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Supporting Place-Specific Interaction through a Physical/Digital Assembly

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This article examines visitor interactions with and through a physical/digital installation designed for an open-air museum that displays historic buildings and ways of life from the past. The installation was designed following the "Assembly" design scheme proposed by Fraser et al. (2003), and centered around five principles for the design of interactive experiences. We discuss how the Assembly framework was adapted and applied to our work on the installation called *Reminisce*, and we then present qualitative data gathered through the shadowing and naturalistic observations of small groups of visitors using Reminisce during their exploration of the museum. Through these data excerpts, we illustrate how interaction occurred among visitors and with the assembly. We reflect on the guiding principles of the adapted Assembly framework and on their usefulness for the design of place-specific interactional opportunities in heritage settings. Results from the empirical study show that the adapted Assembly principles provide HCI (human–computer interaction) researchers and designers with ways in which to flexibly support collocated interactions at heritage sites across artifacts and locations in ways that both complement and enrich the physical setting of the visit and its character.

1. INTRODUCTION

Human–computer interaction (HCI) is increasingly concerned with interactions with and around distributed systems, where individual points of contact with digital

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interactive systems are part of an interconnected ecology of components, building up to a larger interactional narrative. From the exploration of ubiquitous computing systems that are diffused within spaces and everyday objects, to the growing role of mobile and personal technologies that connect and interact with each other and with technical infrastructures, the design and study of interactions between humans and interactive systems are now mindful of how a system may consist of a heterogeneous set of devices and input/output mechanisms populating the physical world. A body of work has been produced so far in HCI detailing how to approach the design of such systems, and reflecting on the nuances of interactions that occur with and around them.

In this paper, we present an empirical study of the interactions with and around an installation that was designed applying one of such existing HCI frameworks, that of "Assembly"[1] (Fraser et al., 2003). The installation and the study pertain to the domain of cultural heritage, a long-established venue for HCI inquiry. Our work was conducted at a specific type of heritage site: an open-air living history museum in Ireland called Bunratty Folk Park, where the exhibition consists of historical buildings, artifacts, and demonstrations illustrating ways of life from the past.

In the paper, we critically discuss previous work on interactive installations at heritage sites, we present the Assembly framework, and how it was adapted and applied to our case. We then describe the *Reminisce* project at Bunratty Folk Park, and discuss data excerpts illustrating the various forms and layers of interaction that occurred around the assembly. In particular, through these examples we reflect on the guiding principles of Assembly and on their usefulness for the design of place-specific interactional opportunities in heritage settings. Our focus is on identifying ways in which to support collocated interactions across heritage artifacts and locations, and to do so in ways that take into account the setting of interaction as *place* – the experienced and practiced qualities of a physical environment.

The proposed contribution of the article is twofold: to contribute to the empirical body of knowledge on collocated interaction at heritage sites; and, through the empirical findings, to revisit and extend the concept and framework of Assembly to guide the future design of installations at museums and other exhibition sites, as technology is increasingly distributed and embedded across spaces, bodies, and artifacts, and physical/digital design requires greater attention to the material and embodied qualities of the environment (Dourish, 2001; Gottlieb, 2008; Messeter, 2009). We argue that the Assembly framework is particularly relevant to current HCI research due to the proliferation of "artifact ecologies" and "multi-device ecologies" in socio-technical systems (personal devices, smart objects such as in Internet of Things scenarios, etc.).

In the next section, we critically examine the body of related work and frame our intended contribution in the context of relevant HCI research. Subsequently, we present our study of Reminisce at Bunratty Folk Park, which was developed

[1] From now on, we use the capitalized word "Assembly" when referring to the framework, and "assembly" when referring to the result of applying the framework for design, e.g., a group of interrelated components supporting interaction around an overarching narrative.

according to an extended version of the Assembly principles. In Section 4, we then articulate a number of analytical themes through data excerpts, before concluding the paper with a discussion of the main findings that emerged from the empirical study of Reminisce.

2. RELATED WORK

HCI and related disciplines such as Computer-Supported Cooperative Work (CSCW) and Interaction Design have focused much attention on cultural heritage institutions as settings for both the deployment of novel digital technologies and the study of human interactions and practices with and around them (Brown et al., 2005; Ferris et al., 2004; Grinter et al., 2002; Koleva et al., 2009; Vom Lehn, Heath, & Hindmarsh, 2001).

On their part, museums and cultural heritage institutions have been early adopters of novel forms of interactive technologies, such as – for example – mobile, context-aware applications, touch-based interaction, and auditory interfaces, with the main goal to explore how technology could aid visitors in comprehending and interpreting what they encounter in these settings in ways that are engaging and sensitive to their circumstances (Gammon & Burch, 2008; Kalay, Kvan, & Affleck, 2007).

Cultural heritage sites are particularly challenging environments for the introduction of interactive digital technologies given the educational, curatorial, cultural, and social concerns that must be taken into account when approaching them (Hooper-Greenhill, 2013; Kalay et al., 2007). Therefore, research about the heritage domain has emerged from the HCI field as some of the most significant research to encourage a human-centered approach focused on enhancing the visitor experience, rather than driven by technological developments only, as indeed heritage professionals advocate (Maye, McDermott, Ciolfi, & Avram, 2014). This has also led to important HCI work adopting participatory approaches to design involving heritage staff and visitors (Iversen & Smith, 2012; Roussou et al., 2015; Taxén, 2004). Leading research on these topics has looked at how interactive technology can support sense-making and how, through interaction with digital resources, visitors can uncover and construct meanings in what they encounter (Fosh, Benford, Reeves, Koleva, & Brundell, 2013; Fosh et al., 2016; Grinter et al., 2002).

The wealth of knowledge developed within HCI regarding museums and other heritage sites includes nuanced understandings of visitor practices and behaviors, and particularly of the social and collaborative interactions among them (Vom Lehn et al., 2001). Another significant contribution is the deployment and evaluation of a wide range of devices and interaction mechanisms at heritage settings, which have shown the potential that specific types of technological interventions can have for this domain: from digital/physical visits (Brown et al., 2005), to Augmented and Mixed Reality (Koleva et al., 2009), mobile devices (Benford et al., 2006; McGookin et al., 2012; Galani, Mazel, Maxwell, & Sharpe, 2013), tabletop interfaces (Hornecker, 2010),

tangible artifacts (Ferris et al., 2004), and large interactive displays (Izadi et al., 2005), just to mention a few.

Heritage is also an important domain for the study of collocated interaction in HCI – interaction between both people and exhibits, and individuals and their companions, or among groups. Notable examples are the classic works of Jon Hindmarsh, Christian Heath, Dirk vom Lehn, and their colleagues (see, for example, Hindmarsh, Heath, Vom Lehn, & Cleverly, 2002; Vom Lehn, Hindmarsh, Luff, & Heath, 2007), detailing the social and collaborative interactions occurring while visiting interactive exhibitions. More recent examples are studies of collocated interaction while actively responding to exhibits via tagging or annotating, as it could be enabled by social media platforms (O'Hara et al., 2007; Weilenmann, Hillman, & Jungselius, 2013).

Recently, many examples of HCI work in and for museums have focused on collaborative interaction on online platforms and communities that are linked to museums (such as, for example, social media). In our view, however, the study of collocated interaction in heritage settings should not leave behind the "same place" dimension, as it touches on a much-discussed issue in heritage studies and exhibition design: the place of an exhibition or of a heritage artifact. The place of an exhibition can be its "original" location (think, for example, of archeological sites), or a specially designated site such as a museum, gallery, or visitor center. In the latter case, the placement of certain artifacts in certain locations within a venue is also a critical curatorial activity, for example by choosing to contextualize an artifact within a certain period, or theme, or by its proximity to other related artifacts. Furthermore, the interactions among visitors in the same place are the result of people purposely visiting for a variety of reasons and motivations (Falk, 2012; Giaccardi & Palen, 2008; McCarthy & Ciolfi, 2008). Another related aspect that needs further attention in HCI is the relationship between the material qualities of physical objects and spaces, and the layer of digital content of behaviors that is introduced at a heritage site (Dudley, 2010). The design of interactive technologies in support of heritage experiences must be mindful of these place-related issues. Place and place-making are important aspects of the experience of cultural heritage that the presence of digital technologies can shape and mediate (Ferris et al., 2004). Although these issues have been touched upon in previous research, more work is needed to explore the interplay of physical and digital, and place-related concerns in examining collocated interaction in heritage settings.

Several approaches to capturing and understanding the environmental and spatial circumstances in which people interact have emerged from the HCI literature (Ciolfi, 2004; Dourish, 2001, 2004; Fitzpatrick, 2003; Harrison & Dourish, 1996, Suchman, 1987). Some examples of this work (Ciolfi & Bannon, 2005; Messeter, 2009) have shown the benefits of actually using these approaches when designing technologies for museums and public spaces. They discussed the need to introduce greater consideration for the physical context of interaction in a way that is more in tune with human activities rather than with its "geometrical" characteristics: this strand – initiated by Harrison & Dourish's seminal paper (1996) – suggests focusing on how we act in *place*, the lived environment that is practiced, and conveys in turn

rich meanings that shape our practices. Doing this, we can gain a better understanding of human activities and of how design can support them. Dourish (2006), in particular, revisits the concepts of both space and place, arguing that they cannot be treated as distinct: they are both "products of social practice." Dourish (2004) also argues how the context of interaction cannot be modeled or designed into ubiquitous technologies, as it is intrinsic to an activity. Thus, instead of attempting to model it, context must be seen as a dynamic interactional process where people "evolve systems of practice and meaning in the course of their interaction with information systems" (Dourish, 2004, p. 28).

Ciolfi (2004) and Ciolfi and Bannon (2005) examine the role of physical places in the design of interactive exhibitions. Extending the definition proposed by Harrison and Dourish (1996) and drawing from the "experiential perspective" developed in the field of human geography (Tuan, 1977), they define place as the lived and practiced experience of an environment that is grounded in physical space: thus, space is the structural and material dimension of place. They state that to gather a thorough understanding of how people experience place and to produce a design that adds value to it, the personal, social, cultural, and structural aspects of place and their interrelationships must be understood and analyzed.

Hornecker (2005a) also examines space and place in her framework for the design of tangible interaction. She focuses on the interrelation between space and place and discusses the role of geometric space and the importance of "structural relations" as they affect how we experience place and the interactions that can occur there. In the tangible interaction framework, Hornecker (2005a, 2005b) proposes the theme of "Embodied Facilitation" to describe how tangible interaction systems can embody a structure that orientates people's situated actions. She discusses how interactive systems provide spaces and structures to act and move in, and how these structures foster experiences and shape people's situated circumstances. For example, within Embodied Facilitation, Hornecker specifies the concept of "Tailored Representations," where interaction is built on representations of people's own experiences that connect and empower them to the use of a system.

Messeter (2009) introduces "Place-specific Computing" as a new "genre" of interaction design. Leveraging off existing research (Ciolfi, 2004; Dourish, 2001; Harrison & Dourish, 1996; Suchman, 1987), he provides examples of interventions whose design embodies and supports interaction with aspects of their environment. He touches on field study methods, such as observations and interviews, and on design tools such as mood boards, which inform design practice of the identity of place.

All this work has generated what are mainly conceptual frameworks, primarily aiding the analysis of how people interact in and make places, while how to support design that is mindful of place experience and place-making remains underdeveloped. Ciolfi and Bannon (2005) attempted to address this; however, their place-centered framework is high level and general, and does not provide detailed practical guidelines. Another limitation of this work is that it does not particularly take into account the peculiarities of the cultural heritage domain.

Other examples of research do show other appropriations of the notions of space and place for designing interactive installations for cultural heritage: Champion (2008) argues that the experience of being physically immersed in heritage environments can be conveyed somewhat by means of Virtual Reality and particularly using gameplay as a narrative to engage users to explore a virtual heritage environment. Researchers such as Crivellaro et al. (2016) and Balestrini, Bird, Marshall, Zaro, and Rogers (2014) have argued how recognizing, capturing, and designing for cultural understandings of place are all key for engaging communities in preserving and contributing to their local heritage (particularly intangible heritage) through digital means. However, these examples do not provide detailed guidance for other designers on how to mindfully integrate digital interactions throughout shared places.

Work in ubiquitous computing and mobile and distributed systems has brought to heritage sites an increasing number of systems where interaction is not focused solely around one device/location (such as, for example, a tabletop installation or a mobile guide), but rather relies on a variety of components that are distributed across an exhibition space, often including a portable element (Gammon & Burch, 2008; O'Hara et al., 2007; Petrelli, Dulake, Marshall, Pisetti, & Not, 2016). The focus of the analysis in these cases explores complex trajectories of visitor interaction and of sense-making in these contexts (see, for example, Fosh et al., 2016).

Benford and Giannachi (2011) proposed a framework to assist in cases where the frame of interaction includes a series of encounters in mixed-reality environments linked by interaction *trajectories*. They focus in particular on the relationship between the "orchestrators" (e.g., designers, performers, etc.) of a public mixed-reality experience and the spectators/visitors.

Reeves, Benford, O'Malley, and Fraser (2005) developed a framework for the design of spectator experience where progressive revelations and suspense are identified as key requirements of interaction with and around installations in the physical world.

As we have shown, the cultural heritage domain has been examined in a wide range of HCI projects, and it has led to conceptual frames that address several important aspects of people's experience of museums and exhibitions, such as place experience, embodiment, sense-making, and enjoyment; however, only limited work has been carried out to address these aspects in conjunction. Therefore, we now focus on one specific framework applied to supporting *ecologies of interaction* with heritage installations – that of Assembly.

2.1. Assembly in HCI

Assembly in the context of exhibitions was originally proposed by Fraser et al. (2003) and Bowers et al. (2007) as part of the SHAPE project (Bannon et al., 2005), who offered a "design scheme" centered around five principles for the design of public physical–digital interactive experiences at heritage sites.

In their work, the authors present examples where low-tech portable artifacts were at the core of interaction with a set of interactive displays. Fraser et al. (2003) detail "The History Hunt": an interactive visitor experience at Nottingham Castle (UK) developed around the Assembly framework where an assembly of artifacts was used to mediate the visitors' interaction with the exhibits. This assembly of interactive technologies, which includes a number of tangible and mixed-reality installations and low-tech paper artifacts, supported the participants' practices of assembling knowledge about the Castle site, and progressively discovering and connecting various locations and themes. The basis of the History Hunt is the definition of a core activity that was then supported over numerous points of engagement and that allowed people to progressively make sense of the context they found themselves in.

Fraser et al. (2003) offer a "design scheme" centered around five principles of Assembly:

1. The definition of a unifying overall activity that people can engage in;
2. The design of an underlying information space that contains a variety of interrelated items that can be revealed as the activity progresses;
3. An assembly of interactive displays, with each display supporting a particular part of the common information space;
4. The use of common interaction or related techniques to promote the coherence of the experience across the different displays;
5. The role of a portable object/component to accumulate a record of their visit and/or support identification as the visitors move around the space.

The principles begin with establishing a situated activity – an overall interaction narrative – that visitors participate in, and then follow with constructing an information space that is intertwined with the activity, providing content and digital behaviors in response to interactions. These are composed in such a way so that people can progressively gather content and make connections. The focus then moves to the design of an assembly of interworking artifacts that supports the visitor activity, enabling people to encounter and interact with the content and functionalities.

These points offer a structure for people to make sense of their interaction with the site and with the exhibition, and provide ways to mediate their sense-making. The principles are quite unique in that they touch both on experiential elements of how an installation can add value to the visit ("define an overall activity in which visitors can be engaged in" and designing a "common information space") and on the structuring of the technical components to support this ("an assembly of interactive displays" supporting the overall activity and "common or related interaction techniques"). Finally, they see as key component of the assembly a "portable artifact" to act as lightweight "glue" throughout the visit by providing material and narrative coherence.

Fraser et al. argue that these principles are in keeping with their view of ubiquitous computing as multiply located computing, which comprises multi-located loci of interaction that support specific purposes but linked together to support the

overall experience. Importantly, the principles also make strong reference to the spatial aspects of the experience.

As we mentioned, the concept was originally based around the authors' research into designing physical/digital installations in museums. They conceptualized the museum space as an arrangement of displays representing the points of engagement with the heritage content, which forms the core of the visiting activity. To increase visitor engagement with the content (and knowledge) embedded in each display, they argue for the need to define an overall meaningful activity to enable visitors to actively gain insights as they progress through the points of engagement. Embedded in the activity is an arrangement of interactive artifacts supporting and facilitating interaction with the points of engagement. Fraser et al. suggest principles for designing an assembly of technologies that mediate specific parts of the museum experience: by understanding how to support the flow of the visit over numerous points of engagement, assemblies enable visitors to progressively make sense of the heritage context.

Their approach does not focus on designing arrays of ubiquitous technologies, but rather provides guidance at a higher level: how the whole visitor experience could be flexibly formulated.

Related work by Hindmarsh, Heath, Vom Lehn, and Cleverly (2005) employs the concept of Assembly to create interactive exhibitions that promote sociability in museums and galleries. They see these as assemblies of actions/practices, rather than a technical assembly of objects. They emphasize the importance of designing "action points" and "view points" of the interaction, and to understanding how the configuration of these actions and effects can support the visitors' sense-making.[2]

We have now seen how assemblies are an interesting case for both examining and designing for collocated interaction with and around cultural heritage: the idea of an overarching narrative (also echoed in the framework by Benford & Giannachi, 2011) provides a coherent underlying support to visitor interaction with others and with the system, but at the same time such an interaction is also somewhat fragmented due to the multiplicity of interaction points and their locations. An open question is how both overall interaction themes and "local" interaction episodes with specific components occur within an assembly.

Furthermore, as we mentioned, a duality exists within the Assembly framework: first, it relates to the activities that people carry out to make sense of heritage artifacts and content; in other words, they assemble together sources of information and opportunities for interaction in order to follow a narrative. Second, however, Assembly is also associated with the array of technologies mediating this sense-making. It can be said that the Assembly framework bridges between conceptual design and

[2] Stuedahl and Smørdal (2011) propose a concept of Assembly based instead on Actor-Network Theory, which conceptualizes exhibitions as spaces of enactments that open new alliances among authors, the work, and the observer. Socio-material interactions are, in this case, regarded as a constituent part of the assembly rather than another form of it.

technical design, thus providing a shared frame to match resources/devices with human activities.

This is important in our view as design practice can easily get caught up in technical design developed on the basis of a limited idea of how it can affect human activities, and a design intervention can become detached from the particular needs it attempts to support. When this happens at heritage sites, the visitor experience is significantly and negatively affected.

Assembly is also a powerful frame to guide design in support of the visitor experience. Reflecting on the dimensions proposed by McCarthy and Wright (2004), we can see how the Assembly principles resonate with salient points of how human experiences should be supported by digital technologies: "In a meaningful and satisfying experience each act relates coherently to the total action and is felt by the experiencer to have a unity or wholeness that is fulfilling" (Wright & McCarthy, 2005, p. 11).

An assembly as a designed system in its entirety is also a relevant interactional artifact as it supports and mediates interaction at multiple locations/foci both with the technological components and with the people, structures, and other artifacts that enliven those locations. The Assembly principles provide a frame for *where* interaction can occur around the system. Such practiced locations, or places, of interaction are very important in the context of heritage, as we have argued earlier. In the following section, we describe our reflection over and our own appropriation and extension of the framework and, subsequently, the physical/digital assembly we created for Bunratty Folk Park and called *Reminisce*.

3. THE *REMINISCE* PROJECT

Reminisce was an assembly of physical/digital artifacts that we designed following the blueprint of Fraser et al. (2003) to provide novel opportunities for engagement to visitors at Bunratty Folk Park, an open-air living history museum in Ireland.

Bunratty Folk Park (opened in 1963) is a popular attraction, welcoming over 350,000 visitors per year. It is a large site, covering 26 acres and displaying 32 dwellings with the goal of reconstructing rural and traditional life in Ireland from the mid-1800s to the 1950s.[3] The buildings on display include (among others) rural farmhouses (Figure 1), a village street (Figure 2), a church, a schoolhouse, and artisan cottages. Most of the buildings were carefully relocated to the Folk Park from various other rural areas of Ireland, whereas others were originally built on site.

Bunratty Folk Park offers to visitors a snapshot of Irish life from the past, with each particular building having a specific role in the history of Irish folk life (e.g., the schoolhouse, the poor farmer's cottage, the rich landowner's house, the forge, the working mill, etc.). Each site has been restored in a period-appropriate manner, and

[3] The entire site can be explored via Google StreetView: https://goo.gl/tCtrj6 .

FIGURE 1. Example of Cottage on Display at Bunratty Folk Park, Its Furnishings, and Animator Demonstrating Traditional Activities.

FIGURE 2. Bunratty Folk Park's Village Street Exhibition.

the artifacts in each house have all been attentively selected on the basis of their fidelity and suitability to the particular buildings and their period.

In some cases, employees animate the activities that would have been originally carried out at the sites; e.g., in some of the farmhouses, female employees act as "*Bean An Tí's*" (Irish for "Women of the House") (Figure 1). They bake using traditional recipes, tend to the turf fires, and oversee the running and cleaning of several of the houses and of the creamery. Another animator impersonates the "*Múinteoir*," the school teacher, holding brief classes in the schoolhouse where visitors are taught some words of the Irish language or simple folk songs. The animators also interact with the visitors in more informal ways, telling them about the activities that they are performing, the history of the site they are in, answering questions, and so on. Surrounding the dwellings, there are a number of outdoor attractions such as animal enclosures, gardens, trees and vegetable plantations, etc.

The landscape, the buildings, their contents, and the activities taking place in them, thanks to human animators, are all elements of a complex display that visitors encounter in their wanderings.

At the beginning of our project, we conducted a series of field studies at the Folk Park to understand the physical layout of the site and the way in which visitors encounter it. We then conducted interviews with staff and visitors in order to grasp the interpretation strategies that characterize the site and how they are deployed. On the basis of our findings from these studies, we ran a series of design workshops that led to a set of scenarios for an interactive installation. One scenario was collaboratively chosen and developed into an installation. Using the Assembly principles, we guided the discussion on the design of various aspects of the installation, titled *Reminisce*. The design process and the impact of the design on the visitors' interpretive experience have been described in detail in previous publications (Ciolfi & McLoughlin, 2012; McLoughlin & Ciolfi, 2011). We now describe the installation in order to properly contextualize the data that we will present in subsequent sections.

Reminisce augmented seven historic buildings on display at Bunratty with personal character narratives that visitors could explore through various devices and in various media forms. The two characters delivering these narratives – "The Farmer of the Land" and "The Woman of the House" – were fictional but were inspired by original historical accounts and by the role-playing and characterizations performed by museum staff.

Visitors collected auditory memories about particular activities (e.g., making butter, cutting turf, etc.) from one or both characters. These memories were placed at different sites, and, as visitors progressed through the Park and collected them, they were given clues about where they could find more memories.

The visiting order for Reminisce was not prescribed, and visitors could explore the buildings in any sequence they wished. However, all visitors receive a map of the Park as they purchase their admission ticket and most visitors tend to follow the suggested visiting order outlined in the map as they journey through Bunratty Folk Park. This happened with the vast majority of the people who tried out the installation and with all the participants in the study from which this paper draws from.

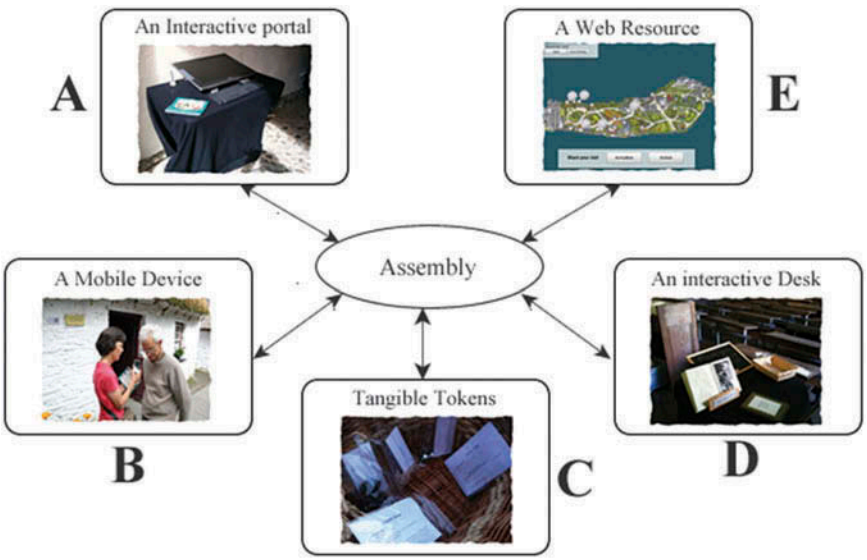
Visitors could use Reminisce free of charge, and the design team provided all the accompanying materials. The technical installation consisted of an array of interactive technologies each supporting specific parts of the activity. When visitors entered the Folk Park, they were directed to a central "portal" (Figure 3, A): here they could create a unique profile where all the content they collected and recorded during their journey would be stored. Here, they could also select the character(s) that they would like to hear memories from, and receive an initial clue about where to find the first memory. The portal was also where they could download the Reminisce mobile app onto their phone or collect a mobile phone that they could use to gather the memories and that we had made available for those visitors who did not wish to use their own phone.

At seven different sites, available memories were represented by QR codes, and using the Reminisce app visitors could scan the codes through the phone camera.

The auditory memories were short (about 10 sec on average) and provided simple descriptive snippets of life in times past from a character's personal perspective. For example: "We'd let the cows graze in the open fields all year round and we'd milk them morning and evening. If by chance they had eaten turnips the milk would be very strong and we'd add salt to mask the taste."

Seven buildings in Bunratty Folk Park were selected to be part of Reminisce: six cottages and the schoolhouse. These buildings were located within easy distance from each other and they constitute the most visited part of the Park. Each building had at

FIGURE 3. The Reminisce Assembly: A) the Registration Portal; B) the Mobile Device (PhonE); C) the Tangible Tokens; D) the Interactive Desk; E) the Web Resource.



least two QR codes available, with the Loop Head House displaying three codes as it is a large cottage with outbuildings. Fourteen memories for each character (24 in total) were available overall to collect throughout the experience.

Once a QR code was scanned, the app would display the specific memory or memories associated with a site in the form of audio recordings that could be played on the phone. Then, if they wished, visitors could use the application to record and save in real time their own memories or comments using the handset's microphone.

At six of the memory sites (the exception being the schoolhouse), visitors could collect specially designed packs of tangible tokens (Figure 3, C; Figure 4), containing a souvenir that they could bring home with them and that was connected with each building (recipes, pieces of turf, small hunks of wool, etc.) and a clue about where they could find other memories. There were six souvenirs to collect in total throughout the experience and the souvenir packs were located at visible locations near the entrance to each cottage. The purpose of these packs was threefold: to provide the visitors with a memento of their visit to a building, to guide them to other memories

FIGURE 4. Example of Tangible Token: A Small Hank of Wool for the Shannon Farmhouse. Each Small Bag Contained an Artifact Connected to the House and a Clue.

available to them, and to allow them access to the memories and comments other people left at the site. The clues were printed on cards with RFID tags embedded in them (see one example in Figure 3, C). When visitors reached the schoolhouse, the last site on the Reminisce trail, they could use the tangible tokens as input for the Interactive Desk in the schoolhouse.

The Interactive Desk in the schoolhouse (Figure 3, D) allowed people to listen to the recordings that other visitors had left at the sites in the Park inspired by the character memories they had heard. Placed on the desk were two books with embedded RFID tags, each of them related to one of the characters that visitors could collect memories from. A bookholder and a basket with embedded RFID readers were also placed on the desk. When one of the books was placed on the holder and one of the tangible tokens was placed inside the basket, the corresponding recordings left by other visitors were played back, i.e., these recordings were from the site where the tangible token was collected from.

Furthermore, after the visit, participants could access their entire activity trail with Reminisce (sites visited, content listened to, and recordings they had generated) on the web (Figure 3, E) using the registration details they had entered at the central portal at the beginning of the visit.

The decision to provide the playback of other visitors' memories in the schoolhouse (rather than in each of the cottages) was made following the testing of an earlier version of the prototype. The cottages are rather small and can easily become crowded, and early testers found that the memories played aloud in the cottages made the environment too noisy, and that people using Reminisce lingered there for very long, making it less attractive for other visitors to come inside. Playing the memories aloud in each cottage was also a distraction for visitors interacting with each other and with the animators in such small spaces. The decision was therefore to have the playback of visitor memories at a dedicated location, and to instead encourage the visitors to record their own at the cottages following the collection of each memory and (often) discussion with companions and animators.

To provide a quick overview of how the visitor experience unfolded, we give a brief walkthrough scenario:

> Jean is an Irish-American Tourist visiting Bunratty Folk Park during a holiday with her husband. At the entrance, they receive maps of the Park, and they are made aware of the Reminisce installation. Jean wants to try it out to find out more about life in Ireland in the past, so the receptionist directs her to the start of the installation (the central portal). She chooses the Bean An Tí (Woman of the House) character and receives a mobile device that she can use to collect the characters memories and to record her own comments.
>
> Looking at the map, Jean and her husband begin their tour from the Loop Head House: there Jean sees and scans the QR code placed near the main entrance and receives a first audio recording of the Bean An Tí talking about life on the remote Loop Head peninsula. Walking around the house and outbuildings, Jean collects several more memories.

As she and her husband look around inside the small cottage, on the kitchen table they notice a basket full of small packages marked "Are you exploring 'Reminisce'? Please Take One." Each package contains a printed recipe for baking griddle bread. At the bottom of the sheet is a clue to another site that contains memories.

"Life in the mountains was difficult in the Winter"

This must mean that more memories are located at the Mountain Farmhouse marked on the map, so they make their way there and find several memories at the farmhouse. Jean here records her own childhood memory of her Irish great-grandmother doing embroidery, which her husband had never heard about. As they leave the house, they collect another souvenir pack: it contains a small piece of fresh turf and a card with the next clue:

"Cheese making was important in the Shannon area"

They keep exploring the buildings listening and recording their own memories, and interacting with other visitors and animators.
They finally arrive at the schoolhouse and at the entrance they find a memory of the Bean An Tí talking about the importance of education for families. Inside, they find the interactive table where – by placing inside the basket the souvenirs they have collected – they can hear other visitors' memories from each house. Upon leaving Bunratty, Jean returns the phone and checks out at the Reminisce central portal.

The design of Reminisce is the result of the elaboration and application of the Assembly principles and we now discuss how we adapted and applied the framework.

3.1. Adapting and Applying the Assembly Framework

In order to apply the Assembly approach to the design of Reminisce, we divided the framework into: conceptual principles focused on conceptualizing activities and information spaces (principles 1 and 2 in Section 2.1); and prototyping principles that guide the prototyping of the technical infrastructure (principles 3, 4, and 5 Section 2.1).

The fundamental element of the Assembly framework is the definition of interrelated activity narrative and information space that people engage with as they explore an exhibition. The nature of the activity narrative and of the information space needs greater discussion and elucidation. Numerous forms of activities and content could be made available to visitors, and it was established by Fraser et al. that, for an activity to support sense-making, it must encourage more than passive accessing of digital content. Instead, it must introduce opportunities to actively participate: in the case of "The History Hunt" that they describe, the task given to the visitors was to create rubbings on paper. In other words, the knowledge space of

the Assembly should allow participants to *actively* add to the circumstances they find themselves in. We believe that such agency enables visitors to better assemble (and make sense of) the overall narrative. Participative models of encounters between visitors and heritage are also increasingly adopted by museum professionals when designing exhibitions and interpretation aids (Proctor, 2015), and therefore we argue that incorporating this concern explicitly into the Assembly framework makes it even more relevant for the cultural heritage domain. Therefore, when defining an overall activity, it is necessary in our view to ensure that it provides opportunities for active participation. Embedded in this structure are the interactive artifacts that make up the technical assembly and that support the activity as a whole. Particular approaches to aid in the conceptual development of the activity and of the related information space have not been discussed by Fraser et al.

In order to extend this underdeveloped aspect of the Assembly framework, we draw from place sensitivities, e.g. how people live and experience a physical environment investing it with actions, meanings, and values. As we discussed in Section 2, place-making has been considered by HCI researchers as a way to shape interaction narratives (Ciolfi & Bannon, 2005; Hornecker, 2005a; Messeter, 2009), particularly in heritage settings. Therefore, developing an understanding of how people experience place, its physical, social, cultural, and emotional nature is in our view a valuable dimension to introduce into the Assembly framework. Introducing a concern for place and place-making can lead to the designing of overall activity narratives and content to engage and support the visitor experience in connection with the rich and evocative environment where it occurs.

The remaining principles of designing assemblies introduce the dimension of technical design, of identifying a set of physical/digital components. Principle 3 is about developing artifacts that work in concert to support the mediation of the overall narrative. Fraser et al. talk about "interactive displays," each supporting a part of the overall experience and revealing a subset of the common information space. This principle allows for a fairly open interpretation of the forms and modes of interaction and of the interactive elements that make up an assembly. We feel, however, that the label "interactive displays" needs to be reconsidered. An "interactive display" suggests a one-way process of interaction between the user and the display (presenting content that could be visual, auditory, etc.), thus limiting the technical Assembly to simply delivering content. We suggest redefining this principle so it refers to a set of "interactive components" rather than "displays." This takes into account a wider range of possibilities, including components that are not just devoted to displaying content, but also to support a more dialogical and participatory interaction with the visitors.

This leads us to the fifth Assembly principle: introducing a portable low-tech artifact, as tie-in among the interactive elements of the Assembly. Again, this is quite generic given the modalities and support for interaction that simple portable technologies can provide. They might not be technically complex, but they could be powerful interactive components in their own right. We suggest amalgamating

this principle with the third principle by emphasizing that the interactive components needn't be only "interactive displays," but that they can also be low-tech components that play a role in engagement and interaction. The resulting overall assembly will always be spatially situated within a heritage site and will add to place experience. Therefore, it should be in keeping with the locale and existing practices.

The fourth Assembly principle is concerned with the interactional qualities that the interactive components support. It emphasizes the need for common modes of interaction to provide a more coherent experience as people negotiate the assembly. Given the assembly's multiple components, there is a need to consider interaction modalities that can be interworked and supported across them. This principle involves more than simply selecting different modes of interaction; it must also examine how they can complement each other as people encounter different parts of the assembly. The idea of "common modes of interaction" must also include the consideration of how these integrate with the visitor activities in place.

The following are the revised principles that we propose and adopt:

1. Define an overall activity that people can actively participate in, informed by the understanding of visitors' situated activities.
2. Based on the overall activity, develop an underlying information space that allows visitors to actively make sense of their situated experiences. This must be structured so it can be progressively revealed and responded to by visitors at different points of engagement.
3. Develop an assembly of interactive components that support aspects of the overall activity and mediate the information space. These components should mediate elements of the information space in a way that is coherent and in keeping with the overall activity narrative and with the locale. Emphasis should be placed not only on developing interactive components to provide opportunities for interaction, but also on developing components that enhance the coherence of the whole assembly, specifically, low-tech components that can offer interesting opportunities for engaging interactions and for mediating the information space.
4. Provide related modes of interaction across components so as to connect them and provide a more coherent overall experience. These modes of interaction must complement each other and be in keeping with visitors' situated interactions at the heritage site.

The design of Reminisce that we have described at the beginning of Section 3 is clearly tightly mapped onto the revised Assembly principles. Although in this paper we have described Reminisce before the adapted framework in order to clarify the installation to the reader as early as possible, the design process saw us first analyzing, discussing, and extending the Assembly principles, and then using them to guide the design of Reminisce.

We now present our empirical study of how the components of Reminisce and its whole mediated visitor interactions and practices, highlighting how the assembly enabled specific instances of collocated interaction within the museum visit. As established by the extended Assembly principles, the design of Reminisce paid particular attention to the qualities of the Folk Park as a place and to the place-specific aspects of interaction, including choice of building materials, content, and narrative sequence. Interaction with Reminisce was not limited to a single device and/or location in the Park: it occurred in multiple forms depending on which part(s) of the assembly visitors approached and used, and how. These instances of interaction emerged in a variety of configurations and patterns (e.g., collocated around the same device/component, or around different devices/components at the same location, or at adjacent locations in the Park) and were mediated by various aspects of the installation.

4. STUDYING VISITOR INTERACTIONS AROUND 'REMINISCE'

The qualitative data presented in this section were gathered through the shadowing and naturalistic observations of small groups of visitors using Reminisce during their exploration of Bunratty Folk Park. We have chosen vignettes that are useful for identifying ways in which the Assembly supported interactions across artifacts and locations, and in ways that it supported connections to the place.

The data were collected throughout three full consecutive days during the public trial of Reminisce in August 2011. Given the prototypical nature of the installation, the user trials were facilitated to some extent by the research team, by giving participants an overview of the project at the beginning of their visit and providing them with mobile phones with the Reminisce application preloaded onto it. Visitors could use their own mobiles if they ran on Android. However, none of the people who agreed to participate wished to do this, as it would have required downloading the app using their own mobile data network. Free public wi-fi was not available at Bunratty at the time of the trial.

Given the scale of the Park and the distributed nature of the installation, two main methods were used to document the visits.

- Shadowing: Participants were shadowed throughout their time using Reminisce by two members of the research team. Whilst one member of the team took notes during the shadowing session, another member video-recorded it at a distance. Bunratty Folk Park management had given their approval of our ethical procedures for collecting data. Notices informing the visitors of the presence of video-recording equipment on site and its purpose were displayed at the entrance to the Park and at the start of the trail. Although the use of camcorders tends to stand out in most spaces, the Folk Park is a busy tourist attraction and handheld cameras are quite common, making the presence of our video camera quite unobtrusive.

Still photographs were also taken occasionally during shadowing, especially in dark places where the video footage would be hard to make out on its own during data analysis. All members of the research team wore identification badges so as to be recognizable to all the Folk Park visitors, even those not participating in the trial, while conducting the study.

- Informal Interviews: After the visit, participants were informally interviewed by one member of the team to gather specific feedback on issues that may not have been apparent or explicit through the shadowing sessions, and also to allow visitors give their own insights and comments into the use of the installation and their opinion of it.

Regarding recruitment, our pool of participants included visitors whom we approached at the entrance to the Folk Park at busy times, volunteers recruited through other channels (e.g., the University's "Events" mailing list, where we advertised Reminisce), and people who had contacted us after seeing Reminisce mentioned in the local press. Participants who agreed to try out the system were excused the admission fee to the Park as thank-you.

We documented 23 visiting units using the full installation on their journey around the Park through shadowing and interviews, and observed approximately another 50 instances of some partial interaction with individual components of the Reminisce by lone visitors and small groups. We refer to "visiting units" to describe the instances of visits by either lone visitors or by pairs/small groups that we documented. The data upon which we draw for this paper pertains to the 23 visiting units that we documented in full. This pool of participants included six lone visitors and 17 pairs/small groups. In the case of lone visitors, the visiting unit comprised only one person. The small groups we documented ranged from two to six people. Large groups were not recruited for the trial. On average, each trial lasted between 40 min and 1 h. No more than two visits aided by Reminisce were ongoing in the Folk Park at any time. This means that, while there was a chance that two sets of visitors using Reminisce would meet each other during the visit, this happened relatively rarely, also due to the large size of Bunratty Folk Park. As Reminisce was available only in English, only English-speaking participants were recruited. The large majority of visitors we observed were Irish, with one group from Sweden, one group from the USA, and one pair from the UK. Of the lone visitors, all were Irish but one, who was originally from Germany but living in Ireland. All participants were first-time visitors to Bunratty.

The data documenting all the 23 visiting units were transcribed in full. The data included the memory/comments contributions generated by the visitors, which were analyzed in the context of the full visiting unit and not separately. The data were analyzed thematically through repeated viewings of the video recordings matched with readings of the related observational notes and transcripts. Codes were generated in order to organize relevant excerpts into themes. Nine themes were generated in total (ranging from issues to do with the usability and robustness of the prototype, to the emotional reactions of the visitors).

In the following section, we present excerpts from data articulating themes that illustrate how Reminisce as a physical-digital assembly mediated and supported collocated visitor interaction: the roles of the assembly components (individually and in combination) in mediating interaction and collaborative understanding among visitors; how interactions through the assembly enabled visitors to make sense of the place; and how interaction with the assembly sustained coherence throughout the visitor experience.

We selected the majority of the examples as they illustrate particularly well certain types of interaction that were documented throughout the study and that coalesced into themes throughout the analysis. One example (Figure 7) shows instead a unique occurrence (two co-visitors each using a phone) that we include here as it is notable in illustrating one of the analytical themes. All examples are presented in the form of "vignettes" depicting both the visitor behaviors in relation to the space and their conversations.

The general pattern of engagement with Reminisce showed participants visiting and collecting memories at all the seven sites included in the experience. All the visiting units that we documented followed the order of the buildings that was suggested by the official visitor map. While all visiting groups collected all the memories at each site, not all of them recorded content of their own at every site. Of the 23 visiting units, however, only three did not record any content at all: the family group from Sweden, one lone Irish visitor, and one pair (also Irish). When asked why they did not record any memories in the post-visit interview, the Swedish group said that they were conscious of time and did not want to make the visit even longer; the lone Irish visitor stated that, while he loved hearing other visitors' recordings in the schoolhouse, he was more comfortable without recording his own voice; the pair explained that they were following the story of the character and did not think that their own recordings would have added to it. Although these people did not record their own content, the observations of their interaction show that they discussed what they heard among each other. The lone visitor had conversations with the animators he met at two of the Reminisce cottages that were triggered by the character memories. In the post-visit interview, he commented on how moved he was while listening to the "Farmer of the Land" story as it reminded him of his late father.

Overall, the large majority of the visitors we observed were happy to contribute and felt comfortable about it, and the data documenting the experience of those people who did not contribute content shows that they were nonetheless engaged in the Reminisce experience.

4.1. The Roles of the Assembly Components in Mediating Collocated Interaction

Each of the components of Reminisce mediated interaction at different points and in different configurations of people, artifacts, and resources during the visit. First of all, when participants began using the system, they established an internal

"ecology" of how to use Reminisce: by assigning roles for using the different components, deciding when these roles would change, and establishing the pace of the visit and of the interaction with the assembly. For example, within a visiting unit, one member could be in charge of scanning the QR codes with the phone and playing the memories audio files, while another member could be collecting and carrying the tangible tokens, and another helping work out the clues about where to go next by looking at the Folk Park's visitor map. These configurations emerged in some cases from explicit discussion about who should do what and from mutual agreement. In other cases, they emerged without an explicit agreement among the members of a visiting unit, but simply due to convenience or unspoken preference.

In some instances, these roles within the group would remain constant throughout the visit; in other instances, the group would coordinate turn-taking and periodically reassign the various assembly components to other members. In the latter case, the transition between one member and another in using a component, such as the phone, happened either by agreement, or by responding to specific interactions or events – e.g., when listening to a particular character memory played on the phone by one member prompted another member of the group to take over the phone so that they could record their own content in response.

An example of an unplanned shift in roles is detailed in Vignette 1 below (Figure 5). At the beginning of their visit, Gemma and her young daughter Sarah[4] mutually agreed that Gemma will be in charge of collecting the tangible tokens and that Sarah will use the mobile phone to collect the memories.

In Vignette 1 the reversal of roles is prompted by a particular event: the character memory being about something that particularly touches Gemma, as it evokes her own memories of her grandmother. Gemma waits for the sound to finish playing having signaled to Sarah that she wants the mobile phone. While Gemma records her memory, Sarah takes over the tangible token, and mother and daughter then continue the visit having swapped their roles.

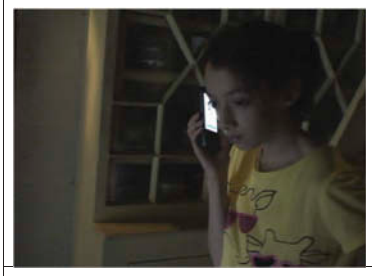
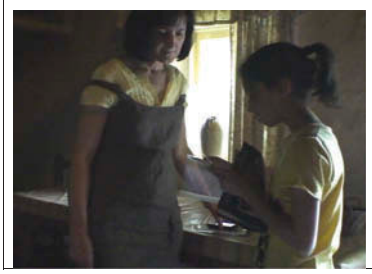
In contrast, one example of "agreed" turn-taking is illustrated in Vignette 2 (Figure 6).

The two vignettes mentioned above show not only the mechanisms of coordination among visitors around the assembly components, but also how the visits with Reminisce were a constant interweaving of artifact handling, placement, and overlap, of active interactions with the assembly (e.g., scanning, playing, recording, etc.), and of linked interpersonal and collaborative interactions among the group. The dialogue in Vignette 2 shows how the content was both used to gain a clearer understanding of the site (e.g., Mary explaining to Robert about the child's bed, Mary and Danny explaining to Robert why the fire is needed) and effective in evoking personal reactions and memories (e.g., Mary remembering when she used to live on a farm).

Both vignettes show that the role takeovers and transitions happened smoothly and without the need for the visitors to give time to figure out how the assembly "worked" in order to take up a new role during the visit.

[4] All the participants' names used in this paper are pseudonyms.

FIGURE 5. Vignette 1: Gemma and Sarah.

	Sarah scans the QR code in the Loop Head House collecting a character memory from the Woman of the House about making bread in the traditional way.
	Sarah then plays the memory on the phone, while Gemma is nearby, looking around the house.
	Gemma approaches Sarah to listen to the memory. Gemma: *"Oh, griddle bread!"* Gemma gently takes Sarah's wrist signaling that she wants the phone as soon as the memory has stopped playing. She then records her own memory about her grandmother baking bread for the family when Gemma and her sister were little girls.
	After Gemma has recorded the memory, she holds on to the phone, while Sarah has now collected a tangible token and is reading the clue suggesting where to go next.

In both vignettes 1 and 2 we also see the assembly fully interfacing with the site, the buildings, the artifacts, and other resources that are part of the regular visit, such as, for instance, the map, which became seamlessly embedded in the interaction with Reminisce. In fact, we can say that the map became – for all intents and purposes – a part of the assembly for all the visitors, although it was

not designed to be so. In the post-visit interviews, when asked about the ease of use of the installation, many visitors commented on how the map made it very easy to figure out the clues.

The assembly was flexible enough to be appropriated and reconfigured in terms of use; it became embedded into the visit and into the conversations. "Seams" – moments where the focus of the interaction shifted from the visiting experience to the workings of the installation (Chalmers & Galani, 2004) – came to the surface when some aspects of the interactions with the assembly had to be renegotiated or explained.

This was particularly evident in the only visiting unit that we documented where the two people involved, friends Nuala and James, each chose to take one phone and

FIGURE 6. Vignette 2: Danny, Mary, and Robert.

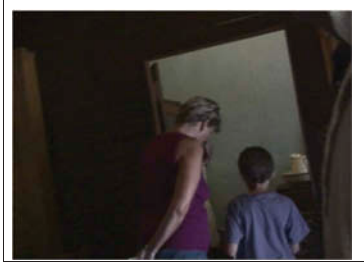
	Danny and Mary are visiting with their grandson Robert. At the beginning of their visit, Danny is in charge of the phone. Robert asks whether he will be allowed to use the phone to scan the codes. Mary agrees. Mary [To Robert]: *"Pops* [Danny] *will do the next one, and then he'll tell you what to do"*
	Danny has scanned the first code and played the memory about baking bread. Mary [To Robert]: *"So – look - that's where they cooked, in here in the open fire, they had the pot over there. They've coals in there. Come over here and feel the heat. Put your hands down there. Do you feel the heat?"* Robert gets closer to the fire. Danny: *"It's a very high roof it must be cold enough without the fire"*
	Moving about the house, Robert notices what looks like a wooden box with padding inside: Robert [To Mary]: *"What's that Nana?"* Mary: *"That would have been your bed there…A child's bed. And they didn't have toilets back then, you'd have to use the potty under the bed. And the basin to wash your hands* [pauses] *It brings me back now. When we lived on the farm".*

FIGURE 6. (Continued).

	Robert takes over the phone from Danny as agreed. They go outside towards the creamery. Mary [To Robert]: *"Where's the next clue?"* Robert [Pointing to the entrance to the creamery]: *"Its up here!"* Mary: *"Oh, it's up here, oh brilliant. Do you know how to do it now?"* Robert nods then [loudly, calling Danny]: *"I found another black thing* [The QR code]*!"* Robert then scans the marker and the memory of the farmer talking about milking cows is displayed on the phone, ready to be played
	Robert and Mary go inside the creamery closely followed by Danny. Robert: *"Is everybody listening? I have the code!"* Robert clicks on "play the memory" on the phone. The recording plays: *"We'd let the cows graze in the open fields all year round and we'd milk them morning and evening. If by chance they had eaten turnips the milk would be very strong. We'd add salt to mask the taste"*
	Several houses later, at the Golden Vale House, we see that Robert is still handling the phone and playing the memories for his grandparents.

follow one character, rather than share one device and one character narrative between them (Figure 7).

In Vignette 3 (Figure 7), we see yet another instance of how the visitors weaved a set of interactions among themselves, the site, and the components of the assembly. We also see two moments where their attention shifts onto the installation itself, and their focus on the narrative is temporarily redirected onto the workings of Reminisce. The first moment is when Nuala and James collect the first token (and thus the first clue) in the Loop Head House. Nuala asks for James' help in figuring out how to work out the next step, also noting the RFID tag embedded in the sheet of paper she is holding as it could provide a way to work out the clue. James suggests that they focus on the map instead.

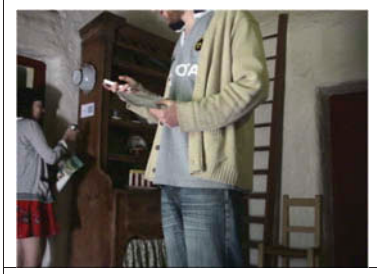
The second moment occurs later in the visit at the Shannon Farmhouse, when James' repeated attempts to scan a QR code fail because of the poor light. Nuala

FIGURE 7. Vignette 3: Nuala and James Using Separate Phones.

	Nuala (on the right in the still image) and James (on the left) are each scanning QR codes, collecting and recording memories separately, with only brief conversations between them in between moving from one part of the buildings to another. At the Loop Head House, James approaches the main house first, while Nuala starts at the creamery.
	Inside the house, Nuala and James each collect a tangible token. They silently read the recipe for griddle bread and then the accompanying clue.
	Nuala reads the clue out loud, James stops reading his own and moves to closer to her. Nuala [reading aloud]: *" "The power of fire helps the land thrive" …Mmmmh, how does it work now?"* James: *"Is it a clue? We have to find something with fire?"* Nuala [touching the paper]: *"There's a tag in here"* James: *"Let's look at the map first"* They figure out that the blacksmith's forge is the next memory site.
	At the forge, Nuala scans the code while James looks at the next clue inside the tangible token that he has already collected. They move on to the Shannon farmhouse.

interrupts her own collecting of memories and uses her phone as a flashlight to enable James to scan the code. She knows how the technology works and quickly finds a workaround to make the camera on James' phone pick up the marker. Both moments are small alterations of the flow of the visit, which soon continues as

FIGURE 7. (Continued).

	At the Shannon farmhouse, Nuala and James continue their pattern of visiting the building separately, taking turns to collect memories with their phones from the same markers. James makes the first attempt to scan a QR code, however the room is very dark and the camera on the phone is not recognizing the marker. Nuala steps in to help, using her phone to illuminate the marker so that James can finally scan it.
	Nuala and James separate again to continue the visit, however they talk briefly comparing the different content linked to the two characters each time they play a memory.
	James, who has now finished listening to the memories, joins Nuala at the table. Nuala moves aside to make room for James. They re-arrange the materials on the table to jointly figure out where to go next.

before. This seemed to be the case with other similar occurrences that we documented for other visiting units.

Vignette 3 also provides another example of how a pair of visitors coordinated activities between themselves, in comparison to Vignette 1 and Vignette 2. Mostly due to the fact that Nuala and James had chosen to use separate phones, their interpersonal interactions occurred most frequently in between interactions with the assembly inside each house, and then as the two friends walked from one building to another. The interactions between Nuala and James inside the houses were briefer than those we documented for visiting units using a shared phone, while they had longer conversations in between buildings.

Overall, the assembly effectively supported several different styles of visiting: most groups shared one set of components, taking turns or sharing "duties;" on the other hand, in the Nuala and James example, we see two phones and two sets of

clues being used, independent interaction with the components by the two visitors, but discussions in between and during transitions between points of interaction. Even in the latter example, the content (both given and user-generated) and overall narrative fed interpersonal interaction, despite the interaction with the technical assembly inside the houses being individual.

Besides these different patterns of visiting, the examples presented thus far also illustrate how the different components making up the assembly (with the addition of the map) came to be handled, shared, passed, laid out on the table, and compared as visitors experienced and discussed Reminisce.

Again, these are only a few select examples of the multiple ways in which these interactions took place, and more will be seen in the excerpts we present in the following sections. As with the coordination of roles around the assembly, in the examples we presented in this subsection we also saw that the components of the assembly could be flexibly rearranged in a variety of ways during each visit. The portable elements had naturally the highest degree of flexibility, but visitors appropriated other aspects of the assembly, such as the suggested order of the buildings to visit, the number of memory markers (RFID codes) they decided to scan, and those they decided to respond to with their own content.

4.2. Interaction through the Assembly and Place-making

One of the key goals of the design of Reminisce was that of connecting to and resonating with the qualities of the place, and highlighting them to visitors, thus becoming a dimension of their own place-making at Bunratty. The features of buildings, of the landscape, and of the activities that took place there in the past were all important aspects to be made more visible to visitors through the technological augmentation of the Folk Park by means of the assembly. In our re-elaboration and extension of the Assembly principles, we adopted the definition of place as practiced and experienced space (Tuan, 1977), where activities, meanings, and values are associated by people to the physical environment and to the material artifacts on display.

Because of the scale and complexity of the exhibitions in the Park, visitors encountered physical elements and qualities of the place at different levels of granularity, size, and scope: from a whole village scene (Figure 2) to entire buildings (Figure 1), to rooms, to smaller objects inside a particular room, and to other sensory qualities such as smells, different lighting conditions, and even tastes (e.g., in the houses where samples of bread or cake were handed out to visitors).

Reminisce mediated the visitors' interpretation of various locales at Bunratty Folk Park, and of details and character of the buildings, as well as their understanding of the activities that once were performed in those environments. The data excerpts that we next present illustrate this, and also show how Reminisce facilitated reflections and discussions based on content that the assembly made available to visitors in addition to the informational material provided by the Folk Park. The auditory

memories, the tangible tokens, and the interactive desk all provided prompts for reflection and commentary about the place. The first excerpt that we present to illustrate how this happened (Figure 8) features a family of four: a grandmother (June), her daughter-in-law (Patricia), and June's granddaughter (Emma) and grandson (Paul). Patricia is Emma and Paul's mother.

In Vignette 4 (Figure 8), we see how the character memories subtly conveyed to the visitors knowledge that otherwise would be not be apparent. The memories were scripted on the basis of the location for their collection at the houses so that visitors could relate the memories to their interactions in the space, and provide a better sense of what they were experiencing. We can see how June's family could coherently

FIGURE 8. Vignette 4: "It Can't Be before the Famine".

	June and Paul are trying to figure out in which period people lived in the Mountain Farmhouse. June: *"Is it in the 1800s?"* Paul: *"It's before, hmmm, it's after the Famine and before..."* June [interrupting him]: *"After the Famine?"* Paul: *"Or is it before the Famine"* June: *"It can't be before the Famine…*.[pauses for several seconds] *It would be in the 1890's or 1880's"* Paul [looking at the map]: *"I think there is a few different ones"* June: *"Is there a year they give you? 'Cos we're too young to be talking about the Famine"* [Laughing] Mary: *"What's this?"* Paul [Looking at the map]: *"It doesn't say what year"* They then move to explore the rest of the house
	Emma finds a memory marker at the box for turf beside the fire. She scans the QR code to collect the memory. She then brings the phone to Patricia and June so that they can all hear the memory. The memory is about bringing home the turf during the Summer using the tractor. Patricia: *"So it was the tractor they were bringing home the turf in"* June: *"Yes, that's very new"* Patricia: *"Not the horse and cart"* June: *"That's modern"* Patricia: *"It's modern, it's much later than we thought"* June: *"Later than we thought, oh well. What do we make of that now"*

FIGURE 8. (Continued).

	June [to Patricia]: *"Were you ever in a bog?"* Patricia: *"Yeah years ago"* June: *"I was too. I remember being in a bog and I remember taking off my shoes. And I have a picture of myself in the bog."* Emma: *"Why did you take off your shoes?"* June*: "because they cut the turf, you remember [to Patricia], off the brow and it was soft like moss."*
	Patricia: *"It was like a cushion!"* June: *"Yeah, your toes would, ah, it was a lovely feeling. It was like walking on a soft mattress, it was wet. And the ooze would go up between your toes, remember that?"* Patricia: *"Oh yeah"* June: *"I used to love that walking, and then you used to have a slane"* Patricia: *"For cutting the turf"* June: *"For cutting down, then you lift it out and you foot the turf. Five and one across."* June: *"Remember how did ye bring the food out?"* Patricia: *"We had bottles of tea."* June: *"Bottles of tea with a cork on top and lovely bread"* Patricia: *"The smell of the tea. I can still taste that tea..."*

assemble together their experience of the Mountain Farmhouse with the information available on the map and with the characters' memories in order to understand more about the period that the house represents. Indeed, we see Paul and June using the map to help find out the period of the Mountain Farmhouse display; Emma collects a memory about the house from the Bean An Tí character's perspective and brings it to Patricia and June for them to listen to. This memory mentions the use of a tractor to bring turf from the bog back to the farmhouse, and from this they deduce that the period that the house display recreates is much more recent than what they initially thought. Then, sparked by the mention of the bog, Patricia and June begin a conversation around their own memories of going to the bog, while Emma and Paul listen in. Interestingly, the family not only draws additional factual information about the house from their interaction with Reminisce, but also actively contributes their own memories and recollections, thus making the Mountain Farmhouse the setting for an engaging family discussion.

In Vignette 5 (Figure 9), Anna, who was born in Germany and is now living in Ireland, is visiting the Mountain Farmhouse. She scans a QR code near the entrance to one of the bedrooms in the house. She listens to the memory from the Bean An Tí

FIGURE 9. Vignette 5: "I Would like to Be Upstairs in Bed".

	Anna chose the Bean An Tí as character of interest. On entering the Mountain Farmhouse, she notices the QR marker over the doorway into one of the bedrooms and scans the code.
	The memory from the Bean An Tí is displayed and Anna plays it. She listens to the Bean An Tí reminiscing about making blankets, sheets and clothing for the entire household. While the recording is still playing, Anna walks around and moves closer to the bedroom where blankets and sheets similar to those the Bean An Tí is talking about are displayed.
	Anna then records her own comment: *"Its very cold in here I would like to be upstairs in bed"* She saves the comment and then proceeds with her visit.

and then examines the bedroom space whilst listening to the memory so as to find relationships between the narrative in the recording and the space itself.

Here we can see how the character memory highlighted an aspect of the site that otherwise might not have been apparent to visitors. We see Anna scanning the code and then moving into the center of the house as she listens; however, she quickly moves back toward the bedroom searching for what is mentioned in the memory – the handcrafted linens. However, her comment illustrates that she did not simply listen to the audio content. Even without prior personal knowledge of such a space (Anna grew up in Germany and confirmed in the post-visit interview that she had not seen a farmhouse such as this in the past), she developed some personal relationship with the space, imagining herself "upstairs in bed."

In this example, Reminisce functioned more as a light guidance system to point out interesting details of the house to the visitor. Nonetheless, the place evoked a personal reaction from Anna, who saw the house not just as a museum display but as a domestic environment where she could imagine herself.

Visitors created their own content relating to what they encountered. This content varied from reflections on what they found at the sites to reminiscing on their own life experiences, and shows how visitors saw, reacted to, and engaged with places. Visitors contributed many rich recordings of them reminiscing about experiences in their own lives. For example, Vignette 6 (Figure 10) shows the family previously featuring in Vignette 4 at the Mountain Farmhouse. Now in the Shannon Farmhouse, June's granddaughter Emma is looking for memories to collect while June and Patricia are resting on a bench in the kitchen. Emma then comes back with another memory on the phone for them to listen to together, and this leads June to reminisce about the use of christening gowns in her family. As she talks, Emma records what she says.

FIGURE 10. Vignette 6: The Christening Robe.

	Emma collects a memory about using linen tablecloths for special occasions and brings it to June and Patricia for them to listen to. Emma then collects another memory. She comes back and plays it for Mary and June. The memory is about making clothes, blankets and Christening gowns.
	When the memory has finished playing, June tells a story about how her own mother's christening gown was used to christen her children and grandchildren. As June talks, Emma records what she says. Patricia [to June]: *"Can you remember whose Christening robe did we have?"* June: *"It was my mother's Christening [gown] that I was christened in. Yes. I got it and it christened my two sisters and brother. And it went down in the family then and christened all my children. And it christened my grandchildren; it christened Emma here, and Paul (…) And it christened other people who got the loan of it in between times, you know. I don't know how many people it christened"*

We can see in Vignette 6 how the family could relate to the memory about the christening gowns and linens displayed in the farmhouse, and how it provoked reminiscing around their own life experiences. June describes how the linen was used and cared for in her family. Patricia starts to think about her own experiences, and she enquires about the gown she had used for her children. June then gives a very rich description of the history of the christening gown in their family, emphasizing the significance of the story by including references to both Emma and Paul, who are there with them. We can see the significance of the story for Emma as she attentively records it. In this example, the qualities of the place are not only appreciated, but the farmhouse becomes the setting for a significant family moment. This was confirmed in the post-visit interview with the family.

Researcher: "So did you enjoy your day out?"
June: "I did, I think we had a great time. I'm glad we came over now… [To granddaughter] Did you enjoy it, Emma?"
Emma: "Yeah it was good. It reminded me of my primary school in there. [Referring to the schoolhouse]"
June: "Did it"
Researcher: "And what did you think about listening to your Granny's memories?"
Emma: "That was good"
June: "Oh she's sick of listening to me"
Emma: "Granddad is the one. They're taping his memories. Paul is taping his memories at home."

The character memories not just encouraged gathering knowledge about the sites that visitors were situated in, but as visitors could relate to the accounts, they were spurred to share related knowledge from their own lives.

In relation to the previous analytical theme of different configurations of interactions with the assembly, in Vignettes 4 and 6 we see the different roles that the family members take in the use of the artifacts that support the visit, e.g., how Emma acts as the operator of the phone, collecting memories, recording content, and coordinating its use so the members of the family could listen to and record memories. This never really changes throughout the visit; her mother and grandmother seem fine with her handling the device and show no interest in taking over this role. While Emma operates the phone, June and Paul orientate the group's interaction with the map, discussing it and allowing Emma and Patricia to view it. While Emma and Patricia don't interact with the phone during their visit, they are nonetheless engaged in the Reminisce experience, and they are the ones who respond with the most personal comments and contributions. In their example, Reminisce almost functioned as a prompt for intergenerational bonding in the family.

The recording of memories or reflections by visitors was sparked not only by the character's memories present at the site but also by what visitors encountered at the sites themselves. For example, Anna (featured in Figure 9, Vignette 5) was very

enthusiastic when she collected the tangible token for the Mountain Farmhouse, a small piece of fresh turf. She had never come across fresh turf before, and thus recorded a comment about how she would definitely take the souvenir home to show her husband.

We can see how the overall theme of the memory trail adds a layer to the experience of the place – already shaped by artifacts, locations, and activities that were extant before the introduction of the Reminisce prototype. The theme supported and augmented visitor immersion in the Folk Park, and this was demonstrated by the fact that on some occasions visitors felt compelled to record a comment even when not prompted by a character memory. Vignette 7 (Figure 11) shows one such occurrence.

In this case, recording a memory was not associated with the presence of a character's memory marker, but the participants took the opportunity to record their own content all the same, responding to the qualities and atmosphere of the place. They did not need a character memory prompt to do so.

The interactive desk (Figure 12) was a key component of the assembly that needed to be carefully embedded in the schoolhouse in order not to spoil its character and atmosphere. From our observations, participants did not find the desk out of place in such a setting; its qualities seem to integrate well with visitors' explorations in the school. This was reinforced by the fact that the animator impersonating the schoolteacher was asked to be given a collection of tangible tokens that he could use to let all visitors interact with the desk, even those not participating in the evaluation of

FIGURE 11. Vignette 7: John and Elizabeth.

	John and Elizabeth, a married couple from the UK, arrive at the schoolhouse. As they look around one of the classrooms, they immediately start to talk about on how similar the schoolhouse is to the school where they were educated as children. Elizabeth: *"Just like my school days"*
	They then recorded their own reflections on the space and on what school was like for them, even if no memory marker and associated character memory were present at that location to prompt them. Elizabeth [starts recording]: *"This is just like my school days, we had chalkboards even still…"*

FIGURE 12. The Interactive Desk in the Schoolhouse.

Reminisce, as he felt that the desk added an interesting dimension to the building and to his own storytelling. While the interaction with the desk was simply that of playing other visitors' memories using the tangible tokens, the animator used this one component of the assembly to integrate his own activities for visitor engagement.

4.3. Interaction with the Assembly to Sustain Coherence Throughout the Visitor Experience

The Assembly principles emphasize how the components of the assembly should sustain overall coherence during a visit, as well as engagement at specific interaction points. In the case of Bunratty Folk Park, supporting this overall coherence and the making of connections between the narratives that were associated with each building so as to present a fuller story were particularly important, as the Park management are keen for visitors to notice the variety of periods, physical spaces, and themes across the site. The data we collected show that visitors reacted with comments and discussions that reinforced the sense of coherence of the overall experience and were not just reacting to "here and now" opportunities.

The tangible tokens provided an effective resource for visitors in support of coherence, being lightweight souvenirs that could be carried around and that reminded them of the places they had seen and the memories they had listened to and shared. The tokens could be kept as mementos if the participants so wished,

providing them with a reminder of their visit to the Folk Park, which extended the overall activity narrative.

One example of the assembly enabling visitors to connect between different parts of the visit is shown in Vignette 8 (Figure 13). Anna is now at the schoolhouse using the interactive desk.

In Vignette 8, we see that Anna could associate another visitor's memory with what she experienced at that particular site, and thus recognize which building it was related to without checking the token, although she is now at a much later moment

FIGURE 13. Vignette 8: "Is that the Mountain Farmhouse?".

	Anna places one of the tangible tokens she has collected into the basket. A recording is then played of a male visitor's voice: Male voice: *"It reminds me of hop picking in Kent, again hard work but what a lot of fun. Kids from London, kids from Kent we all played together it seemed to last forever six or seven weeks of the summer, lovely"*
	Anna [To the researcher observing her]: *"That's the* [inaudible]*... is that the Mountain Farmhouse?"* The researcher confirms that indeed the recording was made at the Mountain Farmhouse.
	Then Anna, smiling, puts another token into the basket and leans in to listen to the next memory that another visitor left at the Mountain Farmhouse: Female voice: *"I still have my wedding dress my mum made it. And keep it up in a box in the roof of our house. I don't think I'll ever wear it or have ever worn it again but it was such a special thing that she did that for me and she made all the bridesmaid dresses as well, lovely."*

of her visit and has collected several tokens. She listens attentively, both pleased to have made the connection and interested in other visitors' contributions.

We can see how the installation provided a set of encounters as visitors journeyed around the sites (the houses, artifacts, characters' memories, etc.), and these were recollected by the visitors, both in the reflections and comments they recorded and in their discussions with companions. The data show many cases of visitors actively participating in the activity, using what they assembled as a basis to understand what they encountered at the sites, and leaving their own accounts of what they encountered. These cases could be seen through their behavior and verbal comments.

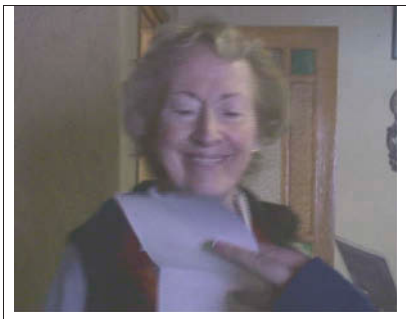
All of the visitors who participated in Reminisce visited every site that the clues led them to, although this was not surprising as the sequence of memory sites was coupled with a portion of the existing recommended trail around the Park. However, although the participants visited all the sites, they did not collect all the digital memories that were available. In some cases, visitors preferred to explore the cottages, listen to a subset of the memories they came across, or none, and when they were satisfied with what they had seen and experienced, they moved on. Based on their continued discussions and conversations about what they were seeing, listening to only a subset of memories did not compromise the overall narrative of the installation. Visitors were still able to comment on what they had seen in relation to the fictional characters, and in making connections between one building and the next. This was particularly evident in the visit by Nuala and James (seen in Vignette 3, Figure 7) as their conversations were mainly concentrated in the transition between buildings due to their choice of using two separate phones. Their discussions were focused on comparing what they had heard about each of their characters and what they could expect at the next site, also, in a way, recounting the coherent story of a character for their companion to hear.

Interestingly, we also saw instances where interactions with the assembly seem to extend the overarching narrative after the visit. In Vignette 9 (Figure 14), June and her family are now at the Golden Vale Farmhouse.

In Vignette 9, we can see that the porter cake recipe included in the tangible token at the Golden Vale Farmhouse provided the family with an opportunity to plan an activity linked to the Folk Park after their visit. Although recipes for porter cake are widely available and Patricia offers to bake the cake, June makes it clear that Emma should take the souvenir home with her and try out the recipe. Their visit then continues on to the schoolhouse. However, a component of the Reminisce assembly has already prompted a possible continuation of the narrative beyond the physical visit.

Guiding visitors to the sites where memories were located for their particular character was a fundamental feature to be supported by the technical assembly because following the character trail reinforced the overall coherence of content and theme. The portal and the tangible tokens were pivotal in this process. The portal provided the visitors with the initial clue to direct them to their first site on the trail. After the initial clue, the tangible tokens placed at the houses provided the

FIGURE 14. Vignette 9: Porter Cake.

	Emma finds the tangible token at the Golden Vale Farmhouse, opens it and finds a recipe for Porter Cake, a typical cake baked traditionally by a Bean An Tí. She shows the recipe to Patricia and June. Emma: *"Porter cake!"* Patricia: *"Porter cake?"* June [to Emma]: *"Ah yeah"* June: *"You should make that now Emma, when you go home"* Patricia [coming closer]: *"I'll make it"* June: *"No let her make it, anybody can make that"…*
	June [giving Emma the recipe]: *"You keep that now and make it, it's really nice and 'tis easy to make"* Emma: *"Ok…We're going to the school next"* The family then moves on to the schoolhouse.

structure to guide visitors and connections between one site and the next. Another significant role of the tangible tokens was to provide the visitor with a record of the sites they visited and to represent these specific sites as a whole narrative during the visitors' interaction with the interactive desk in the schoolhouse. The use of the interactive desk was tightly linked to the tokens, thus providing a sense of coherence between interactions at the houses and interaction at the desk. The latter was based on using elements that they already encountered, and this provided the visitors with a buy-in to the interaction with the desk. The tangible tokens guided the visitors to characters' memories while offering them another point of engagement with the site and a tangible keepsake of Reminisce that they could hold on to. The tangible packs also provided a platform to support interaction across the subsets of the activity and the interactive components of the assembly.

5. DISCUSSION AND CONCLUSIONS

In the previous sections, we have detailed the role of Reminisce in the interweaving of artifacts, spaces, and interpersonal interactions at Bunratty Folk Park. We presented a set of vignettes from the observational data, illustrating how the assembly

mediated a variety of interaction ecologies among visitors, with the site and with the components of the assembly themselves. A second set of vignettes illustrated how Reminisce became part of visitors' place-making, and how the qualities of the place were often highlighted by either the content provided by Reminisce or the presence of its components. Finally, a third set of vignettes showed how Reminisce sustained a coherent overall narrative underpinning the visit, enabling people to make connections between sites, remember interesting interactions, and even possibly connect to a continuation of activities related to their visit after the visit itself. Overall, our findings show that the adapted principles of Assembly guiding our design were indeed realized in an engaging, flexible, and evocative set of visitor experiences that we witnessed during the trial.

5.1. Fluid Reconfigurations of Collocated Interactions

Reflecting on the overall features of Reminisce, we feel that, in comparison to a set of separate standalone installations, the visitors' need or wish to focus on elements of the assembly rather than on features of the Folk Park's display naturally emerged more often, due to the number and frequency of components and the interrelationships among them. However, for the most part, the use of the assembly components was embedded into interactions that equally had to do with experiencing the site. In other words, Reminisce was in our view *more pervasive of the visitor experience than a set of standalone installations* at each of the houses would probably have been, and it was also more tightly woven into the existing features of Bunratty Folk Park. It seemed to get more "in the way" of the visit, but not in a distracting or disruptive way.

Reminisce gave opportunities for *varied, fluid, and easily reconfigured forms of engagement and participation within small groups*. Turn-taking, assignment of roles, and coordination of how and when to make contributions were featured in all the visiting units we documented, albeit taking unique forms and being reconfigured and renegotiated at different paces by each group of visitors. This happened fluidly and without the need to worry about technical glitches or difficulties. Furthermore, the assembly was smoothly extended by visitors with the map. We had already anticipated that visitors would have the map with them as it is given to everyone upon admission to the Folk Park and used extensively as Bunratty is indeed a large site. However, *the map had a much greater link to and role in Reminisce than we had designed for* or expected. Notably, it shaped the sequence of the visit – something that was not prescribed in Reminisce – insofar that all visiting units we documented followed the sequence recommended by the map in exploring the houses. In fact, the map became yet another "portable artifact" to sustain the coherence of the experience, and a resource that helped visitors make sense of the overall activity. It was not a component of the Assembly by our design, but *it became so by practice* and, conversely, *the assembly accommodated it* without negative effects on the overall interaction.

The data do not show that there was a particular site or prompt in Reminisce that visitors tended to respond to more than the others. While individual people did respond to particular themes/locations in different (and often more emotional) ways, based on

their own memories, interests, and personal histories, these were varied; across the visiting units we documented, these standout reactions were evenly distributed across all the Reminisce sites. The prompts and tangible tokens were indeed *designed so that there would not be a specific one to obviously stand out*, and this indeed occurred in practice. Interestingly, as we showed in Vignette 7 (Figure 11), it did sometimes occur that people *reacted to a feature or site without the prompt of the character memory*. This shows how the assembly and its interactional opportunities became situated in the visit, and indeed in the setting.

5.2. Impact on Place Experience and Place-making

In terms of place experience, Bunratty Folk Park is an evocative and engaging setting without any need for technology. People were commenting on how immersive the site is independently of Reminisce. This is something that we gathered evidence of during our early studies of the site, before we developed the design of Reminisce and that we documented in McLoughlin & Ciolfi (2011). However, the Folk Park is also lacking in available information for visitors to make sense of important aspects of the buildings and settings. The visitors' *interpretations of the displays and of the aesthetic and functional character of the place were augmented by Reminisce*. The overall theme for Reminisce – personal memories – made certain aspects (such as the activities that occurred at each house in the past) more prominent in the visit. It supported *identification with certain place qualities* (i.e., how people in the past might have lived and shaped the place) even for people who had no direct experience of memories of that past. For those who did have personal memories, the theme resonated deeply with them, and – as we saw – this led to several instances of poignant visitor-generated personal memories and reactions. In this respect, it was interesting to see *intergenerational and intercultural discussions* between those visitors who had that direct experience and those who did not, such as in Vignettes 4 and 6 (Figures 8 and 10). This happened not only among collocated visitors, but also by means of recordings left by previous visitors (as we saw in Vignette 8, Figure 13).

Regarding the revised Assembly principle of allowing for participative opportunities in the interaction with the system, in Reminisce we saw that the assembling of content, activities, and interactions provided visitors *ample opportunity for agency in place*. Although the fictional characters (and their content) were the link, by being able to *make their own contributions*, visitors also had the ability to include the content they had generated as part of sense-making about the place. Their own contributions, and the act of recording them in the actual settings also meant that place experience for other visitors, such as companions or bystanders, was also enriched. Recording own content was not something that visitors were obliged to do, and in introducing Reminisce to participants, we were careful in saying that this was something that they could do if they so wished. This was aimed at not making people who might be shy or self-conscious about recording their own voice feel excluded from the experience. As we mentioned at the beginning of Section 4, the vast majority of the visitors we observed did record content, with only three exceptions. However, even the people who, for various

reasons, did not record any content were observed to react to and discuss the characters memories animatedly with companions and animators. No member of the three visiting units who did not record content mentioned or questioned their choice once they arrived at the schoolhouse to listen to other visitors' memories, nor did they do so in the post-visit interviews. In our view, rather than feeling that their experience was diminished by this, they were *glad to have used Reminisce on their own terms*. An open question remains regarding whether the assembly could provide more than one way for visitors to provide a contribution so as to suit a wider range of people.

Overall *coherence was also maintained throughout*: people were linking different locations, making comments at one location about what they saw earlier and continuing discussion in between buildings. Although this happens to a certain extent at the Folk Park without Reminisce, it was clear from the data that the overall narrative provided stronger scaffolding for this to occur, e.g., comparing the observational data of visitors using Reminisce with the observational data of visitors we had collected earlier in our project, and before the installation was introduced into the Folk Park.

5.3. Reflections on the Limitations of the Study

Naturally, our empirical study has some limitations and we already mentioned a few earlier in this paper. In addition, we did not study the experience at different times of the year and under different environmental conditions (such as natural light, weather, and different degrees of crowdedness), nor did we have the opportunity to modify aspects of the installation and evaluate it a second time (e.g., embedding the playback of visitor memories in subtle ways at more than one site). Furthermore, the presence of the researchers shadowing the participants (as we were not allowed to place stationary unmanned cameras inside the buildings) could have had an effect on how they interacted around the installation.

5.4. Concluding Remarks

Despite these limitations, which we could not have overcome in the frame of the project, we argue that with our project we have demonstrated how by extending the Assembly framework through refining its core principles and introducing a consideration for visitors' emplaced experiences of heritage, installations such as Reminisce can benefit institutions such as Bunratty Folk Park. Our findings show how structuring design practice around the four extended Assembly design concerns led (conceptually) to an overall interactional narrative that promoted sense-making and (technically) to the development of interactive components that became part of emplaced interactions around exhibits. The examples of participant interaction we have illustrated throughout Section 4 show an array of interactions featuring *personal reflections, thoughtful and/or emotional responses, fun and playfulness, and identification with the site and its character*.

In our view, the usefulness of appropriating and adapting the Assembly framework was in re-elaborating principles to orient design but leave freedom

to adapt to the exhibition site and its qualities. The Assembly principles applied to Reminisce offered us subtle yet salient points to reflect on as our design process evolved, and as we studied visitor interactions with the system on site. The concern for place-making and place experience, which we have introduced in the revised Assembly principles, was significant in informing our reflection and our empirical study, particularly in light of the setting – an open-air museum where visitors can immerse themselves. HCI work at cultural heritage sites has been often critiqued for separating the point of interaction from the holdings on display (Dudley, 2010; Giaccardi, 2011; Petrelli et al., 2016). Deploying designs based on Assembly can help overcome this, as the opportunities for interaction provided to visitors link to multiple features of a heritage site and via a variety of components that can in turn resonate with tangible and material qualities of a heritage site. We argue that this is as valuable a way to overcome the separation between physical and digital in cultural heritage technologies as the proposal of using specific types of technology (such as tangibles) instead of others.

In conclusion, this paper presented a study of visitor interactions at an open-air heritage site mediated by a physical-digital assembly called Reminisce. We aimed to make a twofold contribution to HCI research for the cultural heritage domain: firstly, to present empirical evidence of how visitor interactions occur with and around physical/digital assemblies, and secondly, through the empirical findings we presented in the previous sections and their discussion, to revisit the concept and framework of Assembly to guide other designs of interactive installations at heritage sites. We extended the Assembly framework to include place-specific design concerns, as technology is increasingly distributed and embedded across spaces, bodies, and artifacts, and physical/digital design requires greater attention to the material and embodied qualities of the environment, as previous research has suggested (Bødker & Browning, 2013; Dourish, 2001; Gottlieb, 2008; Messeter, 2009). This is particularly relevant for heritage settings. Furthermore, we believe that the Assembly framework is more generally relevant to current HCI research due to the proliferation of artifact ecologies and multi-device ecologies in socio-technical systems. We saw how the interactions that the visitors performed with Reminisce and with their companions were shaped by the overall activity narrative, associated content, the location where it was encountered, and the tangible components of the installation itself – therefore emerging from all entirety of the Assembly framework. Therefore, although this work is based on a prototypical installation that was evaluated for a short period of time, we feel that our findings and reflections make for a valuable contribution to HCI in the cultural heritage domain.

NOTES

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