

Volvelles, Domes and Wristbands: Embedding Digital Fabrication within a Visitor's Trajectory of Engagement

Bettina Nissen¹, John Bowers¹, Peter Wright¹, Jonathan Hook¹, Christopher Newell²

¹Culture Lab

Newcastle University, UK

²School of Arts and New Media

University of Hull, UK

{b.s.nissen; john.bowers; p.c.wright; jonathan.hook}@ncl.ac.uk, c.newell@hull.ac.uk

ABSTRACT

We present the findings of an empirical design study exploring how situating digital fabrication within a souvenir-making activity can enrich an audience's encounter with cultural events and engage visitors in discussion and reflection upon their experiences. During an incremental accumulative design process, in collaboration with an arts organisation, we developed a series of fabrication activities that offered visitors the opportunity to create their own personalised souvenirs based on their experience of a cultural event. By analyzing visitors' trajectories of engagement with the event we explore three key findings: activity embedded digital fabrication engages new audiences, encourages conversation and reflection, and presents organisations with new and more playful ways to gain insights into audience experiences.

Author Keywords

Digital Fabrication; Souvenirs; Visitor Experience; Cultural Organisation; Trajectory; Research Through Design

ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous

INTRODUCTION

In recent years, HCI has deepened its interest in cultural and artistic settings such as museums, galleries, exhibition spaces, visitor centers and heritage sites. A variety of work has explored how digital technologies can be embedded into cultural experiences. This has included innovative designs for interactive museum installations and exhibits [3, 7, 16, 13, 24], visitor engagement and participation [4, 28], shared visitor experiences [17] and events that combine live action with digital media [1]. Research has also investigated how a set of related devices and performed activities might be 'assembled' into a coherent experience [3] in which

visitors establish a 'trajectory of interaction' through various 'hybrid structures' marked by key 'transitions' [2].

This paper is concerned with how we might support reflection, evaluation and discussion of a cultural experience, and how a sense of 'the visit' might be extended beyond a visitor's departure from the site. We wish to look at enhancing 'ending-transitions' [2] to support people considering *retrospectively* what they have experienced and anticipating *prospectively* the relevance of the visit to their future. Our research explores digital fabrication's potential for personalisation and materialisation to extend people's participation in reflection and meaning making. In so doing, we respond to "a need to enable subsequent reflection and discussion through the use of souvenirs and replay interfaces" [2, p.714].

Existing research examining the use of souvenirs shows not only the importance of the artefacts themselves but also their emotional and reflective characteristics in relation to a person's experience of a cultural event or site. Souvenirs and related artefacts are sold in most cultural spaces and play an important part in people's lives as representations of their experiences and, subsequently, as ornamentations of their domestic environments. For example, Durrant et al. [6] have found that "souvenir-making activities [...] became integral to the visitor's experience." Such activities create a specific opportunity for visitors to reflect upon their experiences of a site through the active process of making a personal souvenir, in Durrant et al.'s case, through the use of digital photography.

However, souvenirs are commonly critiqued as mass-produced kitsch or as trivializing the historical or cultural importance of a site. For example, the activist and performer, Crab Man [5], suggests in *Counter Tourism: The Handbook*, various 'guerrilla' activities for the creative misuse of souvenirs or for surreptitiously planting alternatives of one's own construction in a heritage site's gift shop. This ambivalence to souvenirs can be elucidated by drawing on studies of material culture in anthropology and related fields. Ingold [14] for example distinguishes between the different ways we can relate to an artefact depending on our participation in its making, the extent to which we have an affective relationship to its constituent materials and whether we feel we partake in the 'lifecycle' of the artefact, or experience it as an alien object. The more the souvenir is a standardized artefact of mass-production,

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for components of this work owned by others than the author(s) must be honored. Abstracting with credit is permitted. To copy otherwise, to republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee. Request permissions from permissions@acm.org.

DIS 2014, June 21–25, 2014, Vancouver, BC, Canada. Copyright is held by the owner/author(s). Publication rights licensed to ACM. ACM 978-1-4503-2902-6/14/06...\$15.00.

<http://dx.doi.org/10.1145/2598510.2598524>

presenting us with pre-fabricated meanings and generic associations, comprised of materials we have little sensuous engagement or emotional resonance with, the more it is an alien object. In these terms, Durrant et al.'s [6] exploration of personalised digital photography goes some way to creating a souvenir as a living thing we can intimately relate to. The photograph is annotated, linked to a specific experience, and, in part, made by the person themselves – a rather different kind of souvenir from the mockeries and simulacra critiqued by Crab Man [4].

Research has also begun to explore digital fabrication in cultural contexts such as museums, through interactive Fab Labs [25] and more technically to enable the creation of replicas of craft artefacts [27]. Within HCI, digital fabrication is of considerable emerging interest, in particular in regards to DIY maker culture [18, 29], personal fabrication [12, 19, 21] and innovative interactive uses of the technology in their own right [22, 31]. With few exceptions (such as Ogawa et al.'s [23] exploration of the value of fabrication for social interaction and communication), most research projects focus on technological advancement and educational merits rather than considering how this technology can be embedded into shared activities in order to engage audiences in wider contexts and innovative ways.

We wish to open out the research topic of how digital fabrication technologies, appropriately deployed, can enable new kinds of participation in the material creation of artefacts and extend the significance of a visit through materializing a visitor's cultural experience as a souvenir. In this paper, we describe our incremental design process to develop engaging activities for visitors as well as our findings based on evaluating visitors' trajectories. We found that a personalised souvenir making activity using real-time digital fabrication can engage new audiences, encourage reflection on one's experience and add an element of playfulness to the otherwise dry process of audience evaluation. We conclude by discussing the implications of our work as an initial exploration of the value in situating digital fabrication in shared activities within the trajectory of a visit – and through this to encourage participation, reflection and meaning making.

THE CONTEXT

Collaboration with a local arts organisation offered a specific and challenging context in which to explore how digital fabrication could be used to understand, extend and enhance the audience experience. ISIS Arts [33] is a visual and media arts organisation, whose main goal is to engage new audiences with contemporary media art and facilitate vivid exchanges between artists and their audiences. With this focus, the organisation acquired an inflatable structure called the 'Big M' (Figure 1), which is used as a 'pop-up' exhibition space that can be located in places where art would not normally be exhibited. For this project, the Big M was home to a curated video art show for 2 days in 6

locations over a period of 5 months. The show called *On The Precipice* showed the work of seven international artists in an immersive 3-screen installation inside the dark space (Figure 1). The one-hour long programme exploring "our relationship with contemporary landscape and the effect humans have had on the natural environment." [33] was complemented by the mysterious atmosphere of the space with its subtle movements in the wind and the continuous hissing noise of air being pumped through the structure. Visitors could freely enter, leave and re-enter the space at any point and except for a brief introduction upon entering were not further guided. With little pre-described behaviour visitors were free to engage with the artwork and the space in their own way.



Figure 1 (a) The Big M – pop-up art exhibition (b) Visitors and video installation inside the Big M

Through initial conversations and informal interviews with the arts organisation, the curator and an artist, we gathered an initial understanding of the organisation's and artist's intentions and aims of the show. Three main points that emerged from these initial conversations and observations fed into our research. Firstly the need to find ways to *engage* new audiences, secondly to *inspire* audiences to *reflect* on issues raised by the exhibition, and thirdly to gain insights into the audience *experience*.

The organisation's interest in engaging new audiences, evaluating audience experience and extending the visitor's engagement with the show beyond the duration of the visit led us to explore digital fabrication as a participatory souvenir-making activity. In order not to interrupt or disturb the artists' work and the visitor experience inside the Big M we situated our activity at the exit where the visitor transitions out of the experience, which according to Benford et al. [2] is also a "key moment" in the experience trajectory. Building on Benford et al.'s interactional trajectories, Fosh et al. identify 5 stages [8] further analyzing experience trajectories into approach, engage, experience, disengage and reflect. In these terms, we planned the souvenir making activity at the ending transition as visitors disengage with the show. The fabrication process was intended to enable active engagement with the reflection process. And by positioning the activity at the exit, we envisioned the original trajectory of the visit to incorporate stages of reflection within an extended trajectory of engagement as shown in Figure 2.

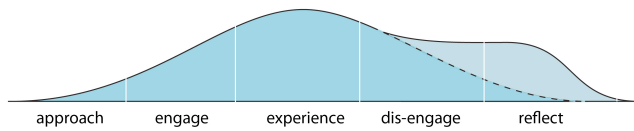


Figure 2: Canonical experience trajectory with an envisioned extension of the reflection phase (following Fosh et al. [8])

THE DESIGN PROCESS

The Big M's 5 scheduled events allowed us to take an exploratory and incremental approach to the design process, in which data gathered at one event would inform the design for the next with each field trial building on some element of the previous one. Our design-led enquiry was hence carried out in two phases with two events as initial inquiries and three events for design deployments. Through these two phases we explored the experience and expectations of both visitors and organisations and designed activities in response. Throughout this process, the observations and reflections of the researcher as both creative practitioner and designer [26] were used to direct and evaluate subsequent activities and artefacts.

Inquiry Phase

With the intention to explore personalised, generated souvenirs the first challenge was to design an activity that would encourage members of the audience to provide us with their impressions and experiences of the exhibition in a way that was accessible, meaningful and engaging. Within contemporary museum culture, visitors have become accustomed to the idea of an audience survey giving the organisation feedback about their visit. With this in mind, a form of questionnaire seemed to offer the possibility of an accessible method to gather data although we purposefully refrained from focusing on an objective form of qualitative feedback. Consequently we sought to design a more playful version of the exit survey, offering audiences the opportunity to respond in creative and surprising ways. The questions in our first questionnaire deployment were generally abstract, open-ended and required free text responses, such as:

- How would you describe your experience?
- How far are we from the precipice?
- What would a precipice souvenir look like for you?

This survey approach was simple but with its abstract questions had nevertheless elements of the creative and ludic characteristics of Cultural Probes [9], which seek to provoke discussion, conversation and reflection rather than purely collect data.

The responses to this initial questionnaire then informed the second iteration that had more of a quantitative, parametric nature using Likert-scales and multiple-choice items. This allowed us to compare the visitors' interactions as well as gather a 'critical mass' of quantitative information that could be incorporated into a shape-generating algorithm.

From the variety of gathered information, a selection of specific questions was made primarily based on relevance, probing characteristics and potential use as design parameters. The adjectives visitors used to describe their experience in the initial survey seemed to be the most meaningful way to gather a better understanding of the audience's experience. So a selection of frequently used words was complemented with a set of more challenging and thought-provoking ones. In addition we felt that the more conceptual question relating to the topic of the show (How far are we from the precipice?) was key to encourage conversation and reflection.

Design Considerations

In addition to the questionnaires, an important starting point for the development of our fabrication activity was the idea that the fabricated artefacts were not so much representations of a visitor's experience. Rather, the focus was on the souvenir making process as an occasion to engender reflection and conversation about one's experience. It is through being co-created by the visitor as part of the visit that the souvenir comes to have its meaning and significance. With this in mind, we had to consider technological fabrication constraints, such as duration, accessibility and transportability, and compare different digital fabrication technologies, such as 3D printers, laser cutters, cutter plotters or CNC milling machines. With each technology having its own set of guidelines and constraints, this decision played an important role for the development of design concepts and had to be made early on. We specified immediacy, speed and accessibility as the most important characteristics of the technology in order to engage visitors in the relatively short transition phase. We choose a mobile, desktop cutter plotter [34], which cuts shapes from pre-printed cards allowing a fairly immediate result so that souvenirs could be fabricated on site. Based on this decision, we established loose design guidelines focusing on 2-dimensional shapes, which could be cut, layered, folded and assembled into 3-dimensional shapes.

Deployment Phase

In all three design deployments, the visitors were shown the artefact upon leaving the Big M and were told they could create their own personalised souvenir by digitally responding to a survey that was shown to them by the researcher. The generated shapes were then individually fabricated by cutting them out of pre-printed materials. We developed three different designs with each exploring different elements of the interaction, fabrication limitations and the aesthetics of the souvenir. All three of them shared the combination of individual opinion and collective average to challenge perspectives and spark conversation. Each component of the design was annotated with the relevant words of the interface so that the layers could be easily aligned and explored.



Figure 3: (a) The workstation located next to the exit (b) The setup of computer, interface, cutter and materials

The interface of the interactive questionnaire and the live shape generating algorithm was custom built using the programming language *Processing* [35]. It included a set of sliders that allowed visitors to ‘evaluate’ their experience of 12 chosen words on a scale from 0 to 3. Each slider was linked to one point in the generative shape of the design. The Likert-scale slider for the conceptual *On The Precipice* question caused the shape to either pucker or bloat to give an immediate visual indication of either a more pessimistic or optimistic perspective – inspired by Gestalt Psychologist Wolfgang Köhler’s experiment [15] mapping people’s perception of the imagined words *Takete* and *Maluma* (Fig. 4(a)) to visual shapes. By extending this phenomenon to a relationship between shape and feeling, we related the replies in the first questionnaire to precipice souvenirs as being bumpy, rocky, crisp or sharp.

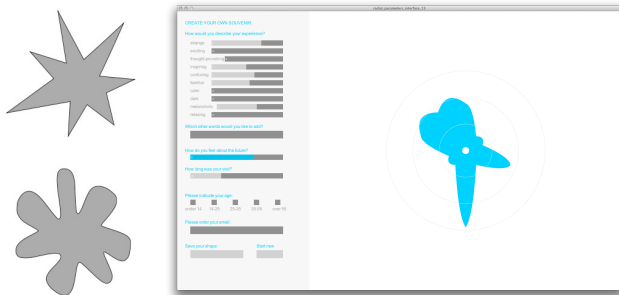


Figure 4: (a) Takete-Maluma Phenomenon (b) The initial generative souvenir interface

Once the shape was generated, additional data was then entered by the participant (age, duration of stay and email address) both for analysis purposes as well as audience information for the arts organisation.

First Design: Experience Volvelles

Ultimately our first fabrication activity took inspiration from historical Volvelle shapes, a type of wheel chart with rotating components that has been used for a vast variety of applications and data visualisation. The Volvelle form was chosen as a simple, interactive design that would allow for an easy assembly of the personal and collective layers whilst also being easily understood by the participant as a way to situate their opinion in the context of other’s views.

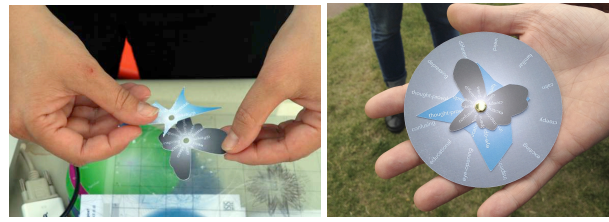


Figure 5: (a) Assembling the Volvelle (b) Example Volvelle showing the average (grey) and personal (blue) shapes

A couple of issues arose during this initial design deployment, the main concern being the level of abstraction in its form showing no visual relation to either the Big M nor the exhibition itself. Also, the interactive element of the Volvelle didn’t offer any additional benefits to the shape itself than a fixed version. Another emerging point was that the object itself had little use, though its potential as a wearable souvenir was discussed.

Second Design: Experience Domes

For the second iteration we took into account two concerns, a) the visual coherence between souvenir and experience and b) testing out a combination of pre-fabricated with live fabricated elements. This led us to devise both the interface and shape of the souvenir to show a stronger visual connection to the Big M and the artwork it contained. To the two generated shapes of individual and collective opinion, another layer with representations of the artwork was added into a mini version of the Big M combined under a transparent plastic dome-like structure, slightly resembling a snow globe (Fig. 6). Our intention of these added layers was to a) draw a stronger connection between experience and souvenir, and b) give the shape a more 3-dimensional character, which would be more strongly evocative of familiar souvenirs than the 2-dimensional Volvelles. This fairly simple acetate cover added a certain value to the otherwise only paper-cut shapes, which made it more of a finished artefact in comparison to the previous flat design. The intention of this assembled souvenir was to give the visitor a souvenir with potential longevity that would be kept rather than being quickly forgotten about.

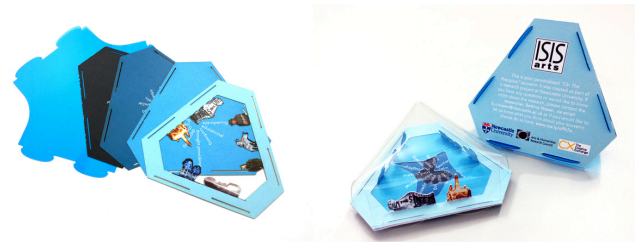


Figure 6: (a) Pre-fabricated components (b) assembled Dome

The interface underwent minor changes for creating this new shape and to allow visitors to identify the films they have seen so that small silhouette representations could be incorporated into the Domes. Either the researcher or the participant themselves did the assembly but it was noticeable that with this more complex shape, the assembly

took slightly longer and seemed less accessible to the participants compared to the simpler Volvelles.

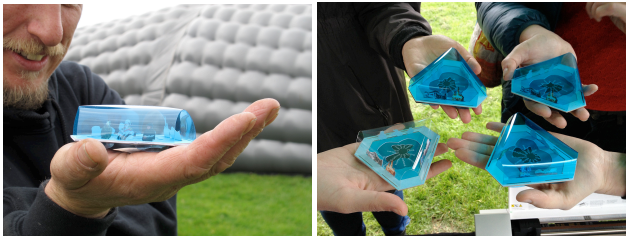


Figure 7: Participants with their Domes



Figure 8: (a) Participant creating a wristband and (b) several participant's wristbands

Third Design: Experience Wristbands

For the last event, several school groups were scheduled to visit. To maximize participation in souvenir making, we sought an alternative to the more time consuming Domes. This third design, a wristband or bracelet, could be fabricated quicker and also allowed the participant to wear their unique shape afterwards – a possibility which emerged through reflecting on our first deployment. A wristband also seemed fitting for the younger age group. The more straightforward design only showed the basics of the individuals' responses on one side of the shape and the collective on the opposite side without the need for assembly. Additionally the participant was able to choose from images of the artwork to select their favorite. This design also allowed the interface to integrate the interactive elements of sliders into the actual form that was then generated, see Fig. 8 (a).

FINDINGS

Over the course of the deployments 120 visitors participated in creating souvenirs and 280 visitors filled out initial questionnaires. Participants ranged from under 14 to over 50 years of age. The majority of participants were passing visitors who were unaware of the organisation and artwork. Throughout the deployments, observations were recorded in the form of field notes alongside photographic, video and audio documentation. This data was analysed to,

in particular, focus on the different kinds of trajectory that characterised a visit and how our souvenir making activity related to that. In outline, we observed three different kinds of trajectory that visitors followed, which we depict in Figure 9 in terms derived from Fosh et al. [8]. We will now unpack these results in more detail.

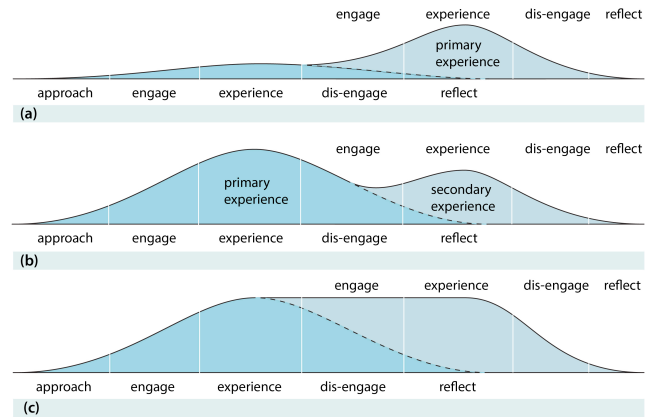


Figure 9: Participants trajectories (a) An experience in its own right, (b) Prompting reflection and discussion, (c) Extension of the experience

(a) An Experience in its Own Right

In many cases, visitors approached the Big M out of curiosity, with the intent of looking inside the inflatable space. Sometimes this led visitors to quickly pass through the space in a few minutes without engaging with the artwork or its content in much depth. Some of these visitors were however intrigued to create their personal souvenir.

For example, one girl and her family waited for 15 minutes so she could make her souvenir although she only saw a few minutes of the show. Another participant who was working in the nearby museum really liked the object and wanted to make a Dome for her nephew as a gift. It was interesting to witness people wanting to make a souvenir without necessarily relating it to the experience.

In another case, three boys walked in and out of the show fairly quickly and were not interested in leaving feedback but were instantly excited and curious when they saw the souvenir that they could generate by answering the questionnaire. They were also intrigued by the fabrication technology, which was highlighted by their comments: “Wow, that’s so cool. I have never seen anything like it” and wanted to know more about how it works. They went on to make a souvenir together whilst engaging in conversation with the researcher and each other. This shows how an interest in the object and curiosity about the technology engaged them in the process of reflection. This was demonstrated by a number of participants, often a younger audience, who were very keen to know more about digital fabrication, materials and how it worked. This indicates a more active engagement in the souvenir making activity than the artwork itself and highlights that the

novelty of this technology added value to the engagement that can be explored further.

We found that for some visitors the souvenir making activity became in fact an experience in its own right rather than a secondary process. One could argue that the engagement and experience of the show was minimal whereas the souvenir making activity became the primary experience thus allowing the visitor to still engage with the topic of environmental issues, see Fig. 9(a). This seemed especially the case with younger people, whom the artwork didn't speak to, but who could, via the appeal of the technologies we were using, still find themselves reflecting on the topics of the show.

(b) Reflection on Experience

Some visitors engaged with the show more than described above but were confused by the artwork or didn't understand it. Upon leaving the space, the visitors were still interested in learning more about the show and were keen to engage in an additional conversation and activity to gain a better understanding.

Quite often visitors would leave the Big M asking "What does it mean?" and the souvenir making activity at the exit allowed the visitor to engage in a conversation with the researcher about their thoughts on the subject and artwork. Through the questions that were asked in the digital generative interface the visitors were challenged to think about and reflect upon their experience and the artwork.

By engaging with the reflective process of thinking about their opinions or feelings concerning the show, the visitors were given the opportunity to enter in a conversation with each other as well as the researcher. This allowed visitors to ask questions about the artwork in order to make sense of their experience. In several instances visitors were asking the researcher about the artwork and its meaning whilst thinking about how they felt about the work. One particular family (grandmother, mother and daughter) were creating a shape together and discussing what they thought whilst asking the researcher what the meaning of one of the films was because the mother didn't feel she understood it but "It really made me think." Once the researcher initiated a conversation, they engaged in a deep discussion about the work and what they thought amongst themselves while answering the questions to make a shared souvenir together.

In other instances where individuals of a group all made souvenirs, the tangible object and the ability to compare shapes amongst each other started conversations about the shapes, what their significance is and if there can be right or wrong opinions. Upon explaining the souvenir, the average and individual opinion shapes, one teenager inspected the difference quite intently and commented "I got it wrong then", which led her to discuss her thoughts and why she made the word choices. Eventually she noted that when using the digital interface she "wasn't really paying attention with the sliders" and didn't think about it in too

much detail but holding the finished shape in her hand changed her opinion.

This conversation not only shows how the social comparison between individual and collective challenges participants to reflect on their thoughts but it also highlights that the tangible nature of the souvenir can add a level for reflective exploration the digital interface alone does not.

Another participant who was very interested in the show and its topic was critically examining his souvenir and discussing its legibility and the importance of annotation to understand it. In his case the personal shape differed strongly from the average (Fig. 5(b)), which triggered a conversation and critical thought-process: "Wow, I guess I have a very different view than everybody else."

One woman with two young boys was very keen on making a souvenir because she found the work interesting but couldn't stay long because of her restless children. But she was very engaged in the process of making the object and the topic of the show while explaining to her family that she was making her own shape from her experience: "What's to say a feeling isn't a shape? Something really tangible that you can touch."

Two teenagers who were interested in the show were not very keen to leave feedback and were beginning to walk away. But on showing them the object that they could create, they got engaged and started opening up a conversation about the show and their thoughts. In addition they also started to compare this activity with other feedback forms and noted that "It's much better than a piece of paper. More fun. And you get something for it [your opinion]." It seems that giving feedback is often seen as providing information to the organisation for little benefit to the visitors themselves. We found that by engaging the visitor more playfully in this process, they saw value in it for themselves and not purely for the organisation, hence diverting the attention back to their own experience and opinion.

By re-engaging the visitor in discussion around the concept and meaning of the show, we slowed down the 'ending transition' by incorporating elements of the reflection phase into the souvenir making activity, see Fig. 9(b). Normally the primary experience would take a fairly abrupt ending when stepping out of the space, leaving the visitor to reflect on their experience by themselves. By extending the transition phase through souvenir making we gave visitors a starting point for reflection beyond their visit.

(c) Extension of the Experience

In those instances where the visitors were more interested in the artworks the possibility of creating a souvenir was seen as a way of creating a reminder of their visit. In three specific instances, the participants talked about the meaning of the show and how relevant it is today. In particular, one participant felt rather strongly about a particular film in the

show and talked about “How we never think about the things we can’t see and what their impact on the environment is.” He was excited when he found out that he could make a personalised souvenir: “That would be a nice memento.” In these instances, our making process played an important role in extending the primary experience with value often being attributed to the tangible object as well.

In another case, we asked a couple of teenagers who were very excited and interested in the souvenirs and our process to make a small follow-up video featuring what they had made so as to get an insight into what they thought of the artefacts and the making process. The teenagers used the souvenirs as props in the video while focusing their conversation on their personal experience of the artwork. “I found it quite personal because people are changing the environment and killing off animals.”

This shows that the souvenirs can have a certain relevance as triggers of an experience or emotional reaction. Because of the considerable challenges of research ‘in the wild’ what we know of the fate of our artefacts in the future lives of the people we encountered is limited. Nevertheless in one instance, a participant responded in saying that he kept his souvenir for a few months as a reminder of the artwork but also of “how my impressions of the films varied from the norm or consensus of views that were collected.” This shows that the fabricated object has potential to become a lasting souvenir and point of reflection beyond the event and, as one of the participants said, “I really like the idea of people taking part of their experience with them.” With limited data in this study, the potential longevity of our souvenirs will need more in depth exploration. This is beyond the scope of the current paper but is the subject of current work by our team.

In terms of this participant’s trajectory, we would like to highlight that, although the participant spatially disengaged with the artworks, they stayed concerned with the topic of the show so that the souvenir making activity became an extension of their visit, see Fig. 9(c).

DISCUSSION

We have described how we created an activity in which visitors to an art exhibition could digitally fabricate a souvenir of their visit, which expressed their experience of the show and the issues it raises. We described the design of three artefacts (Volvelles, Domes and Wristbands) which vary in their complexity of conception and production but which all allow an individual’s experience to be compared, in some respects, with others. We have seen how these artefacts can engender reflection and discussion. We have discussed three different ways in which digitally fabricating a souvenir could be incorporated into the trajectory of the visit depending on people’s relative interest in and engagement with the show and the fabrication process. Drawing on these, we synthesise and analyse some

common themes that emerged and reflect on the challenges and design implications for related research in HCI.

Extended Sense of Visit

As discussed above, we have shown that the fabrication activity extended and enriched the visitor experience to various degrees. If it was merged with the overall experience or became an experience in itself, the souvenir making activity added value to the overall visitor experience in most cases. By encouraging visitors to take an active role in reflection and through the ‘reward’ of the souvenir, participants seemed to be more personally involved, more willing to express opinions, and to care for an object they created themselves.

Engendering Curiosity

For Gaver et al., “systems [...] should provide resources for people to appropriate, rather than content for consumption” [11, p.888] in order to promote curiosity and reflection. Not only did the novelty aspect of fabrication evoke initial curiosity, the interactive personalisation and fabrication activity can be seen as a process of appropriation that engaged audiences in reflection. Similar to the visitors’ approach to the Big M itself being often driven by curiosity, participation in souvenir making was equally driven by curiosity about the process, the technology and the forms we had designed. This became particularly clear in the second trajectory identified above with the fabrication activity becoming the primary experience of the visit. As mentioned before, this seemed to be the case for younger visitors in particular, supporting the engagement of a new audience that would have otherwise engaged little with the concept of the show.

Occasion for Reflection

Curiosity in the objects, the making process and the technology created a moment to slow visitors down and subsequently give them the opportunity to engage in reflection and discussion with each other as well as with the researcher on their own opinion of the artwork and the challenging topic of the show. By creating a souvenir we initiated a discussion which might have not taken place without the shared activity, or didn’t when filling out individual questionnaires. Additionally, by combining the individual’s opinion with the collective average, we encouraged participants to think about their opinion beyond themselves and, to various degrees of success, actively engage in reflection on different viewpoints.

Reflections on the artwork differed, depending on the kind and depth of the visitors’ primary engagement with the show. For instance, in the first trajectory above, where the souvenir making activity became the primary experience, visitors were less focused on the artwork itself but still discussed the overall environmental topic of the show.

Playful Evaluation

Besides the visitors' evaluations, we also received varied positive comments and interest from the collaborating partners, as well as other arts organisations and artists, who felt quite strongly about using playful processes for engagement and evaluation. One participating artist suggested that every art organisation should use design objects for playfully engaging visitors with the evaluation of their exhibitions to encourage more meaningful evaluation rather than just collecting visitor metrics.

The Tangible Benefits

Although the novelty of the technology often played an important role interesting visitors in participating, the tangible souvenir was equally essential to this process. Frequently, visitors only participated when they were shown the souvenir and what they could make, often openly revealing their interest or disinterest in the object. By testing three different designs we could get a better comparative understanding of visitors' responses. This showed that the appeal of an object was vital. One of the organisers, who made several souvenirs, pointed out that the Dome seems to be "much more of a souvenir of the Big M, almost precious" compared to the much simpler and more abstract Volvelles. In the last event we gave visitors a choice between two designs, a dome and a wristband, and this showed that allowing for different aesthetic options could encourage a broader spectrum of visitor engagement.

We have already explored the souvenir making activity as a valuable prompt for discussion but want to also highlight the interaction of the participant with the souvenirs themselves. The artefacts as personalised, tangible souvenirs were observed being used by visitors as props to engage in comparisons and conversations in a playful way. In particular with the Volvelles, people in small groups were comparing their shapes and asking each other "What does yours look like?" or making comments on each other's shapes: "Your shape looks wrong." This allowed for further dialogue about the value of different opinions. Accordingly, the created souvenirs and making activity could be referred to as a "Social Object" in the sense of Simon [28] – as objects or processes that encourage shared conversations and interpersonal interactions through the means of a prop rather than directly engaging in conversation with another person. This shows the supplementary layer that tangible objects can add to our understanding, and emphasises McCullough's point [20]: "Hands feel. They probe. They practice. They give us sense."

Fabricating Meaning

Whilst digital photography has often been used for personalisation and capturing visitor experiences [6, 30], digital fabrication has not yet been explored for its value in meaning making. As Ingold [14] argues, involvement in the making of an artefact gives a person more stake in it and therefore a deeper connection than with mass-produced

objects. He refers to making not only as the crafting process by one's own hands but extends this view to any form of creation. "I want to think of making, instead, as a process of growth." [14, p.21] From this perspective, a souvenir is a very different thing if one participates in its creation and the use and meaning-making that it is part of. Through partaking in its formation we bring ourselves into what Ingold would call "an affective and sensuous relationship" with its materials and the artefact itself. By allowing visitors to create a shape from their personal experience we gave them the opportunity to think about the show and what it means to them. We believe that we have shown the potential digital fabrication holds in encouraging deeper engagement and reflection through the making of souvenirs. But we are aware that further studies are necessary to substantiate the meaningfulness of this engagement and the created souvenirs. In particular, it is relevant to consider not only the participant's role but also the designer's in the process of meaning making, as Wright and McCarthy [32, p.11] wrote "how an individual makes sense of a situation, interaction, episode or artefact is as much about what the individual brings to the experience as it is about what the designer puts there."

Facilitation by the Researcher

Although the novelty of technology and the souvenirs played a vital role in visitor's engagement, the active role of the researcher or member of staff who facilitated the activity needs to be touched on as well. The active participation of the researcher was necessary for drawing people to the fabrication activity as well as for explaining the process and guiding people through it. The researcher was also often a conversation partner in discussing the show and the works in it. To what extent the researcher's influence may be essential in the engagement with such processes and reflection itself is a topic that goes beyond the scope of this study. Naturally, this would be an important issue to explore if one were concerned to design more autonomous systems. However, we feel it is potentially a more interesting research path to think of artefacts and fabrication technologies as embedded in activities, which are acknowledged to involve the co-participation of the public and facilitators from the start. From that point of view, it is not a weakness of our work that it needs facilitation by a skilled individual.

Activity-Embedded Fabrication

Indeed, our research opens out the possibility that we can think of *digital fabrication as a process embedded within a live social activity* – in particular, an activity which exists at a key moment in a trajectory of interaction. This gives digital fabrication a social interactional standing and treats it as more than a tool for the realization of design ideas. Digital fabrication is equally a means to incite discussion, provoke reflection, engender curiosity and so forth. This contrasts somewhat with the more technologically based research on digital fabrication in HCI.

Conceiving of digital fabrication as embedded within a live social activity opens out a range of new research challenges and new perspectives. For example, although the time restraints of digital fabrication were initially thought of as a limitation, we have found it valuable to allow further conversation to take place while the souvenir was made. We do however suggest from our experience that the timing and duration of fabrication need to be carefully planned as not to create awkward waiting moments.

In live activities, fabrication takes on a *performative* aspect with the facilitator acting as performer. Although this was not a substantial part of our initial design study, we definitely noticed its importance in order to create fluid and engaging trajectories and to encourage participation and stimulate conversation. In addition, it should be noted that although this initial study was highly facilitated (and this helped us gain first hand insights into the processes we were exploring), there is room for further exploration with varying levels of facilitation and hands-on participation.

From this perspective, a variety of research issues come to prominence, depending on the context or planned situation, they include: duration of activity, level of hands-on participation, technical limitations and other setting related factors, for instance mobility, target audience or organisation-related requirements.

Summary

In summary, let us draw together the core considerations that we have discussed to outline the issues we feel should guide future research into digital fabrication when situating it in activities and settings like the one we have studied:

- **Relating to other activities.** Our souvenir making activity is part of people's visit to an art installation. In this context, the activity has to be seen in relation to other activities that make up the overall visit. The different ways in which fabrication can be designed and situated within other activities is worthy of additional exploration.
- **Situated activity design.** We have argued that fabrication should be seen as situated and embedded activity that encourages social interaction and reflection. In this sense, the activities themselves become as much a topic for design as the artefacts or the fabrication technologies.
- **Playful reflection.** We employed a number of playful strategies for provoking reflection and enabling evaluation. The different ways in which fabrication can engender reflection and can be part of playful explorations of people's experiences are topics for further study.
- **Making, meaning and material things.** We have emphasised the intertwining of meaning and material artefact in the making process. This is a richer perspective on fabrication than ones that see fabrication as the mere realisation of design ideas.

CONCLUSION AND FURTHER WORK

In this paper we have explored how digital fabrication can be used to extend and enrich audience experience of a cultural event, by embedding a personalised act of fabrication within the trajectory of the visitor experience. Our findings suggest that such an activity-embedded fabrication process offers the possibility for the act of making to become not only a means of expression of the experience, but simultaneously a stimulus for reflection on the experience. In addition, the playfulness and ambiguity [10] of both the 'data gathering' interface and the fabricated artefacts themselves provided occasions for reflective discourse on the meaning of the exhibition and people's experience of it.

Our design of the fabrication activity allowed us to explore how the act of making affects the meaning of the objects as souvenirs. Ingold's [14] analysis of how an artefact becomes a living *thing* (*rather than a mere 'object'*) for someone through their involvement in its making offers us a way of understanding why not just the personalisation but the fabrication of an object is significant here. Even in situations where visitors were not hands-on making and preferred the researcher to assemble the artefact, there was nevertheless a strong sense of affective connection prompting for example, explorations of the relationship between feelings and form. For many visitors the act of fabrication became an experience in its own right other than simply an expression of the visit. This points to the experiential power of the fabrication process.

Our research shows that digital fabrication can be embedded into a trajectory of shared activities in cultural contexts, in our case through souvenir making, to engage new audiences, enhance experience, inspire audiences to reflect whilst also providing cultural organisations with potentially novel ways to learn more about their audience. Although there is a lot of scope to develop this idea and process further, it can be concluded, that the interactive, real-time souvenir-fabrication process holds potential to not only engage audiences in reflecting upon their experiences but in addition, to use generative souvenir making and digital fabrication technology to explore new ways for cultural organisations to engage with the audience evaluation process. We hope that this paper contributes not only to HCI research around cultural and heritage settings but is also an initial exploration into a new area of research situating digital fabrication in shared activities to encourage participation, reflection and meaning making.

ACKNOWLEDGMENTS

This research was funded by the AHRC Creative Exchange Knowledge Exchange Hub. Many thanks to ISIS Arts for their support and to the Big M visitors for participating.

REFERENCES

1. Benford, S., Crabtree, A., Flintham, M., et al. Creating the spectacle: Designing interactional trajectories through spectator interfaces. *ACM Trans. Comput.-Hum. Interact.* 18, 3 (2011), 1–28.
2. Benford, S., Giannachi, G., Koleva, B., et al. From Interaction to Trajectories: Designing Coherent Journeys Through User Experiences. In *Proc. CHI '09*, ACM (2009), 709–718.
3. Bowers, J., Bannon, L., Fraser, M., et al. From the disappearing computer to living exhibitions: shaping interactivity in museum settings. In N. Streitz, A. Kameas and I. Mavrommati, Eds., *The disappearing computer*. Springer-Verlag Berlin, Heidelberg, 2007, 30–49.
4. Ciolfi, L. and McLoughlin, M., Designing for meaningful visitor engagement at a living history museum. In *Proc. NordiCHI '12*, ACM (2013), 69–78.
5. Crab Man. *Counter-tourism: The Handbook*. Triarchy Press, 2012.
6. Durrant, A., Rowland, D., Kirk, D.S., et al. Automics: Souvenir Generating Photoware for Theme Parks. In *Proc. CHI '11*, ACM (2011), 1767–1776.
7. Ferris, K., Bannon, L., Ciolfi, L., et al. Shaping Experiences in the Hunt Museum: A Design Case Study. In *Proc. DIS '04*, ACM (2004), 205–214.
8. Fosh, L., Benford, S., Reeves, S., et al. 'See Me, Feel Me, Touch Me, Hear Me': Trajectories and Interpretation in a Sculpture Garden. In *Proc. CHI '13*, ACM (2013), 149–158.
9. Gaver, B., Dunne, T., and Pacenti, E. Design: Cultural Probes. *Interactions* 6, 1 (1999), 21–29.
10. Gaver, W.W., Beaver, J., and Benford, S. Ambiguity as a resource for design. In *Proc. CHI '03*, ACM (2003), 233–240.
11. Gaver, W.W., Bowers, J., Boucher, A. et al. The Drift Table: Designing for Ludic Engagement. In *Proc. CHI EA '04*, ACM (2004), 885–900.
12. Gershenfeld, N. *Fab: The Coming Revolution on Your Desktop-From Personal Computers to Personal Fabrication*. Basic Books, 2008.
13. Hornecker, E. and Stifter, M., Learning from interactive museum installations about interaction design for public settings. In *Proc. OZCHI '06*, ACM (2006), 135–142.
14. Ingold, T. *Making: Anthropology, Archaeology, Art and Architecture*. Routledge, 2013.
15. Köhler, W. *Gestalt Psychology*. Liveright, New York, 1947.
16. Koleva, B., Egglesstone, S.R., Schnädelbach, H., et al. Supporting the creation of hybrid museum experiences. In *Proc. CHI '09*, ACM (2009), 1973–1982.
17. Kostoska, G., Fezzi, D., Valeri, B., et al. Collecting memories of the museum experience. *Ext. Abstracts. CHI '13*, ACM (2013), 247–252.
18. Kuznetsov, S. and Paulos, E. Rise of the Expert Amateur: DIY Projects, Communities, and Cultures. In *Proc. NordiCHI '10*, ACM (2010), 295–304.
19. Malone, E. and Lipson, H. Fab@Home: the personal desktop fabricator kit. *Rapid Prototyping Journal* 13, 4 (2007), 245–255.
20. McCullough, M. *Abstracting Craft: The Practiced Digital Hand*. MIT Press, 1998.
21. Mota, C. The rise of personal fabrication. In *Proc. C&C '11*, ACM (2011), 279–287.
22. Mueller, S., Lopes, P., and Baudisch, P. Interactive construction: interactive fabrication of functional mechanical devices. In *Proc. UIST '12*, ACM (2012), 599–606.
23. Ogawa, H., Mara, M., Lindinger, C., et al. Shadowgram: A Case Study for Social Fabrication through Interactive Fabrication in Public Spaces. In *Proc. TEI '12*, ACM (2012), 57–60.
24. Petrelli, D., Ciolfi, L., Van Dijk, D., et al. Integrating material and digital: a new way for cultural heritage. *Interactions* 20, 4 (2013), 58–63.
25. Posch, I., Ogawa, H., Lindinger, et al. Introducing the FabLab as interactive exhibition space. In *Proc. IDC '10*, ACM (2010), 254–257.
26. Schoen, D.A. *Educating the Reflective Practitioner*. John Wiley & Sons, 1987.
27. Segreto, T., Caggiano, A., and D'Addona, D.M. Assessment of laser-based reverse engineering systems for tangible cultural heritage conservation. *International Journal of Computer Integrated Manufacturing* 26, 9 (2013), 857–865.
28. Simon, N., *The Participatory Museum*. Santa Cruz: Museum 2.0, 2010.
29. Tanenbaum, J.G., Williams, A.M., Desjardins, A., and Tanenbaum, K. Democratizing Technology: Pleasure, Utility and Expressiveness in DIY and Maker Practice. In *Proc. CHI '13*, ACM (2013), 2603–2612.
30. Viégas, F.B., Perry, E., Howe, E., and Donath, J. Artefacts of the Presence Era: Using Information Visualization to Create an Evocative Souvenir. In *Proc. IEEE INFOVIS '04*, IEEE Computer Society (2004), 105–111.
31. Willis, K.D.D., Xu, C., Wu, K.-J., et al. Interactive fabrication: new interfaces for digital fabrication. In *Proc. TEI '11*, ACM (2011), 69–72.
32. Wright, P. and McCarthy, J., The value of the novel in designing for experience. in A. Pirhonen, P. Saariluoma, H. Isomäki et al., Eds., *Future Interaction Design*, Springer London, 2005, 9–30.
33. www.isisarts.org.uk/the-big-m [acc. on 7 Apr 2014]
34. www.graphtecamerica.com/cameo.html. [acc. on 19 Jan 2013]
35. www.processing.org [acc. on 19 Jan 2014]