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Articulating Co-Design in Museums: Reflections on Two Participatory Processes

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ABSTRACT

In this paper we reflect on the process of co-design by detailing and comparing two strategies for the participatory development of interaction concepts and prototypes in the context of technologically-enhanced museum visiting experiences. While much work in CSCW, HCI and related disciplines has examined different role configurations in co-design, more research is needed on examining how collaborative design processes can unfold in different ways. Here we present two instances of co-design of museum visiting aids, one stemming from an open brief, another from an initial working prototype; we discuss the process in each case and discuss how these alternative strategies presented the team with different possibilities as well as constraints, and led to different patterns of collaboration within the design team. Finally, we draw a set of themes for discussion and reflection to inform and aid researchers and practitioners participating in similar co-design processes, particularly in the domain of cultural heritage.

Author Keywords

Co-design; collaboration; participation; design process; museums; cultural heritage.

ACM Classification Keywords

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

INTRODUCTION

This paper reflects on the process of co-design, and particularly details and compares two different, although related, ways to conduct participatory activities in the context of designing and developing interactive technologies for museums and other heritage sites.

The work was conducted as part of a large collaborative project where tangible visitor experiences in museums and other heritage settings are designed and developed through a co-design approach involving cultural heritage professionals (CHPs) [23]. The project's final aim is to deliver a DIY toolkit to empower CHPs to design and configure tangible installations in heritage settings. One of the main goals of the project is to reflect on the process of co-design (particularly within cultural heritage), on the multiple forms that participation and collaboration can take in this particular setting, and to produce insights on how technology design and adoption for this domain may be facilitated by such an approach.

Much research within CSCW, HCI and Participatory Design has examined the dynamics of participation in design, the phases and techniques of the PD process, and the roles that different groups of stakeholders, facilitators and coordinators can play in the design process [2; 5; 27; 17]. Here we focus not on individual roles, but on the collaborative process itself: how different patterns of collaboration occurred in two different sets of co-design activities conducted as part of our project. We detail and discuss how each unfolded, and the issues that emerged around each process that was followed. The paper makes a contribution to the substantial community employing participatory design methodologies in CSCW and related disciplines, furthering the knowledge of how alternative participatory processes occur and unfold and can offer both possibilities and constraints.

Within our project, a number of co-design techniques are being employed including brainstorming sessions, scripting, storyboarding, rapid prototyping, and making and tinkering workshops towards the realisation of tangible interactive installations for cultural heritage: the eventual goal of these activities is to gain an in-depth understanding of how cultural heritage professionals and institutions design and

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develop interactive experiences, thus to richly and collaboratively inform and develop the design of the DIY toolkit. Furthermore, the interaction concepts and prototypes resulting from the co-design activities will populate the toolkit: these concepts and prototypes will provide examples and blueprints of interactive installations developed by cultural heritage professionals, and future users will be able to appropriate and customise them through the toolkit itself. The co-design activities involve a varied group of participants: three cultural heritage institutions are full partners in the project, together with industrial and product designers, social scientists and technology developers; furthermore, a number of external collaborators from the cultural heritage domain (curators, educators, heritage volunteers, etc.) regularly join the team for specific participatory activities such as creative workshops, hands-on design sessions and technology trials. The process resembles, in many ways, the one described by Fuks et al. [14], but in our case the collaboration involved not only museum professionals, but also professionals from other partner institutions.

In this paper we focus on two particular instances of co-design of similar tangible interactive heritage experiences that have occurred in the project and that, however, have followed two alternative processes: in the first instance, the development of interaction concepts and of a prototype began with an open brief developed jointly by heritage and design partners on the basis of reflections on the needs and wants of a museum; in the second instance, a basic working prototype developed by design and technical partners was chosen out of several by the participants and used as inspiration for the participatory ideation of interaction concepts for other heritage settings. There is a connection between these two activities in the context of the wider project: initially, the project's workshops were exploratory in nature and had the goal of generating broad concepts and ideas for museums. As the project evolved, we began investigating the validity of our ideas and technologies, and their appropriateness beyond our team and for a wider cultural heritage audience. This was reflected in a co-design phase that mixed divergent and convergent activities of creative design, the former exploring open themes in an unconstrained manner, the latter focusing on more specific design goals. These two types of activities continued for some months in parallel so to explore the opportunities and challenges offered by the two approaches. Parallel analysis of the two approaches has indeed highlighted key challenges, similarities and differences with regards to the process of design. The two examples we describe here occurred at different times in the overall process albeit within the same co-design phase of the project, and they also intentionally adopted different processes, as they were also meant to explore two different ways in which CHPs design. These two strategies were also employed to enable participation in design in the context of the overall project activities, and to offer material for reflection on how such processes can be facilitated and managed as we progress towards our goal of developing a toolkit for cultural heritage professionals.

DETAILING PARTICIPATION IN DESIGN

An existing body of literature is dedicated to examining co-design processes, which have been widely adopted within CSCW and HCI for a number of years and applied to a variety of domains including government services [1]; health services [8]; the design of persuasive technology [9]; the design of new technologies for children [13]; and the automobile industry [21]. However, to our knowledge, no direct comparisons have been made between alternative processes used and explored within the same design and development project. Existing work has reflected on the nature of participation in design [27; 17], examining the participants' multiple forms of involvement and the role that a facilitator can take in participatory activities, from coordinating, to observing, to full participation. Other studies have explored methods and approaches to co-design for successful user involvement and understanding [5; 16; 19] while other research has identified which design goal is best met by different techniques, particularly in the specific domain of designing technologies for children [13].

The body of work on PD involving children has generated substantial knowledge on the role that participants can play in the design process as part of various co-design techniques [13]. Druin's "onion model" focuses on participants' roles and is an approach to unpacking the process of PD that resonates with other research on detailing roles, power and decision-making in PD such as [6; 27]. Druin, however, elaborates further on the model to outline dimensions of participants' involvement in the technology design process for each role: relationship to developers; relationship to technology; and goals for inquiry. The second dimension is particularly relevant for our work as it articulates that the participant's relationship to technology "*can range from ideas to prototypes to fully developed products*" [13], thus linking to complex shifts in the roles that participants play, from simple users to fully-fledged co-designers.

Similarly, in [6] Bratteteig and Wagner detail the complex power relationships and the intricacies of the decision-making process that characterise and shape participatory projects. Bratteteig and Wagner analyse different cases through a practice-focused conceptual lens on decision-making, revealing how various factors in the design team and in the broader context of a project are at play in the way crucial decisions are taken during the co-design flow.

Indeed, these significant contributions have told us much about the articulation of roles and relationships in PD. However little has been said about the ways in which the collaboration processes unfold within the same frame, about how the activities can lead to different design outcomes, and about the possibilities that ensue from the process.

Many co-design projects commence with an open and flexible brief, with the goal of forming relationships and understandings of practices, their context and possible solutions to existing challenges [6; 17; 20]. Researchers in these cases apply various kinds of exploratory techniques as a means to facilitate collaboration amongst multi-disciplinary groups, such as: exploratory design games [3]; cultural probes as a means to represent the users' environment and context in an open, inspiring way [15]; inspiration workshops around examples of interaction concepts and prototypes [16]; and open-ended, flexible scenarios [26]. Techniques applied at this stage of design are dependent on the level of information that is required. These approaches often lead to convergent design ideas and shared understandings of users' challenges and desires that potential interactive systems can support.

As well as cases where the process of co-design originates from a brief that is often jointly developed within the group of participants as in the examples above, many researchers have also explored how digital and interactive technologies can be used as prompts, tools, or development environments in the design process. Reasons for using such technologies in co-design are varied: they can be based on the day-to-day influence they have on the users [19]; their potential for unearthing creative solutions [5; 22]; as a motivational factor for getting involved in the co-design process [13] and to demonstrate existing prototypes and discuss potentials for re-design [22; 17]. For example, researchers have explored how technological prototypes can be used as probes, forming rough design concepts for developing tools for urban renewal and placing them in the hands of users, leading to unexpected uses and ideas for novel technology solutions [22]. Another example includes the use of online journals by very young design partners (children), who were hesitant to use paper and pencil to record design ideas, but who embraced the process of recording ideas through the means of technology enhanced, digital journals [13].

Regarding the domain we address in this paper, co-design methods and techniques have been deployed in the design of technology for cultural heritage as means to create novel museum engagement programmes and exhibitions. Some of these cases have explored means for applying co-design effectively with particular user groups [2; 25; 28]. In many of these instances, CHPs, visitors and designers were involved, beginning with a brief for design and arriving at a technological solution for interacting and engaging with museum collections and exhibitions. In other instances, the starting point was technology-driven; for instance, this approach was adopted to explore how the technologies children use on a day-to- day basis can influence the design of an interactive exhibition [10]. Existing research has explored these approaches separately, but it has not, however, addressed how they relate to each other, and particularly how they can serve different purposes and support different forms of participation within the same complex design process and project team.

In the following sections we present and discuss two examples. In the first, the co-design activities that led to the realisation and testing of a prototype were kick-started by an open brief, where the particular theme for the exercise was proposed by museum partners after a process of reflection on their institution's requirements. In the second example, the co-design activities started from an already existing technology prototype, which was then adapted, appropriated, modified and contextualised for a museum setting by design participants. Both instances revolve around a similar interactional need: that of a lightweight way to direct visitors around a museum. We will describe our approach to co-design and each example in detail in the following sections.

CO-DESIGN METHODOLOGY

As part of the project, our remit as partners is to participate in, organise and facilitate a series of co-design activities with the cultural heritage partners and collaborators involved. Here we provide a brief description of the overall project co-design strategy, in order to properly contextualise the two examples we will subsequently focus on. In the first 18 months of the project (February 2013 – July 2014), we conducted a series of 5 large-scale co-design workshops involving participants from the 3 partner museums, as well as other designers, social scientists and technologists from within the project consortium. The facilitators had also visited and studied the 3 project partner museums, to gain a thorough understanding of these institutions, their goals in engaging visitors, their audiences and the different challenges they face in presenting their collections. In addition to these, in the same period a further 7 co-design sessions were organised and facilitated by various consortium partners involving representatives from collaborating cultural heritage institutions from their local areas.

With regard to scheduling these activities, the project consortium co-design workshops were interspersed with the local co-design sessions so that we could frame in a broader way how experiences with cultural heritage sites and exhibits could be enhanced, and to develop deeper insights into appropriate co-design methods with the cultural heritage professionals (CHPs) that are part of the project team. The duration of the workshops varied from several weeks (with activities involving partner museums taking place on several days a week), to 2-3 days (as in the case of some of the consortium-wide events), to a full working day (approximately 7 hours). The workshops involving local participants have tended to be shorter, due to the limited availability of CHPs who are not full partners in our project.

A number of techniques were used during the various events: workshops held earlier on in the project included more open-ended activities such as brainstorming around

keywords and around existing examples from CHPs practice, as well as rapid prototyping and tinkering exercises using hardware platforms (such as .Net Gadgeteer), so that all participants could familiarise themselves with a set of technologies and with platforms for rapid prototyping, thus encouraging them to imagine how interactive installations could be used to enhance visitor experiences at cultural heritage institutions.

Later workshops were more focused on the needs of certain museums, and on specific interaction concepts that had emerged during discussions with the co-design team and that were then further developed. Participants were also involved in activities such as storyboarding, scripting and realising short stop-motion animations representing a tangible interaction scenario or concept.

As we mentioned briefly above, different types of activities were run in the co-design phase this papers refers to through convergent and divergent moments of design exploration. They thus intentionally adopted different processes as they were meant to explore slightly different issues and different approaches that the CHPs adopted for the design of interactive visitor experiences.
The activity briefs ranged from broad and exploratory (for example "*Envisage visitor interactions that would enhance their experience at your museum*"), to highly focused ones (for example, "*Describe the workflow of a Cultural Heritage Professional building an interactive installation*"). This depended on the theme and goals of each workshop, and on the specific participants attending, alternating divergent and convergent phases of design exploration. For a number of the workshops, we asked the CHPs to prepare beforehand, by choosing material from their own institutions (such as objects, documentation, and visitor engagement tools such as educational toolkits) to be used during certain activities at the workshops. On other occasions, the facilitators chose the material to be used during the workshops and then presented it to the participants.

As we have explained in the introduction to this paper, the overall goal of our project is to empower CHPs to design their own tangible interactive experiences for visitors, therefore we have a strong focus on them as primary stakeholders in co-design and we wished to explore their design expertise and their knowledge of visitor engagement. The workshops explored the ways in which CHPs design with other collaborators when planning exhibitions. Furthermore, the design phase is not only about the interaction/interactivity envisioned, but also a way for CHPs to think about the content relating to an exhibit. Visitors are very seldom included in this process in their current practice [20]. Therefore, while we have involved heritage visitors in other project activities, the series of workshops that this paper refers to was focused on unearthing how CHPs make design decisions regarding the functionality, interactivity and role that technology can play in an exhibit – thus building (as well as design prototypes) shared representations of future users' practices, as described in [6, p. 15].
All these activities helped us to better understand how participants with different profiles and goals co-create, and which limitations and barriers have to be considered and possibly removed to support a more engaging and enjoyable co-design process for cultural heritage professionals. Some of the local activities were organized as one-off events, while others occurred on a regular basis.

Throughout all the workshops, designated members of the project team carried out observations in order to document the process and the involvement of all the participants. The sessions were documented through extensive note and photo taking, as well as through video recordings whenever possible. The data collected has been used to reflect on the process adopted, to refine the project's co-design strategy, and to plan for future activities. From this variegated set, we will now focus specifically on two instances of co-design activities in order to describe for each the details of the process and to reflect on two different approaches for engaging participants and for developing interaction ideas. The two examples are part of the broader strategy for co-design that we have outlined in this section, and the trajectories in terms of ideation, engagement and decision making that each portrays are interconnected.

In our analysis, we want to focus on each specific case to highlight how different ways to frame co-design activities lead to different processes. For each example, we detail the activities conducted, the knowledge and skills shared and employed by the co-design team, and how the roles of the participants shaped the process. We will then discuss how the different processes (summarised in Figure 7) supported the making and shaping of collaborative design decisions, particularly with respect to the use of technological prototypes. Our analysis is not aiming to identify which of the two approaches is more effective or successful, but rather to illuminate how different processes may unfold within the same participation frame, and to point out to a number of issues and concerns emerging from these processes in varying ways. In describing the examples, we will use fictional names to refer to participants so to preserve anonymity.

EXAMPLE 1 - STARTING FROM AN OPEN BRIEF

The majority of the co-design workshops started with a brief that focused on artefacts, exhibitions or challenges that the partner museums brought to the table. As a rule, there was always a museum representative in each workshop working sub-group.

The first exemplar we present here involved the team from one design partner institution working together with the team of a partner science museum in the same country. The lead designer, Richard, visited the museum and held an initial session with two of the cultural heritage professionals

at the museum, Henry and Francis, during April 2013. The discussion revolved around the key challenges the museum had been encountering: it became apparent that the museum was focusing on visitors "*learning through a complete experience*" (as Henry explained), and not on the collection itself. As a science museum, it already included a large number of interactive installations as part of exhibits, and the ambition of the CHPs at the museum was not to add yet another exhibit, but to interconnect the existing exhibits in personalized thematic tours that would further engage visitors – mainly schools and families with children - and contribute to the overall museum experience.

One of the challenges identified by Henry, Francis and their colleagues was making way finding in the museum easier, and providing some guidance to visitors interested in specific themes, as the space occupied is vast and densely populated with artefacts and exhibits. The idea of an augmented compass as a tool for way finding emerged from this discussion (e.g. a compass that would not just provide directions to the user, but also additional digital information), and all the participants agreed that it should be turned into a physical prototype for further creative exploration.

At the following co-design session in May, the design team led by Richard presented the museum team a non-functional prototype of the compass for discussion and elaboration (Figure 1).

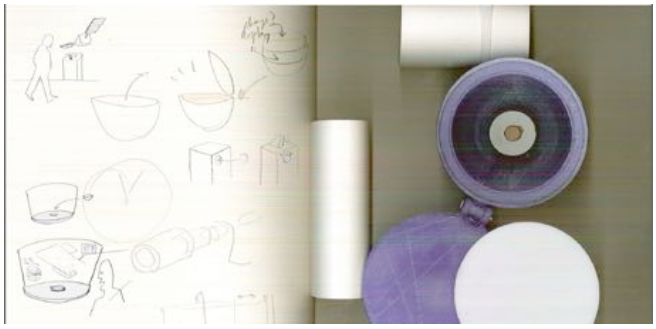

Figure 1. The augmented Compass concept

Three sub-groups were formed, each including at least a designer and a cultural heritage professional. Each sub-group then moved through the museum holding the compass and brainstormed about its possible functionalities in the physical context of the exhibits. The designers acted as facilitators, stepping back and allowing the CHPs to explore and apply the concept according to their own vision, museum mission, content and audience(s), and to make contributions and suggestions as to how the concept could be further developed into a functional prototype (Figure 2).
The CHPs formed a plethora of ideas that were further investigated by the whole group through scenario-building and low-fidelity prototyping after the in situ bodystorming.

Figure 2: One co-design group exploring the compass as a way-finding device

The most well developed scenario was based on the idea for a self-guided tour: "*Travel around the world in 80 minutes*". The CHPs, working together with the designers, suggested that each visitor would receive an augmented compass when entering the museum, getting the chance to configure it according to their preferences. Their chosen guide appearing on the face of the compass could be, as Henry put it: "*a zen monk, a pizza delivery driver, or even Superman*". Visitors could link/connect their compass to those of co-visitors, allowing for shared experiences. The chosen character would come to life inside the compass and give the visitor cues (both text and images) about where to go next on their journey. As the visitor approached an exhibit on his route (chosen based on his profile and the type of guide selected), the compass needle would indicate it and the compass would vibrate slightly. When in front of the exhibit, the compass would be used for projecting an extra layer of information on the closest available white surface. Another idea emerged was that of visitors being able to choose between a guided tour (like the one described above), an assignment mode (for school visits) or a game mode. The compass would be able to activate itself when the user opens its lid. Different points of interest or artefacts would hold an assignment for the visitor or provide a hint for finding the next artefact on the route. Based on the answers provided and the route taken, the compass could reveal a video or a cipher allowing the opening of a special room or treasure chest, possibly through the united efforts of co-visitors.

In the scenario evaluation discussion, the compass was valued for tackling the way finding challenges, providing a way to adapt to the visitor's preferences and to store the visit's footprint.

When it came to developing a functional compass prototype, Richard and his design team discussed building it: identifying a suitable round screen, embedding required processing power, battery needed and so on. Moreover, the compass concept was further critiqued as it could only show the connections between objects in the museum space, with little scope for providing additional information. Ensuring that visitor attention would remain on the museum objects rather than the device, the decision

was made to add Augmented Reality content on a screen (triggered by the device's ability to recognise museum artefacts), and to adopt a shape that would put visitors in an active position (similar to that of researchers or collectors, rather than 'just' consumers). The chosen form factor was that of a magnifying glass. As time was an issue, they decided that the quickest way to offer the required functionalities would be to encase a smartphone into a round wooden frame, as it offered all that was needed in terms of functionality (Figure 3). By developing the original concept and technically realising the prototype, the original compass turned into the form factor of a loupe. The screen is larger and the handle allows visitors to have a strong grip on it and point it at artefacts in a comfortable way. The loupe is a magnifying glass visually augmenting objects or locations in the exhibition space, and providing clues to visitors for moving to the next point of a recommended trajectory: visitors use the loupe to view particular objects or location markers; the device recognises these and provides visitors with content about them and with directions to related objects/locations, which is displayed on its face.

Figure 3: The Loupe prototype

An in situ evaluation of the Loupe with museum visitors was jointly planned and conducted by Henry, Francis and Richard (Figure 4). Further development of the prototype and its evaluation with visitors within the museum allowed Francis, Henry and their museum team to identify some key concerns about its effectiveness.

Figure 4: Testing the Loupe with museum visitors

For instance, Henry, who participated in the design of the Loupe from the very beginning, voiced his doubts about some of the conceptual aspects of the prototype when it was tested in the museum, describing that a loupe may not be the best metaphor for a way finding tool and that the device appears more to distract attention from the real objects than to enhance the visitor's interaction with the objects on display.

Overall, this first example presented a process that had unfolded from an open-ended brief, included several iterations of brainstorming, prototyping and evaluation, and was concluded with a functioning prototype tested with museum visitors. We now describe a second example.

EXAMPLE 2 - STARTING FROM A WORKING PROTOTYPE

In a convergent moment of the co-design process, we explored how some of the prototypes developed earlier (through processes similar to that of the Loupe) could be re-appropriated to support other museum experiences.

In November 2013, a one day long workshop was organised by the same design partner institution with 6 CHPs from 5 collaborating museums, some of which outside of the project consortium, with foci ranging from archaeology to history and science. Richard and Henry participated also in this second activity. Each of the CHPs participating in the workshop brought with them a museum artefact (either replica or authentic) from their institution. Choosing one of 5 exploratory prototypes that the project had built, the CHPs, working in groups together with designers and technologists, were encouraged to build on their knowledge of the museum artefacts and on their ideas for visitor engagement in their own museum to envision interactive experiences for visitors. The CHPs were also asked to think about how the prototypes could be physically re-designed - in terms of form factor and material - to suit their needs. Every CHP collaborated with one of the designers of the exploratory prototype he/she had chosen. Six use cases for the prototypes were developed during the workshop; all the use cases were showcased and documented at the end of the co-design session. The use cases included: creating personalised museum experiences; generating guided and way finding experiences; and augmenting physical museum artefacts with digital information. The theme of way finding and subtly guiding visitors around heritage sites had been voiced repeatedly by all the museum partners well before the design and realisation of the Loupe. A number of other exploratory prototypes addressing this need were developed in parallel as a result. In this section, we will describe how one specific exploratory prototype (the Way Detector) was repurposed to support a way finding experience at a particular museum.

The Way Detector (Figure 5) is a white, oval-shaped device. Its physical form was designed to be comfortably held in one's hand and to promote as little design association with other objects as possible. It guides visitors

using haptic feedback, following a simple "hot or cold" metaphor: as a visitor approaches an artefact or narrative of interest, the Way Detector vibrates faster as a means to indicate that a point of interest is getting nearer. The Way Detector also contains an NFC tag, which can be used to activate personalised content within the museum. When the Way Detector is placed on top of an NFC reader information is read from the tag and used to trigger text, images, audio or video content. At this design workshop, speakers and tablet screens were available for presenting content. The Way Detector was presented to the cultural heritage professionals in the workshop as the "Egg": a simple way-finding device that could be used to create paths for visitors around the museum.

Figure 5. The Way Detector

Julie, a CHP working in a historic house museum, was immediately attracted by the simple appearance of the Way Detector; she was interested in exploring the device as a means to address the need for lightweight way finding at her institution. She talked with the rest of the group about the historic house she works in and the object she chose to bring from her collection: a pie dish from the nineteenth century. The historic house collection spans two floors; however, visitors rarely take time to explore both areas. Julie felt that the Way Detector could be used not only to guide visitors through the history of the making of the pie dish, but also to encourage visitors to explore the upstairs and downstairs of the house during their visit. In collaboration with her team, Julie developed a use case for the Way Detector addressing these issues. The team included four other participants: Niall, one of the designers of the Way Detector; Mary and Linda, two other designers within the project; and Matt, a cultural heritage professional from a science museum. The team collaboratively drafted this scenario through sketches and storyboards; once the concept was drafted, the Way Detector prototype was partially modified to mirror the scenario.

Discussions began with the team, brainstorming potential uses for the Way Detector in the historic house, with the prototype designer, Niall, sketching these ideas on paper (Figure 6). Everyone in the group had an input in the brainstorming process: Julie shared some videos, original house menus, pictures and digital recipe files that described how the pie dish was made and used with the group; Niall began sketching potential paths in the museum; and all the rest of the participants contributed ideas for the intended scenario. Together with the other co-designers, they discussed a potential path for the visitors to take: the visitors would begin their journey in the pantry with the Way Detector guiding them through the kitchen area located downstairs in the house. Julie suggested that the first point of interest should describe the recipe of the pie to the visitor. Niall then discussed the potential journey the visitor would take in the kitchen area, where the focus was on how the pie was made. He was then inspired by some of the digital content that Julie had presented, stating that some of it could be edited to show the recipe for the pie and demonstrate how it was made.

The Way Detector prototype was meant as a "blank canvas" in terms of form factor: it was a means to demonstrate the functionality of design concept without imposing a particular look and feel, a sort of template that could be modified by the participants. All the same, as the group were storyboarding the scenario for the Way Detector, it was initially challenging to encourage Julie to think about the design beyond its current physical appearance. It was suggested that the physical design could be a replica of the pie dish itself – the object that Julie brought with her to the design workshop. Niall also proposed other forms, such as wearable garment (hat, bag, etc.). However, Julie felt that this could have a negative effect on the visitors' experience: visitors might be more concerned about their own appearance when wearing a hat than about the visit; therefore, they may be more willing to hold something like the pie dish. Furthermore, it was also challenging initially to encourage Julie to suggest extra functionality for the prototype. Mary then suggested that the Way Detector could also make a timer-like sound that would communicate whenever the pie was ready. Afterwards, Julie began suggesting new ideas as the workshop progressed, suggesting that smells could also be added so the visitors could have a multi-sensory experience of the pie-making process.

Figure 6. Niall and Julie working on the pie dish scenario: sketching ideas (left) and choosing digital content (right)

The development of the use case scenario adapting the Way Detector to Julie's museum led to several discussions, particularly with how content would be presented to visitors. The designers began discussing ideas for physical interaction with museum objects: for example, discussing how by placing the Way Detector on the kitchen table or another surface, relevant information about the objects related to that space would be given to the visitors. However, Julie noted that this was not possible because all

of the objects including the kitchen table were original and that visitors would not be allowed to directly touch the objects or place anything on them. Julie was also concerned with using screens in conjunction with the Way Detector to present the content to visitors: she felt this would impose too much on the visitors' experiences of the museum objects. However, she was not quite sure about how to present content without screen technology. Niall and Mary inspired Julie to think of other options to present content, including the use of a projector lamp that accompanied another prototype presented at the same workshop. Nevertheless, Julie felt this technology was inappropriate due to power issues within the museum. In the end, the group agreed that the story of the pie could be projected on a glass plate; therefore, complementing the museum's ethos and goals.

As soon as the use case scenario for the prototype was developed, the Way Detector was modified to reflect this scenario. Although Julie was not actively involved in technically modifying the prototype, she was involved in selecting the digital content that would be presented to the visitors (Figure 6). Julie and Mary explored together an open source sound database for sounds that would be appropriate for the setting and the use case concept. Niall's responsibility was to implement the ideas generated by the group: he edited the digital content and linked it to the code operating the Way Detector. Unlike during the development of the use case scenario, there wasn't too much dialogue between the members of the group at this stage, each being busy with their specific tasks: discussions occurred only when content was chosen, edited, or applied to the prototype.

Due to time constraints, not all of the ideas formulated in the use case scenario were translated into practice when the prototype was modified: such as, for example, the projections on glass plates. However, the pie dish scenario using the modified Way Detector was demonstrated to the other participants at the end of the workshop.

DISCUSSION

The descriptions of the examples we have provided in the previous sections highlight, first of all, how the two processes are part of a larger co-design strategy and are interconnected: the Loupe example which was developed earlier in the co-design phase of convergent/divergent exploration, was spread out in a longer time-frame and involved participants only from the project team. On the other hand, the Way Detector example took place later in the same co-design phase, involved also external collaborators and was framed by the much shorter time of a one-day event. The two co-design processes (which are summarised in Figure 7) were planned and executed with consideration of these different constraints, and the choice of working with an open-ended brief vs. an existing prototype reflected also the knowledge that the project team, and the workshop facilitators in particular, had gained of the domain and of the needs of cultural heritage institutions to engage visitors.

With this in mind, we now discuss further what we have gleaned from each example regarding how the two processes unfolded, the challenges of each, which insights were best given by which strategy, how the design idea was developed in each case, how the participants' contributions to the design concepts emerged and what were the dynamics of collaboration and participation in each of the 2 cases. The themes of discussion here have emerged following extensive thematic analysis of the qualitative data as collected throughout the entirety of the co-design activities. We see the themes of discussion and the open questions they address as useful categories that other CSCW researchers can also use for reflecting on and refining the co-design process and for preparing to facilitate collaborative design activities.

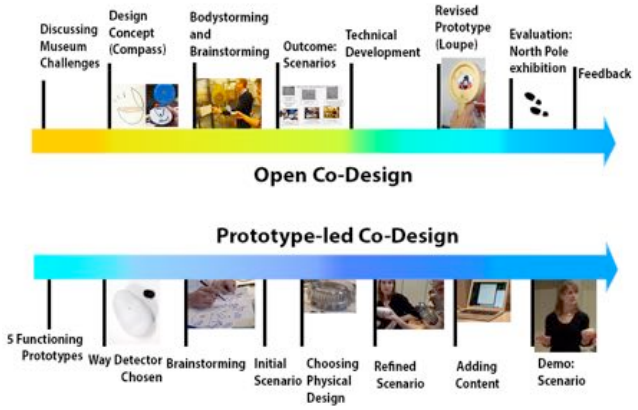

Figure 7. Overview of the two co-design processes

Skills and Knowledge Shared

How do participants share different skills and knowledge with collaborators when designing using low-tech representations compared to high-tech prototypes? Co-design as a discipline has referred to the concept of sharing in various ways. For example, it can refer to sharing knowledge required for empowering other stakeholders, e.g. enabling them to contribute further, or differently in the design process [7]. Sharing may also be defined as part of the mutual learning process, whereby professional designers learn more about the context and needs of the other stakeholders, and conversely their needs and constraints are made clear [24]. Mutual learning is the only way in which mutual respect can be achieved between the different stakeholders; this is imperative for maintaining trust in sharing information and knowledge effectively within co-design teams.

Speaking of sharing, we refer here to how mutual learning progressed during both examples of the co-design process. We detail how knowledge and information were shared between the CHPs, designers and technologists, keeping in

mind the opportunities provided for such sharing in each kind of co-design activity. In the Loupe example, at first, the focus was on low-tech design techniques to allow the CHPs to present their ideas, rather than on the technical requirements to realise them. Participants were encouraged to come up with new concepts without worrying about what is technologically possible and what is not. For example, the original compass concept involved a round screen to show a chosen guiding character indicating a direction and clues to the next museum exhibit, but also included the ability to project information on white surfaces in the museum. At this point in the process, designers and technologists refrained from expressing concerns about how this could be technically built in the time available, preferring to encourage the CHPs to express their ideas freely. However, about halfway through the process, the designers had to find a practical solution to implement the compass idea at least partially, and this saw the concept transformed into a different form factor, that of the Loupe, which became the focus of the process and of subsequent developments and adjustments by the entire team. Paraphrasing Ehn & Kyng, coloured cardboard compasses do not become magic guiding instruments by themselves. The needs and constraints shaping the design had to be communicated and made understood by the rest of the team. The advantage is that "low fi mockups lend themselves to collaborative modifications" [12].

In the second example, the CHPs could see and understand from the beginning how the Way Detector worked and what possibilities it offered. The technical designers were first to share their knowledge and to offer their skills at modifying the prototype in whatever way the CHPs wished. Clarity regarding the prototype's features then enabled Julie and the rest of the team to develop the scenario focusing on the content, form factor and context of use. Furthermore, the CHPs also experienced first-hand how technological solutions can be adapted quickly and in real time to fit their own needs, and also acquired the ability to envisage how their existing digital content can be re-purposed to suit these scenarios. The specialised knowledge of the CHPs was shared not only in the initial phases of the discussion (e.g. Julie's description of the historic house), but also during the development of the scenario (e.g. Julie explaining that the prototype could not be directly placed on a table in the house).

Indeed, in these examples, the process of sharing knowledge and skills varied greatly. However, it is interesting to see that in both cases the CHPs were eager to contribute their professional knowledge to inform the design during all stages of the activity. Mutual understanding and learning was built during all stages of the activity in both scenarios. Additionally, while the designers and technologists learned about the challenges and the practices of CHPs, the CHPs had the chance to learn about co-design and acquire new collaborative methods and techniques, as well as a better understanding of the state-of-the-art regarding available technologies. The decision regarding whether the technological know-how should be shared earlier in the co-design process depends on whether the potential pitfalls of placing boundaries on design ideas are lesser than the advantage of giving all the members of the team a better understanding of how the technology works and how it can be integrated within a design scenario. Time is certainly a concern in this case: with the Loupe, the team had a longer time frame to develop ideas, refine scenarios and identify the appropriate technology to realise it; with the Way Detector, the limited time available was focused on the development of the specific scenarios based on the existing prototype.

Influence of the Prototypes' Form

How did the form of the prototypes used during the process influence participation in the development of design ideas?
In Example 1, the concept of the augmented compass was translated into a physical object that reminded but did not closely reproduce the shape of an actual compass, making the object pleasant to hold in one's hand, but also providing some space for the technological elements to be built in later on. This non-functioning prototype gave free rein to the participants' imagination and allowed them to come up with wishful thinking ideas. The paper used for sketching the content of the round screen in different scenarios allowed ad-hoc materialisation of ideas and for documenting the process.
In Example 2, although the shape of the Way Detector was meant to be as neutral as possible (a blank white 'egg') and the participants were informed that the shape of this prototype could be easily altered, Julie still had difficulties imagining the technology actually embedded in a different shell, i.e. the pie dish. Once this was achieved thanks to the skills of the designers in the team and after a lengthy group discussion, the ideas started flowing freely. Working with a functioning prototype, albeit an intentionally "generic" one, requires a stretch of imagination in regard to adapting the form to the context. Once the new form is identified and appropriated, new functionalities can be envisaged to complement the existing ones (such as adding a smell component proposed by Julie).

Openness vs. Defined Concept

How does a non-functioning prototype support interpretation? Is a functioning prototype less open to interpretation than a low-tech representation or idea, as a low-tech representation provides a broader picture of how the prototype may work and what technologies may be applied? In our cases, a metaphor such as the one of the compass afforded a broader exploration of desired functionalities and served as a prop for eliciting more information from the CHPs tacit knowledge of their visitors. This way, designers also gained a better understanding of the challenges encountered by the CHPs. Openness is desirable when the partners do not know each

other very well and time is not an issue. On the other hand, a defined concept (and a functioning prototype) can make the design process addressing a specific challenge encountered by a museum more immediate and focused, such as in the case of the Way Detector. In [16] Halskov and Dalsgård discuss how the use of Technology Cards (abstract representations of technological platforms) in combination with broader Domain Cards encouraged participants in a co-design workshop to bring actual examples of designs from their own domain and re-contextualise them within the activity. Similarly in our example, Julie selected the Way Detector as the prototype that suggested the most potential to her, and developed her ideas by adapting the characteristics of the Way Detector to the historic house. Therefore, while presenting the CHPs with a specific defined concept in isolation might be problematic in the early stages of the co-design strategy, it seems that offering a choice from a portfolio of such concepts can provide good scaffolding for their ideation in relation to their domain and interests.

Alternating divergent to convergent thinking as part of a design flow is a strategy to move back and forth from open to more specific solutions: in the 2nd workshop the facilitators were already thinking about implementation and consequences for the CHPs handling prototypes.
Again, the time frame of the process is key when considering whether to start with an example of technology so to give participants an idea of what is possible, or to leave the technical realisation out of the brief. When time is limited, the presence of an already functioning prototype can also provide more time to discuss other ideas and concepts, although the prototype has to be introduced and framed carefully at the beginning of the activities.

Shaping of Design Decisions

How did the two processes support the shaping and making of design decisions? Which activities occurred in each case to underpin design development?

In the Loupe example, open brainstorming and bodystorming were critical at the beginning to shape a brief and to focus the subsequent work on scenario development. In the Way Detector example, the process began with the CHPs choosing a prototype that could potentially solve problems for their museum, followed by a brainstorming session to allow the participants to come up with ideas featuring the prototype in their museum. While the technical development of the Loupe had to take place separately before the working prototype could be brought back to the museum team for adjustments, the customisation and adaptation of the Way Detector to Julie's historic house scenario could happen in real-time during the workshop. The actual design scenario evolved in both cases through a dialogue among all the members of the team that alternated open-ended proposals (e.g. the addition of a certain interaction, or the introduction of particular content) and discussion of how they would fit in the envisioned scenario.

In both the examples we presented, open brainstorming and technical specification were crucial activities. Brainstorming revolved around the challenges encountered by the museums in both examples, however while in the first case the design space was vast and completely uncharted territory, in the second case the brainstorming stemmed from museum challenges already identified. Regarding technical specification, with the Loupe it drew certain boundaries around a scenario (e.g. the size of the screen, and the difficulties of projecting content in the way envisioned by the CHPs); with the Way Detector it encouraged the participants to propose more ideas regarding form factor and additional functionalities, using the description of the current prototype as an example to show the potential of the technology and of physical design.

Also, in the particular context of a large project, the goals and power relationships in the two examples (which are interlinked with decision-making, as argued in [6] and [27]) were influenced by the overarching goal of the project. In the Loupe example, based on technology constraints, the designers and technologists decided for a shift from the main issue pointed out by the CHPs – way finding – and the compass concept, in order to build a prototype that was both technically feasible in the amount of time available and offering a wider range of functionalities. They were able to bring major modifications to the original concept because, at that point, coming up with a series of functional prototypes to populate the toolkit was one of main challenges in the project. In the Way Detector example, the participating CHPs taking part in the process contributed their knowledge, their content and their time and gained an understanding of the prototypes' potential for adaptation and appropriation. Participation, in both cases, was configured [27] to suit the needs of the project team, who initiated and directed the process and who held the "bigger picture" behind the co-design activities.

There seems to be a delicate balance to find between the more open and creative activity, and the more constrained one: the framing of both brainstorming and technical specification in the co-design process is critical in establishing how the subsequent collaborative development of ideas and decision-making will occur. The placing of these activities at particular moments of the process is also a crucial decision by the facilitators.

Participants' Roles and Involvement

How were the roles and the involvement of the participants affected by the two processes? Although the focus of this paper is on process rather than on individual roles, the accounts we have presented provide some material for reflection on the nature of the participants' involvement.
Both examples show how the composition of the team – cultural heritage professionals, designers and technologists - allowed for sharing information across professional and disciplinary boundaries. In both cases, the co-design activities were facilitated by design project partners, who

created space for the decisions and contributions of CHPs. However it was CHPs who were in charge of choosing the challenges to work with, and thinking of interactions to implement. Henry and Francis came up with the augmented compass idea, and Julie was the one who chose the Way Detector to work with from the 5 available prototypes. Applying Druin' s 'onion model' [11] to these two scenarios would situate the CHPs between the Informant and Design Partners roles of the model, signifying that they have been involved at multiple stages of the design process using technology. When moving from the inner circle of the onion model to the outer circles, the involvement of participants in design changes in two ways. They become more active and responsible in their participation, and furthermore the participation takes place in more stages of the design process. Looking at our two examples, in both cases the involvement of participants changed as the process evolved, both regarding their relationship with the technology and with the developers (in our cases, designers and technologists), although the time frame of the two processes was different. This indicates that even within phases of co-design, and within specific activities/exercises, roles ad forms of involvement are continuously shifted and re-defined as the process evolves and as collaborators jointly make decisions and share expertise. This shifting of roles does not just apply to the non-technical participants (e.g. the CHPs in our case), but to all participants. In the case of the Way Detector, technologists had to play their part in facilitation as well, due to the need of clarifying the technology's functionality. In the Loupe example, technologists were not heavily involved in the initial phases, however they drove the phase of prototype development that occurred halfway through the process. In this case, following the initial co-design phases of concept development, bodystorming and brainstorming sessions between the CHPs and technologists, internal discussions, time and budget constraints led Richard's design team to alter the original concept and deliver this practical solution for evaluation. The decision as made by the participating designers to replace the compass idea with the Loupe was made without the real-time input of the CHPs. The consequence of this facilitator-driven decision-making (as we explained in the previous section) and subsequent prototype development resulted in the overshadowing of the primary functionality of the original concept as conceived of by Henry and Francis and making it difficult for them to accept the new concept, although they subsequently agreed to testing the Loupe with the public in their museum. While the first example describes an earlier activity in the co-design phase, when members were learning about each other's field and exploring a wide range of ideas and prototyping supported this endeavour (divergence), the second one shows a case were what was learned was already incorporated in generic exploratory prototypes and allowed a much faster design and development cycle (convergence).

CONCLUSIONS

This paper has presented a reflection on two different and somewhat alternative participatory processes within the same large project (which is aimed at the co-design of a toolkit for tangible interactive museum installations) by a team of designers, CHPs, social scientists and technology developers. The two examples we have detailed involved participants from heritage institutions in developing concepts for interactive visitor experiences which will illustrate the type of interventions the CHPs wish to offer at their institutions, and which will populate the toolkit's 'library'. We have outlined the project's overall participatory design strategy and its goals and, subsequently, described two instances of co-design of two prototypes both addressing the issue of providing lightweight guidance around museum exhibits: the first unfolded around an open brief focusing on a science museum, and led to the realisation of the Loupe; the second developed an existing and fully working technical prototype called the Way Detector, which was chosen out of a set of options and was then adapted and reconfigured to suit a historic house museum. We have analysed and reflected on the two examples focusing on a number of aspects of how the process unfolded in each: we reflected on the skills and knowledge that were shared by the team members in order to contribute to the design, on the influence of the form of the prototypes on the collaborative ideation process, on the tension between openness and definition of design concepts, on the activities that shaped design decisions and, finally, on the dynamics of participants' involvement in each instance and in driving and shaping the design in two instances of a collaborative team, with particular attention on the composition of the team. While existing research has examined the process of co-design and the strategies that facilitators and coordinators of participatory activities can adopt, our original contribution lies in the parallel analysis, reflection and discussion of two alternative processes that were deployed within the same project frame and the same co-design phase, aiming at alternating moments of divergent and convergent design thinking. We did not adopt an experimental approach in order to conduct a controlled comparison, but rather purposefully explored alternative processes within the same design phase characterised by convergent and divergent moments. We do not see these two approaches as mutually exclusive, but both useful to support valuable participatory practices within the same frame.

This approach to documenting and reflecting different instances of our co-design strategy is novel and useful in order to highlight which aspects of co-design are shaped and re-configured in specific activities under the same project, and how similar methods and techniques can nonetheless lead to different forms of participation and collaborative decision-making in each instance. Furthermore, we see our analysis themes as a useful set of issues to aid other CSCW researchers to refine and reflect

on the co-design process seen as a complex instance of collaborative work, particularly in complex participatory efforts featuring a variety of dedicated activities and of stakeholders and contributors.

We found that each way to frame a co-design activity presents opportunities and challenges, and that the choice of either or both frames, and their timing and management, should be dependent on the specific requirements and goals of the design process and the participants. The roles of an open brief vs. an existing prototype are particularly crucial in this respect: while an open brief allows for broader exploration of ideas but necessarily adds pauses in the collaborative process to allow for technical development, existing prototypes can frame and focus the ideation process in a more constrained way, but allow for continued joint work among the team members who are all grounded on an existing basis.

We also saw how the participants share their skills and expertise in order to develop mutual learning and understanding at different times and at different degrees in each example, adapting to the flow of discussion and contributing at points where it is understood is necessary and/or appropriate.

The importance of the time frame of co-design processes is another important finding: not only regarding the need to time carefully the duration of an activity in itself (e.g. a longer process lasting days or weeks vs. a one-day workshop), but also with respect to planning subsequent subsets or phases of the overall co-design strategy. Our goal was that of alternating divergent and convergent design thinking: while the two examples feature similar techniques in how the co-design activities were conducted, they are different instances of the participatory process due to their different intended roles in our strategy.

The goals of reflecting on our process in a detailed way are twofold: firstly providing examples and drawing insights that can be relevant for other researchers and projects of a similar scope approached through co-design, particularly for the domain of museums and exhibitions; secondly we aim to empower cultural heritage professionals to become more active players in the ideation and realisation of digitally-enhanced visitor experiences, and offering them accounts and in-depth discussion on the design process is part of facilitating their participation as designers, and not simply as informants.

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REFERENCES

1. Leo G. Anthopoulos, Panagiotis Siozos and Ioannis A. Tsoukalas. 2007. Applying participatory design and collaboration in digital public services for discovering and re-designing e-Government services. *Government Information Quarterly 24*, 2: 353 – 376.
2. Claus Bossen, Christian Dindler and Ole S. Iversen. 2012. Impediments to user gains: experiences from a critical participatory design project. In *Proceedings of the 12th Participatory Design Conference: Research Papers - Volume 1 (PDC '12)*, 31 – 40. http://doi.acm.org/10.1145/2347635.2347641.
3. Eva Brandt. 2006. Designing exploratory design games: a framework for participation in Participatory Design? In *Proceedings of the ninth conference on Participatory design: Expanding boundaries in design - Volume 1 (PDC '06)*, 57 – 66. http://doi.acm.org/10.1145/1147261.1147271.
4. Susanne Bødker and Ole S. Iversen. 2002. Staging a professional participatory design practice: moving PD beyond the initial fascination of user involvement. In *Proceedings of the Second Nordic Conference on Human-Computer Interaction (NordiCHI '02)*, 11 – 18. http://doi.acm.org/10.1145/572020.572023.
5. Tone Bratteteig and Ina Wagner. 2012. Spaces for participatory creativity. *Co-Design 8*, 2-3: 105 – 126.
6. Tone Bratteteig and Ina Wagner. 2014. *Disentangling Participation. Power and Decision-making in Participatory Design*. London: Springer.
7. Tone Bratteteig, Keld Bodker, Yvonne Ditrich and Preben Holst Mogensen. 2013. Methods: organizing principles and general guidelines for Participatory Design projects. In *Routledge Handbook of Participatory Design (1st ed.)*, Jesper Simonsen and Toni Robertson (eds.). Routledge, NY, USA, 117 – 144.
8. Jane Clemensen, Simon B. Larsen, Morten Kyng and Marit Kirkevold. 2007. Participatory design in health sciences: Using cooperative experimental methods in developing health services and computer technology. *Qual Health Res 17,* 1: 122 – 130.
9. Janet Davis. 2012. Early experiences with participation in persuasive technology design. In *Proceedings of the 12th Participatory Design Conference: Research Papers - Volume 1 (PDC '12)*, 119 – 128. http://doi.acm.org/10.1145/2347635.2347653.
10. Christian Dindler, Ole S. Iversen, Rachel Smith and Rune Veerasawmy. 2010. Participatory design at the museum: inquiring into children's everyday engagement in cultural heritage. In *Proceedings of the 22nd Conference of the Computer-Human Interaction Special Interest Group of Australia on Computer-Human Interaction (OZCHI '10)*, 72 – 79. http://doi.acm.org/10.1145/1952222.1952239.
11. Allison Druin, 2002. The role of children in the design of new technology. *Behaviour and Information Technology (BIT) 2*, 1: 1– 25.

12. Pelle Ehn and Morten Kyng. 1991. Cardboard Computers: Mocking-it-up or Hands-on the Future. In *Design at Work (1st ed.),* Joan Greenbaum, J and Morten Kyng (eds.). L. Erlbaum Associates Inc., Hillsdale, NJ, USA, 169 – 195.

13. Jerry Alan Fails, Mona Leigh Guha and Allison Druin. 2013. Methods and Techniques for Involving Children in the Design of New Technology for Children. In *Foundation and Trends in Human-Computer Interaction – Volume6, No.2 (2012) 85-166.*

14. Hugo Fuks, Heloisa Moura, Debora Cardador, Katia Vega, Wallace Ugulino and Marcos Barbato. 2012. Collaborative museums: an approach to co-design. In *Proceedings of the ACM 2012 conference on Computer Supported Cooperative Work (CSCW '12)*, 681 – 684. http://doi.acm.org/10.1145/2145204.2145307.

15. Bill Gaver, Tony Dunne and Elena Pacenti. 1999. Cultural probes. *Interactions 6*, 1: 21 – 29.

16. Kim Halskov and Peter Dalsgård. 2006. Inspiration Card workshops. In *DIS'06 – Proceedings of the Sixth Conference on Designing Interactive Systems*, 2-11. http://dx.doi.org/10.1145/1142405.1142409.

17. Hilary Hutchinson, Wendy Mackay, Bo Westerlund, Benjamin B. Bederson, Allison Druin, Catherine Plaisant, Michel Beaudouin-Lafon, Stéphane Conversy, Helen Evans, Heiko Hansen, Nicolas Roussel and Björn Eiderbäck. 2003. Technology probes: inspiring design for and with families. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '03)*, 17 – 24. http://doi.acm.org/10.1145/642611.642616.

18. Finn Kensing, Jesper Simonsen and Keld Bødker. 1998. MUST: A Method for Participatory Design. *Human-Computer Interaction 13*, 2: 167 – 198.

19. Maaike Kleinsmann and Rianne Valkenburg. 2008. Barriers and enablers for creating shared understanding in co-design projects. *Design Studies 29*, 4: 369 – 386.

20. Laura A. Maye, Fiona E. McDermott, Luigina Ciolfi and Gabriela Avram. 2014. Interactive Exhibitions Design – What Can We Learn From Cultural Heritage Professionals? In *Proceedings of the 8th Nordic Conference on Human-Computer Interaction: Fun, Fast, Foundational (NordiCHI '14)*, 598 – 607. http://doi.acm.org/10.1145/2639189.2639259.

21. Cecelia B. Merkel, Lu Xiao, Umer Farooq, Craig H. Ganoe, Roderick Lee, John M. Carroll and Mary B. Rosson. 2004. Participatory design in community computing contexts: tales from the field. In *Proceedings of the eighth conference on Participatory design: Artful integration: interweaving media, materials and practices - Volume 1 (PDC '04)*, 1 – 10. http://doi.acm.org/10.1145/1011870.1011872.

22. Christina Mörtberg, Tone Bratteteig, Ina Wagner, Dagny Stuedahl and Andrew Morrison. 2010. Methods That Matter in Digital Design Research. In *Exploring Digital Design: Computer Supported Co-operative Work (1st ed.)*, Ina Wagner, Tone Bratteteig and Dagny Stuedahl (eds.) Springer, London, UK, 107 – 147.

23. Daniela Petrelli, Luigina Ciolfi, Dick van Dijk, Eva Hornecker, Elena Not and Albrect Schmidt. 2013. Integrating Material and Digital: A New Way for Cultural Heritage, *ACM Interactions*, July+August 2013.

24. Toni Robertson and Jesper Simonsen. 2013. Participatory Design: an introduction. in Routledge Handbook of Participatory Design. In *Routledge Handbook of Participatory Design (1st ed.)*, Jesper Simonsen and Toni Robertson (eds.). Routledge, NY, USA, 1 – 18.

25. Maria Roussou, Elina Kavalieratou and Michael Doulgeridis. 2007. Children designers in the museum: applying participatory design for the development of an art education program. In *Proceedings of the 6th international conference on Interaction design and children (IDC '07)*, 77 – 80. http://doi.acm.org/10.1145/1297277.1297292.

26. Hanna Strömberg, Valtteri Pirttilä and Veikko Ikonen. 2004. Interactive scenarios—building ubiquitous computing concepts in the spirit of participatory design. *Personal Ubiquitous Computing 8*, 3-4: 200 – 207.

27. John Vines, Rachel Clarke, Peter Wright, John McCarthy and Patrick Olivier. 2013. Configuring Participation: on how we involve people in design. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '13)*, 429 – 438. http://doi.acm.org/10.1145/2470654.2470716.

28. Gustav Taxén. 2004. Introducing Participatory Design in Museums. In *Proceedings of the eighth conference on Participatory design: Artful integration: interweaving media, materials and practices - Volume 1 (PDC '04)*, 204 – 213. http://doi.acm.org/10.1145/1011870.1011894.