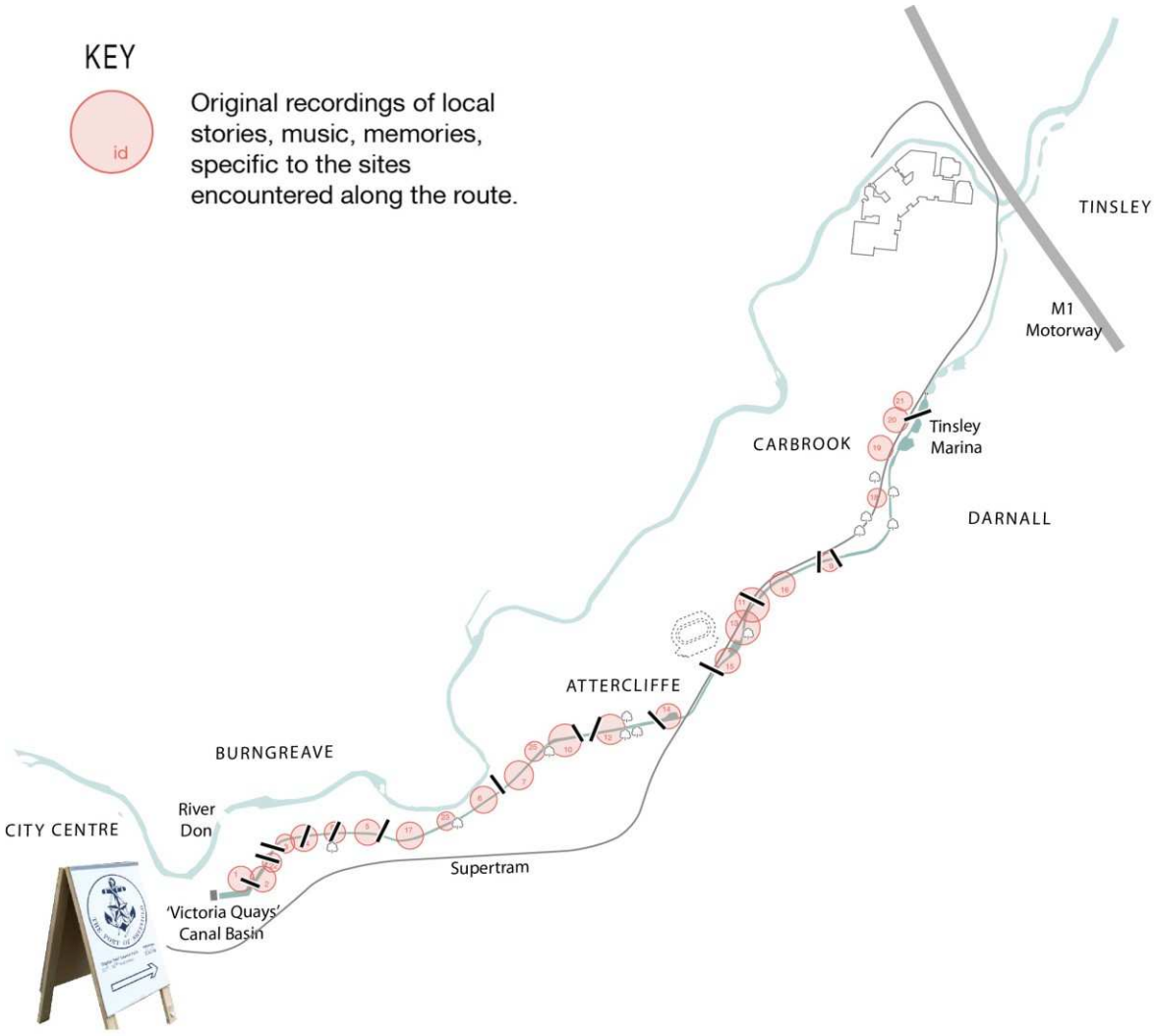

Figure 4. The Port of Sheffield site and structure.

Design for mobile interaction with a large-scale urban heritage site

In common with other examples of urban heritage infrastructure of this scale, a number of statutory and voluntary institutions share responsibility for the management and maintenance of the Sheffield and Tinsley Canal. This is due to the overlapping uses of urban canals and towpaths which, as well as heritage sites, operate as public spaces or rights of way, places to live, functioning waterways, sites for fishing and walking, and potential magnets for commercial activity and residential development. As an urban typology, the canal presents a number of challenges in terms of management: the risks to canal users of falling or jumping in the water, the multiple entry and exit points onto the towpath, maintaining long stretches of footpath with little vehicular access, protecting working heritage sites from decay and vandalism, and balancing the safety and enjoyment of multiple different user groups.

Our review of recent research and practice has revealed a number of alternative approaches to design for mobile interaction with this type of complex urban-scale site. Each of these approaches is influenced by the scale and complexity of the site, the project budget, the availability and accessibility of the technologies involved, and the desired balance between physical and digital interfaces. Previous examples have included the installation of speakers in the site itself which are triggered by buttons or radio tags (Miller 2003), the loan of specialist audio-visual equipment to small groups of participants (Betsworth et al. 2014), the activation of mobile audio-visual material through the use of QR codes located in the site ('Lagan Valley Heritage Audio Trail' DOC nd-c), and the use of downloaded digital audio content in tandem with a map that instructs participants ‘when to press play’ ('Ports of Call' DOC nd-e).

More recently, designers have turned towards location-based applications and live streaming of digital audio-visual content, a reflection of the dramatic growth in ownership of smartphones with online connectivity (3G or 4G) and GPS enabled location-sensing capability. According to recent research by OFCOM, the UK is now a 'smartphone society', with 66% of adults owning a smartphone, rising to 90% of 16-24 year olds (Ofcom 2015: 65). These high levels of smartphone ownership give greater confidence to designers of location-based apps, particularly in terms of the average user's ability to download, launch, and operate a range of smartphone apps. Once the location-based mobile app is loaded and activated, the participant's body becomes a trigger within the physical site, city, or region. As the participant walks or moves through the site, their smartphones monitor and update their locations – checking their positions against the data stored online.

Furthermore, the availability of free and open-source frameworks has made the process of developing and publishing this type of app more straightforward, with platforms such as PhoneGap enabling designers and developers to publish customised apps across multiple smartphone operating systems ('Adobe PhoneGap' DOC nd-a). In the case of the Port of Sheffield app, the PhoneGap platform supported the collaborative development of the mobile app within the project team. This not only made the project more affordable to produce, but also enabled the team to add app features iteratively as the project progressed. An example of this was the survey tool for gathering and processing participant responses, which was embedded directly into the app and was therefore more integral to the experience of the walk. Figure 5 presents an overview of the app development and its intended public uses.

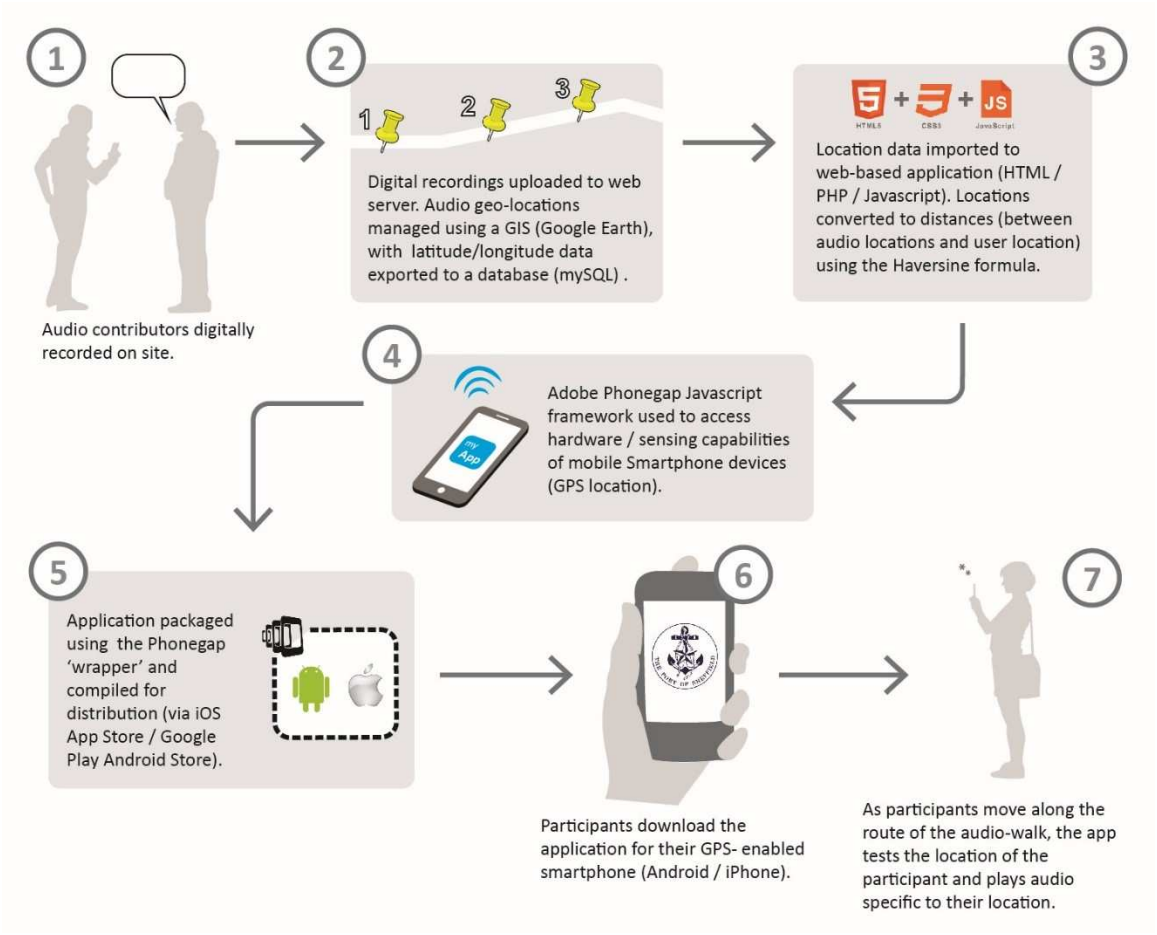

Figure 5. Mobile technologies and frameworks used to produce the Port of Sheffield app.

Upon launching the Port of Sheffield app, an initial check is performed via a GPS call to determine whether the user is near to the canal site, with the app re-checking the user's location every 5 seconds from then on. Each of the audio stories within the Port of Sheffield audio-walk is assigned a location as a set of latitude and longitude coordinates, and if the user's current location is more than 50m away from any of these locations, the app will warn the user that the app is geo-locative and that they need to go to the canal towpath site to access the audio-walk content. When the user is within a radius of 50m of any of the audio locations, the app will first download and play the introductory audio from the web server, providing further details on how the app and audio-walk work, and then the audio is downloaded and played. Once a story had been played, it cannot be triggered a second time. Further audio stories could be 'triggered'

by moving along the towpath towards other locations. Although the linear nature of the canal towpath imposes a common order and progression, the audio stories are non-sequential and the app does not require the user to complete each story before moving on. Stories can also be manually skipped if the user does not find the content particularly engaging, or manually paused if users want to take a break. At any moment, users are kept updated about the number of stories left to find and the distance to the next-closest stories via a simple line of text at the top of the app.

From location-based to 'place-based'

Researchers across a range of spatial and technological fields have discussed the impacts of 'pervasive' mobile interactions on our experience of space and place (e.g. Coyne 2010). Some have argued that these technologies potentially contribute to a sense of 'placelessness' in the contemporary city by eroding the link between shared physical presence and meaningful social encounters (Shepard 2011; Willis 2007). Notions of place and placelessness have played an important role in the development of site-specific art and performance practices. In the 1960s and 70s, site-specific art (particularly sculpture) developed as a reaction to the modernist indifference to the place, but in recent years site-specific practitioners have become more concerned with creating works that address place-identity and 'deterritorialisation' in the networked city (Kwon 2002). Jen Harvie has suggested that these art forms can help us to understand urban dwelling as a process of negotiation, and help us learn to co-exist in places with other people and communities (Harvie & Etchells 2009: 4). Meanwhile, critics such as Gay McAuley and Lucy Lippard have appealed for creative practitioners to work in a way that is not just site-specific but 'place-specific', using the arts to explore and reveal the human, economic, political and historical layers that make up a particular site or neighbourhood (Lippard 2009: 157; McAuley 2005). In doing so, place-specific arts practitioners can help to

explore the ‘throwntogetherness’ of urban communities and the challenges they face in negotiating what ‘place’ is or means in the here and now (Massey 2005: 140).

This concept of place-specificity can be identified in the design and conception of location-based mobile interactions that engage local communities in the production of the audio-visual content. In the case of the Port of Sheffield, the public launch of the mobile app represented the culmination of a year-long process to identify local people willing to share their stories and memories – in order to represent both the life of canal and the role it still plays within the wider narrative of the city. Potential storytellers emerged from the local resident community of boat-dwellers, recreational users, voluntary groups, local businesses, and those organisations responsible for the management and operation of the canal. The process of recruiting potential storytellers took place over several months to build a level of trust and dialogue with individuals and groups before they decided whether to donate their personal story. The majority of the recording activity took place on the site itself, aboard a narrow boat serving as a recording studio or whilst walking with storytellers along the towpath. In these cases, the heritage of the canal site became an additional ‘prompt’ for conversations, stimulating new encounters with others along the canal and provoking other stories to emerge unexpectedly. The gathering process was therefore not just as means to acquire audio material for the app, but also as a way of developing a deeper connection to the site, including its social and economic, and historical dimensions. Just as the canal site has multiple entry and exit points, the project was conceived in a way so that different individuals and groups could engage at different points in the process and with varying levels of commitment. Participation in the project could be as simple as donating short story, while others became more involved and volunteered time as part of the production team (Figure 6).

Figure 1. A Port of Sheffield recording session at Tinsley locks.

Storytellers included a canoeist who trained on the canal in preparation for the 1972 Munich Olympics, a former steelworker who once dived in to rescue a drowning man, and a producer from the feature film 'The Full Monty', which featured the canal in the memorable opening scene. The following is an example of a story in the app from a local woman who recounted her childhood games on the canal banks:

> "From 11 years old, this is where we used to play – this was our playground basically. Obviously Mums and Dads did not know that because we would have been hung!
>
> We used to swim. We used to build dens on the side.
>
> There used to massive factories all the way along here, spewing rubbish into this place – but they were building all sorts of steelworks.
>
> So you used to be able to ask them for things that you were building your dens with.
>
> We were their slaves, obviously. They would shout out of the window 'go and fetch us a beer.'

> And you could take the bottle back so that you had a penny, so by the end of the day you might be rich and have a pound!
>
> And when you used to go home, your Mum would say ‘where have you been!’
>
> The only reason she would know that you had been around here was the smell on your clothes – that you’d been diving in and out of canals.”
>
> (Transcribed excerpt from the Port of Sheffield audio-walk story ‘Childhood’ by Deborah Pullen)

These stories were set alongside more formal historical information and input from city authority representatives that described how the proposed regeneration might transform the area with waterfront housing and new leisure facilities. As well as recruiting storytellers, members of the research team were also involved in the design of the interface between audio content and participants, looking at how to embed audio content within the physical locations referred to in the various stories. The process of selecting stories and curating the listening experience was carried out through cycles of recording, editing, geo-tagging, and in-situ testing. This iterative process, which involved repeatedly walking up and down the canal testing the sequencing, timing and tone of the audio content, was distinctive in the way that it required a regular and prolonged presence on the site, and this in turn sparked further encounters and conversations with people along the canal, and new suggestions for additional contributors who may want to become involved in the project.

Data collection methods

When launched on the participant’s smartphone, the Port of Sheffield app prompted first-time users to complete a short registration form, which involved the voluntary submission of contact details, some brief information on demographics, health and safety information, and the

provision of consent as part of the University of Sheffield's research ethics procedure. At this stage, participants were also able to opt-out of the research aspects of the project but could still take part in the walk. All registered participants were sent a link to the questionnaire hosted on the project website, which presented a series of questions about their experience of both the walk and their use of the mobile app, allowing them to add their own stories to the trail (Figure 7).

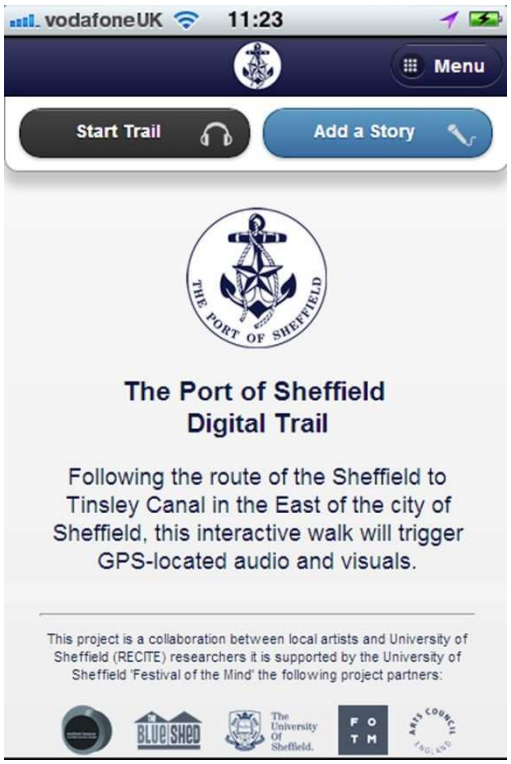

Figure 2. Screenshot of the Port of Sheffield iOS app graphical user interface.

In addition to the questionnaire, observation and short structured interviews were carried out during a monthly series of Port of Sheffield guided walks. The guided walks were an opportunity to invite back storytellers to undertake the walk alongside members of the public and the project team. This enabled the researchers to gain additional insights and feedback from the participants' interactions with the app, the stories, and the site itself. During the 12 months

period (September 2012 - September 2013), there were 168 downloads of the app, of which 46 (27%) registrations made, and 20 (12%) questionnaire responses received. The following reflections have been produced from these field notes and meeting records throughout the project and semi-structured reflective interviews with the project collaborators.

Findings and discussion

In common with more traditional forms of interpretation, such as guidebooks and signage, location-based mobile interactions can be considered in terms of an interpretive lens – one that is authored with the aim of framing or filtering the complexity of a site's heritage or histories in order to make these visible or audible (Kaye 2000). Previous research has highlighted ways in which location-based audio and visual content can 'enrich', 'energise', or 'heighten' the connection between participants and the site of the interaction (Montola et al. 2009; Veronesi & Gemeinboeck 2009). A number of participant responses reflected that the experience of the using the Port of Sheffield app made the site *"come alive"*, both in terms of its past history and current use (Port of Sheffield participant questionnaire response, 2013). A common response from participants who had previously walked the towpath route was that the experience mixed familiar histories of the industrial past with new stories and perspectives. Further, a number of respondents discussed how the experience changed their view of the canal and its potential: "*we see the canal more integral to the city, rather than something hidden"*; and, *"this has been a good way to bring them (the waterways) back to life, and discuss their future use"* (Port of Sheffield participant questionnaire responses, 2013).

For some participants, use of the Port of Sheffield app was their first experience of the canal and this part of the city. As might have been expected, discovering a new place was associated with a sense of curiosity and excitement. However, a number of responses indicated that the

experience went beyond the simple pleasure of walking somewhere for the first time. This was described by one respondent as a sense of "*familiarity with a completely new and unknown place*" (Port of Sheffield participant questionnaire response, 2013). Other responses indicate that the sense of excitement was linked to the unexpected discovery of a new place within a city in which they had lived for many years. This 'discovery' of the canal, as an unexpectedly new experience, challenged participants' negative preconceptions about this area and their personal geography of Sheffield.

In response to a question about the future of the site, a number of respondents expressed resistance to the idea of the site being 'completely regenerated' as a leisure destination or site for housing. These comments echoed many of the conversations held during the production phase and gathering sessions with storytellers and other contributors. While some, particularly the business owners, were keen to see the development of new housing and facilities in order to bring greater footfall to the canal, many other respondents were more reticent. The attachment to the canal environment, as expressed by fishermen, walkers, and other users, went beyond the basic desire for green or outdoor recreational spaces in the city. Instead, the positive value attached to this oasis in the urban landscape was linked to its 'forgotten' or hidden status. Rather than seeing the dereliction in the area simply as a negative aspect, the stories told by the Port of Sheffield begin to reframe the narrative of decline and its impact on the existing heritage value of the site. This reframing of heritage/regeneration issues appears to resonate with the view of the canal as representing a site of 'dialectical change', whereby in which the 'failure' of the industrialised economy has made way for a new narrative. One example of this, as highlighted by Spencer (2011), is the way that nature has begun to reclaim territory from human interests, and, in doing so, has created a semi-hidden place to be enjoyed and cherished by a

range of different users. Deborah Egan, co-creator of the Port of Sheffield, described the artistic intentions of the final stretch of the walk (Park, Peng & Egan, 2013):

> "Now nature's insurgents have reclaimed that empire and newcomers, ranging from bats to kingfishers, have colonised its flanks and offer their own testament to a changed and cleaner world. The end of the walk echoes those changes, incorporating the industrial sound archive of Martyn Ware, whose recordings of planishing hammers punctuate the piece, alongside the night recordings of the pipistrelle bat."

Challenges and future development

As well as examining the way that place-based mobile interactions can reframe participants' understanding of the site, it is important also to reflect on the limitations or failures of the methods and technologies that underpinned the Port of Sheffield. A number of these have been documented in previous research and practice, particularly the issues around the potential for this form to exclude a particular demographic, i.e., those unable or unwilling to use smartphone technology, and issues of usability when the technology goes wrong. A particular issue for participants in the Port of Sheffield was the intermittent quality of GPS, which was reported as sometimes displacing the location at which stories were played. Although these errors may have resulted in confusion or frustration for participants on the ground, they do act as a useful reminder that location-based technologies rely on a chain of successful material and virtual connections (i.e., the chain of user-device-GPS satellites-device-Internet-database-playback-user), and are therefore potentially more vulnerable to technological or user error than more traditional forms of heritage guide.

A number of additional barriers were identified from participant feedback and reflections within the Port of Sheffield project team. One such issue related to the promotion of the project, and the associated difficulties in attracting people to try out what is still a relatively new type of mobile experience. This particularly relates to outdoor heritage sites such as the Sheffield and Tinsley Canal, which often lack the kind of visitor hub that would give potential participants confidence to 'give it a go.' Despite the limitations and site-specific barriers encountered in piloting the Port of Sheffield, here we see an emerging experimental framework that can be further tested and extended:

- To provoke and sustain citizen participation and engagement with the past and future of a city's heritage sites, location-aware mobile applications can be developed and turned into digital carriers of memories, stories and histories of heritage sites affording place-based interactions.
- The development of such site-specific mobile apps is best approached via a co-creation process facilitated by an ensemble of creative practitioners including performing arts producers, heritage conservation and management agencies, local historians, digital media designers, and mobile application programmers.
- Live memories, stories and histories of seemingly 'forgotten' heritage sites should be sourced and curated through the process of community engagement and participation.
- New questions, knowledge and frames of interpreting heritage sites could emerge from public use of such mobile apps, which could be communicated more widely through links to other social media platforms.

Conclusion

We report in this article the development of a mobile application for 'place-based' interaction with a large-scale urban heritage site. A practice-based collaborative inquiry was undertaken,

which resulted in the co-creation of the Port of Sheffield mobile app and its public use. Reflections and feedback were collected from the project partners, the institutions involved in the management of the canal site, and members of the public who used the app *in situ*. In common with other community heritage initiatives, the development of the Port of Sheffield app relied on significant voluntary efforts from a range of different groups and individuals. The latter phases of the project, from the development of the mobile app through to the public engagement, raised further considerations for the development of mobile interactions with heritage sites, particularly when designing for large or dispersed heritage sites without a visitor hub. Even as potential participants become more accustomed to the use of location-based mobile technologies and interactions, the self-directed nature of audio-walks can be daunting, and technical difficulties can easily result in frustration or abandonment of the walk. Particularly important is the interface design and app testing process, including testing by a range of potential participants outside of the immediate design team. We should also acknowledge the ongoing challenge of an app's longevity which is contingent on the 'freshness' of content renewed continuously by contributors who may or may not still inhabit the site.

Despite potential social and technical challenges in this form of practice, reports from our public participants suggest that this form of mobile interaction can be effective in encouraging greater exploration of a forgotten heritage site. By combining multiple voices and perspectives – present and past, here and there, real and virtual, personal and institutional – place-based mobile interactions open up the possibility of more multi-layered and dialectic histories that challenge the often singular narrative of a place.

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