Introducing Participatory Design in Museums

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ABSTRACT
This paper describes how a set of participatory design methodologies have been introduced to and adopted for museum exhibition design. It provides a brief historical account of museums and reviews some current trends in museum exhibition design. Furthermore, the paper outlines a number of reasons why participatory methods may be appropriate for museums, and two such methods are described: one for evaluation of exhibits, and one for exhibition concept development. Evaluation of the methodologies suggests that they are efficient; both in terms of resources and in the richness of the data they produce. In addition, it appears that they are capable of both supporting and extending established museum design practices.

Keywords
Museums, Participatory Design, Evaluation, Concept Development

1. INTRODUCTION
Most participatory design (PD) projects are rooted in a desire for change, often with respect to the way a workplace organisation functions or in the way users are being involved in the design of new technology artefacts. A majority of the early cooperative projects in Scandinavia had a political agenda in the sense that their aim was to empower workers to shape and influence the introduction of new technology into their work environment [15]. The project described in this paper has a family resemblance with these early projects in the sense that it actively seeks to empower museum visitors to influence the design of the exhibitions they visit, to a larger extent than what is common practice today. However, as we shall see, our approach is somewhat less confrontational.

The fact that participatory design is able to produce high-quality user-oriented information technology does not necessarily mean that it is straightforward to introduce such methods into other domains. In our case, we have found that there is a need for continuous evaluation of our methods, not only to "validate" the products of the design process with respect to the established design practice (i.e., that our participatory methods actually contribute to the museum design process in general), but also with respect to how the different stakeholders involved regard their participation.

The next section briefly describes the museum context and how design work is typically done in museums today. It also draws out a number of similarities between the circumstances that led to the development of cooperative design in the 1970s and current trends in museum exhibition design. Section three introduces our project and describes its most prominent influences. Section four contains an overview of the first main achievement of the project: a participatory evaluation methodology for museum exhibitions. Section five constitutes the main part of the paper and describes, in some detail, how we have worked with visitors to develop concepts for a new exhibition at the Vasa Museum in Stockholm. This section also presents an analysis of the concepts, and shows how they can be related to trends within current museum research. Section six presents an evaluation of our work method and section seven contains some directions for future research.

2. MUSEUMS
In the mid-15th century, Italian nobles begun to arrange acquired artworks from ancient Greece and Rome with the specific intention of exhibiting them to invited guests holding important social positions. As a result, a new general interest in these cultures was raised, and a few hundred years later, private collections of items from around the world were abundant in Europe. The way of displaying them gradually changed, however: the function of the collections developed from being tools for forwarding the owner's social position to exhibitions of an encyclopaedic nature. Some collections were kept for teaching purposes by individual researchers at universities, but many were put together to represent the owners' view of the world. A classic example of these kinds of displays is the *Wunderkammer*, the "cabinets of curiosities".

During the mid-17th century, the Royal Society was formed in England. One of its aims was to develop a shared language among tradesmen, scientists and the church. To support this process, the Society assembled a collection of items, known as its Repository, to physically represent the language. By arranging for an institution to own the collection rather than a private individual, it was hoped that it would stand a better chance of surviving and growing than private collections, which tended to disperse at the death of the owner. The Royal Society also appointed a *curator* to manage the laboratory that was made available in connection with the Repository. At this time, the collection was not accessible to

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the public; it was only available to members of the Society. Today, the Repository is a part of the British Museum.

After the French revolution, the collections of the aristocracy were appropriated in the name of the new Republic, gathered together, reorganized and transformed. The aim was to make the collections available to all citizens of the Republic. Another reason for organizing this new type of museum was to display the decadence and forms of control of the old regime and to represent the democratic values of the new. Thus, the nature of the content changed from that of a three-dimensional encyclopaedia to less specific, changeable information. A similar perspective was gradually adopted throughout the rest of Europe.

The evolution of the modernist philosophy in the nineteenth century influenced the transformation of museum collections into representations of chronology so that the exhibitions evolved into a physical record of the past. This is a practice that remains today, but many other presentation and grouping techniques are also used in contemporary museums. More detailed descriptions of the history of museums can be found in, e.g., [4][24].

Thus, most modern museums are concerned with collecting, preserving, and providing access to important cultural and historical artefacts, with the explicit intention of educating and informing the general public about those artefacts. The curator role remains extremely important. Curators often plan and oversee the arrangement, cataloguing, and exhibition of the museum's collections and, along with technicians and conservators, maintain the collections. They are frequently expected to coordinate educational and public outreach programs, such as tours, workshops, lectures, and classes, and may work with the boards of institutions to administer plans and policies. Additionally, they may research topics or items relevant to their collections [29].

2.1 Museum Exhibition Design

Historically, the curator often single-handedly designed exhibitions. Today, most museum design teams also include educators, designers, artists, carpenters, technicians and maintenance staff. New exhibition projects typically begin with a *conceptual phase* in which a subject and a visitor target group are selected. It is common to make use of a *front-end analysis* to generate subject candidates [10]. In such an analysis, previous projects are assessed and demographic data of the visitor population is acquired. It is also common to assess the kinds of knowledge the target group have of the chosen subject, their interests and priorities, or to attempt to find ways to attract visitors from community groups that seldom visit museums (e.g., [14], [17], pp. 179-181). After the production team has generated a number of ideas, available resources for completing the project are assessed, together with the appropriation of a suitable time slot in the exhibition schedule.

A *development phase* follows in which funding is acquired and the physical and educational design of the exhibition is completed. After a project budget and an exhibition plan have been completed, production can commence. Activities include building, preparing, mounting and installing the exhibits, and also involve training of the educational staff and marketing. Since it is costly to redesign exhibits after they have been put on display, many museums have adopted a prototype-oriented design process where mock-ups or early exhibit versions are tested by selected groups of visitors ([10], pp. 39-43). Such evaluations of prototypes are often referred to as *formative evaluation*, and can be directed at both physical and educational aspects of the exhibits.

The time period when the exhibition is on display is often referred to as the *functional phase*. In this phase, educational programmes are implemented and the exhibition is typically also presented to the public through pre-scheduled guided tours. It also includes personnel administration and maintenance work, and ends with the dismantling of the exhibition and the balancing of accounts. In this phase, *summative evaluation* is used to determine if the exhibition met its goals. Such evaluation is often relatively easy to conduct, but may lead to expensive re-design of entire exhibits.

The production cycle ends with an *assessment phase* where the exhibition development process is evaluated. The intended outcome is a number of suggested improvements to the production process and ideas for future exhibitions. A large number of evaluation methodologies exist, including questionnaire surveys, in-depth interviews, structured and semi-structured interviews and behavioural observation [5]. Often, several of these evaluation methodologies are combined to triangulate the findings and strengthen the conclusions of the data analysis.

2.2 A New Arena for PD?

The main principles of museum exhibition evaluation originated in seminal work by Robert Miles' group at the Natural History Museum in Britain in the 1970s [26]. A gradual increase in interest in evaluation has led to the formation of the *museum visitor studies* research field, which builds on theory from sociology, psychology, education, marketing, management and leisure studies. It covers subjects such as demographics, data on attendance, psychological profiling, patterns of visitor behaviour, and the development of educational assessment methodologies. During the last decade, a growing number of authors within visitor studies have argued for a focus shift in exhibition production from curators and subject specialists towards educators and evaluators (e.g., [34][25][22]). As a result, evaluation, front-end analysis and formative evaluation are becoming increasingly more important in museum exhibition design.

Thus, visitors or visitor representatives contribute to the design of exhibitions in different phases of the exhibition design cycle, but they are rarely invited to become part of the design team itself. In the terminology of Druin and Fast [13], visitors today are asked to assume the roles of user, tester or informant, but they are very seldom invited to become design partners. The reasons are probably largely historical. Traditionally, the main tasks of most museums have been to maintain a number of collections and to make those collections available to the public. This means that the curator and/or the museum staff must have expert knowledge about the museum's different artefacts. In the 1970s and 1980s, most museums became heavily influenced by communication theory, which led to exhibition design approaches where content was "encoded" by these experts into the exhibition and subsequently "received" by visitors [25]. The visitor studies field largely arose from the need of determining whether this "encoding" was successful or not. Visitor "representation" has increased through the inclusion of educators, evaluators and

designers in most exhibition design teams, but the fact that visitors have expert knowledge too – they know what it means to be a visitor – is still not acknowledged enough to allow them to take an active part in exhibition design.

In many ways, this situation resembles the situation in the information system industry that led to the formation of cooperative and participatory design. The focus on usage models, psychological profiling and human factors within human-computer interaction in the 1970s and 1980s (c.f., [3]) appears to be common within visitor studies research today. Another similarity is that museums are subject to a strong extrinsic pressure for change, just as the Unions in Scandinavia constituted a pressure for change in the way technology was being designed for the workplace in the 1970s and 1980s [15]. Today, most museums face increasingly fierce competition from other entertainment providers, such as theme parks and similar attractions. Multimedia-capable computers with high-bandwidth Internet connections are becoming ubiquitous in Western homes and schools, providing a readily accessible and extremely rich source of information. At the same time, the attendance figures for many museums are decreasing at the same time as their governmental financial support is gradually being withdrawn. Thus, many museums are seeking more visitor-focused ways of approaching (and extending) their audiences, a reorientation that requires a more substantial visitor-designer dialogue than the field of visitor studies currently seems to be able to provide.

Thus, it would seem that museums might benefit from the introduction of participatory design methodologies. However, there appears to be very few documented research projects where such approaches have been implemented and evaluated. At the time of writing, we have only been able to identify one example: the HIPS project [6], where the aim was to allow people to navigate both a physical space (e.g., a museum) and a related information space at the same time (e.g., information about the items in the museum). The project initiated a number of workshops where visitors and museum staff worked together to design the user interface of a portable appliance that would allow visitors to acquire information about a museum artefact or a piece of artwork. The participants included a museum director, an art expert, a museum custodian, a fine arts superintendent, the administrator of a museum bookstore and two tourists. While these workshops provided a number of very useful ideas for technology design and implementation, they did not focus explicitly on exhibition design [7].

3. PARTICIPATORY DESIGN IN MUSEUMS

The goal of the project described in this paper is to strengthen visitors as stakeholders in technology-oriented museum exhibition design through the use of participatory design methods. The methodologies we use are developed in collaboration with museum production teams to support current museum design practices. Thus, the project is not only about technology development, but just as much about methodology adaptation: modifying and appropriating design methods from the human-computer interaction field to support and strengthen another, previously established, design practice. It is this latter aspect that will be of concern in this paper. See [38] for an overview of some of the technological aspects of the project.

The project is now approaching the end of its second year. A large amount of this time has been devoted to establishing different partnership roles and securing the commitment of the different participants (c.f. [9]), work that is embodied in a long-term installation that we developed for one of our partner museums [37]. Our approach is to gradually introduce participatory methods where they are deemed appropriate by both the partner museums and the project researchers. In order to ascertain that the outcome of the project is useful from a museum perspective, each method introduced is also evaluated and validated through different means.

Currently, we are working with the Museum of Science and Technology (www.tekniskamuseet.se) and the Vasa Museum (www.vasamuseet.se) in Stockholm. We also collaborate with Swedish Travelling Exhibitions (www.riksutstallningar.se).

3.1 Project Influences

Our project builds upon the work of a number of previous cooperative and participatory projects. The main influences are the "tools perspective" from UTOPIA [16], the future workshop [27], and the KidStory variation of Cooperative Inquiry [36][12].

The KidStory project worked with school children (ages 5-9) and teachers to design new storytelling technologies. The design cycle consisted of three main types of session activities (figure 1): educational (assisting the children in acquiring knowledge of a particular role or concept related to the project), evaluation (generating suggestions for improvement of existing technologies) and brainstorming (exploring ideas and possibilities without having to make a commitment to act upon them).

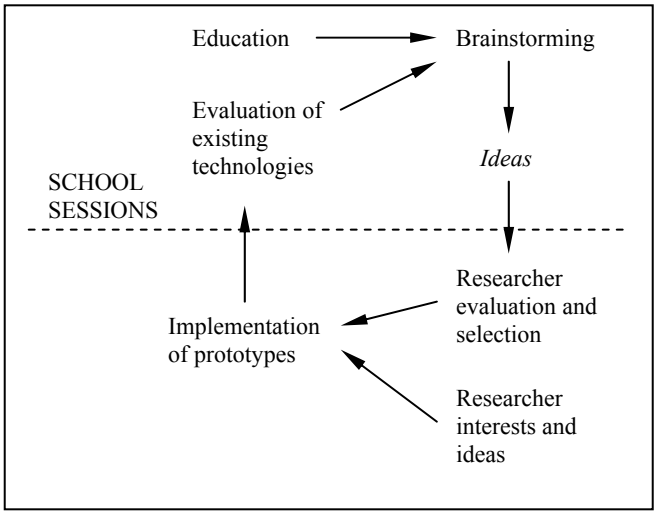

Figure 1. The KidStory design process (after [36]).

The education and evaluation sessions provided the children with a framework for thinking critically about technology and also helped them to develop a shared design vocabulary. The outcome of these sessions was typically a number of design suggestions that were either used to make changes to existing pieces of technology or were fed into brainstorming sessions where ideas for new technology were generated and elaborated upon. The researchers then analysed the subsequent ideas and selected a number of them for implementation. Both researcher interests and

constraints on time and technology influenced the selection process. Prototypes that implemented the ideas were then built and brought back to the children's school for further refinement.

Although they were not thought of as such at the time they were developed, a number of the KidStory prototypes can be seen as interactive exhibits and/or installations. Examples include a "story owl" that would tell you stories from around the world, a "magic sofa" that would transport its users to exciting places, a "magic carpet" that allowed a number of users to collaboratively navigate a virtual environment, and a "technology fair" where a number of the prototypes were integrated and exhibited to the children's parents and relatives. This, in conjunction with fact that the design methodology worked very well with such young participants, made it appropriate as a candidate for adoption to the museum domain. However, the first task of our museum project was to develop a participatory methodology for museum exhibition evaluation.

4. PARTICIPATORY EXHIBITION EVALUATION

The Museum of Science and Technology is currently planning a redesign of its Science Centre gallery. To support the process, the museum has initiated a number of evaluation activities, including assessment of the current exhibits and observations of other Science Centre galleries in Europe and the United States. However, much of this data is based on behavioural observation and the data seemed to lack detailed feedback from visitors. Because the museum's resources are limited, interviewing a larger number of visitors was not an option. Since the evaluation methodologies used by the KidStory project had been shown to be both efficient and provide a large number of design suggestions (apart from generating feedback), we decided to attempt to adopt one of them for the museum. One of the temporary installations in the Science Centre gallery was selected as the target of the evaluation. The method we appropriated is a variation of the future workshop [27]. It also shares some features of the grounded theory method [20] and the Post-Its-based evaluation activity described by Allison Druin in [12].

We hosted three two-hour workshops at the museum, two with target group representatives (school classes), and one that was open to the public. We began each workshop by encouraging all participants to interact with the installation while the facilitator gave a brief talk outlining the installation's implementation and main goals. When every participant had been given a chance to familiarise themselves with the exhibit, we moved to a quiet conference room in an adjoining part of the museum. Here, the facilitator briefly described the workshop goals and its different stages. Then, the participants were given green and red Post-It notes and were asked to write down at least three positive aspects of the installation on the green notes (one statement per note) and at least three negative aspects on the red notes, and put them on a random location on a whiteboard. When all Post-It notes were positioned on the whiteboard the facilitator asked the participants to collectively attempt to group similar notes together and summarise their content in a heading. When all notes had been accounted for, we took a short break after which the participants were asked to form groups of about five persons each. The groups were encouraged to examine the whiteboard and try to think of ways in which the negative aspects of the installation could be improved while preserving the positive aspects. Each group was shown to a quiet, private area and were given about half an hour for discussions. When the groups had reconvened in the conference room, we spent another thirty minutes talking about what the groups had discussed and what design suggestions they had thought of. Each workshop was documented by two note-takers.

In order to attempt to assess whether our new method also produced data that correlated to standard summative evaluation methods, we triangulated the workshop data with data from observations and interviews. The results suggest that the participatory evaluation method brought forward the same general themes (both positive and negative) as the summative evaluation, as well as generating a large number of ideas for improvement. For further details, see [37].

5. PARTICIPATORY EXHIBITION CONCEPT DEVELOPMENT

During the autumn of 2000, a number of sulphate deposits were discovered on the surface of the world-famous Vasa vessel [11]. Vasa is a Swedish 17th-century warship that sunk just a few minutes into her maiden voyage. The ship was rediscovered and salvaged in 1961 and was preserved through a 26-year conservation process. Unfortunately, the wood contains a large amount of sulphur (assimilated from the water when the ship was resting on the sea bottom), which has gradually reacted with oxygen to form sulphuric acid. The acid and its deposits threaten to destroy the ship if nothing is done to terminate the process. Today, the reasons behind the problem are well understood, but a satisfactory solution does not yet exist. Therefore, five different chemistry and conservation research teams have been engaged. The Vasa Museum has very recently initiated work on a new large-scale exhibition that will describe the sulphuric acid problem to the public and present the outcome of the chemical research on a continuous basis. Because the visitors to the museum constitute an extremely heterogeneous group (the Vasa Museum is one of the largest tourist attractions in Sweden), and the exhibition will feature modern technology, the issue of usability became important. Thus, our museum project at the Centre for User Oriented IT Design (CID) was engaged to assist in the exhibition development process.

It soon became clear that a reasonable start for the usability work would be to focus on the part of the exhibition that will describe the sulphuric acid problem. The Vasa Museum had already established a number of educational activities where the problem was brought up and discussed, e.g., during their guided tours, through a small temporary exhibition, and through high school teaching activities.

This meant that through the teaching programme, the museum had already established direct contact with different groups of visitors when CID was approached (adolescents is one of the target age groups of the sulphuric acid exhibition), and that these visitors already had some knowledge of the problems the new exhibition is intended to illustrate. Consequently, by working with these students, the educational activities that were initiated at different occasions in the KidStory project were not immediately necessary.

Thus, the museum re-engaged the ten most recent high school student visitors that had worked with the sulphuric acid problem. Together with three members of the museum's educational staff, these students participated in four different two-hour workshop activities between December 2003 and January 2004 to develop concept sketches and ideas for the new exhibition. The overarching goal of the sessions was to assist the students in formulating the aspects of the background material that they thought was most important, and to gain insight into how they, as museum visitors, would like to encounter those aspects in an exhibition.

The goal of the first session was to allow the visitors to formulate a set of criteria for "good" and "bad" exhibitions. The session discussed exhibitions in general and what visitors feel to be efficient, educational and fun. The first session also included an evaluation of the museum's existing exhibitions to see whether they incorporated the criteria or not.

The second session initiated an exhibition concept development process. The goal was to generate ideas for concepts that embodied the positive criteria from session one, while avoiding the negative criteria. At the end of the session, the participants evaluated the concepts. This evaluation was the foundation of a selection process, where CID researchers identified a number of interesting aspects for the participants to refine during session three.

The third session refined and concluded the concept development work, and the outcome was documented (by the participants themselves) in the form of scenario videos. The session ended with a general discussion about the videos.

The last session was devoted to feedback. Researchers from CID and museum personnel gave an account of how the students' work had been analysed, what the results of the analysis were, and how the museum intended to use the results. The session ended with an evaluation of the work method itself.

Because sound and video recording was deemed impractical, we decided to document all sessions through observational notes and digital camera images.

5.1 Session 1

The first session was hosted by the Vasa Museum. After a brief introduction, the session facilitator distributed a number of Post-It notes – red and green – and encouraged the students to think of the best exhibition they had ever visited, and to write *why* it was good on green notes. Correspondingly, the students were asked to think of the worst exhibition they had ever visited and note why it was bad on the red notes. As they finished writing the notes, the students positioned them on a blackboard at random locations. The facilitator then encouraged the students to work together to group the notes on the blackboard, so that aspects that belonged together were positioned close to one another, and to formulate a suitable heading for each group of notes. The headings for positive aspects were: "guides", "visual images", "physical environment", "sound", "do yourself (experiments)", "models" and "other issues". The headings for negative aspects were: "guides", "balance between play and fact", "physical environment", "too much text" and "other issues".

After this, the students were asked to copy the headings to paper and read through all notes on the blackboard. The students were then divided into three groups (about 3-4 persons in each group) and were asked to find examples of the aspects mentioned in the notes in the Vasa museum. After about one hour, the groups reconvened to discuss the results.

The discussion indicated that the students thought that the design of the museum's exhibitions had been largely successful. Models (large and small), the design of the environment, and informative multimedia presentations gave an impression of "how it felt" to live with and on the Vasa. However, the lighting level was thought to be too low in general (this is a requirement of the conservation process), and this, in combination with poor placement of text labels made many of the exhibitions difficult to understand.

The discussion also raised a number of more general issues that the students considered important for museum exhibition design, including:

> One should strive to provide a feeling of authenticity, to transport the visitor to a different place, environment or age. It is important to use authentic artefacts and create a sense of quality in the physical design of the exhibition environment.
>
> Visitors want to be able to come close to artefacts, without restrictions, and it is important to be able to see artefacts from all directions.
>
> It is important that the goal and context of the exhibition is immediately obvious to the visitors.
>
> Language aspects are important in a museum like the Vasa museum. Should all texts be in English as well as Swedish? Should other languages be included? How much text should there be?
>
> The exhibition must be accessible to everyone.
>
> The exhibition should have a certain tempo in its presentation – not only in image and text, but also in the way visitors are guided through the gallery.
>
> Points of view: most visitors want to be able to see through artefacts, see inside, or see artefacts from the inside, etc.

As we shall see, many of these discussion topics, as well as aspects from the Post-It notes, are embodied in the concepts the groups began to develop in session two. Thus, the first session both provided the students with a number of "basic requirements" to work from, as well as providing evaluation data on the museum's existing exhibitions. Furthermore, members of the museum staff have corroborated the evaluation data to a large extent: most of the issues mentioned by the students had been raised by the museum's different summative evaluations. However, our workshop method required far less resources.

5.2 Session 2

The second session was hosted by CID at the Royal Institute of Technology. The same student participants as in session one were present, together with three members of the Vasa museum's

educational staff (two of these persons were present but did not actively participate in the first session). The groups (same as session one, with the addition of one museum educator each) were asked to work together to develop exhibition concepts, without presupposition with respect to available technology, funding, and the physical environment. This phase of the workshop took about one hour. The groups used low-tech material to illustrate their concepts: coloured paper, pens and pencils, scissors, glue, tape, marbles, newspaper and magazine clippings, clay, LEGO bricks, etc.

After a 10-minute coffee break, the groups continued to work for about 25 minutes. The facilitator then asked the groups to present their concepts, in their current state, to the rest of the participants. During these presentations, the participants also evaluated the concepts: each participant was asked to write (anonymously) three positive aspects and three negative aspects of the concepts (excluding their own) on different pieces of paper. The facilitator collected the papers at the end of the session.

5.2.1 Concepts: Group 1

The first group chose to organise their work around a paper sketch. The exhibition was conceived of as a collection of individual interactive exhibits, situated close to the real Vasa vessel. The concept included the following features:

> A projection onto the real ship that illustrated the negative effects of the sulphuric acid problem. The rationale for this projection was to generate a general interest in the rest of the exhibition.
>
> Access to paper-based information in several languages that visitors could take with them.
>
> Touch screens where visitors could search a database.
>
> Several short films in connection with the exhibits that illustrate how the chemical process proceeds. The process would be visualized in different ways, to better match a large range of target groups.
>
> A large number of robots that could follow visitors around the exhibit, to answer questions (in many languages). The robots would remember what people asked it, and make use of cameras and microphones. The robots were not guides, but "helpers".
>
> A poster with text for older visitors. Models and texts for younger visitors.
>
> An "experiment station" where visitors could attempt to reverse the sulphuric acid process in a piece of wood.

5.2.2 Concepts: Group 2

The second group had positioned a large glass dome at the centre of their exhibition design (figure 3). Inside the dome was an animated 3D hologram. This non-interactive animation begun by showing the entire Vasa ship and then zoomed into the wood, peeling off layer after layer, illustrating the sulphuric acid development process. The holographic "camera" also moved around the ship interior (which is inaccessible to visitors for security reasons). A suitable text would rotate around the bottom edge of the dome, and would also be read by a speaker voice.

The group had positioned a number of smaller domes around the large hologram where visitors would be able to, through interactive virtual experiments, discover how the sulphuric acid is to be removed from the ship. These displays were also holographic, so that the content was visible from all angles (although only one person at a time would be in control). Each dome would illustrate a separate concept (the chemistry of the preservation process, the physics of the supporting scaffolding of the ship, etc.). A number of encouraging questions would also appear on the domes.

Figure 3. A glass "dome" containing Vasa as a 3D hologram. The small "domes" are interactive exhibits where further information can be found.

5.2.3 Concepts: Group 3

The third group worked with a concept that involved models and mechanics to a large extent. Their exhibition consisted of a large, long wall containing a moving model (figure 4). The model was designed as a timeline where time flows from left to right. A physical icon representing the Vasa ship would move along the wall, illustrating how the ship was launched, how it sank, how waste in the water would provide the sulphur, etc., until the ship was salvaged and brought into the Vasa Museum at the far right. There were also a number of "binoculars" set into the wall. By looking through these, visitors would be able to view short films that illustrated the aspects presented on the wall in further detail. There were also a number of explanatory texts (read by a commentary voice) and images positioned on the wall.

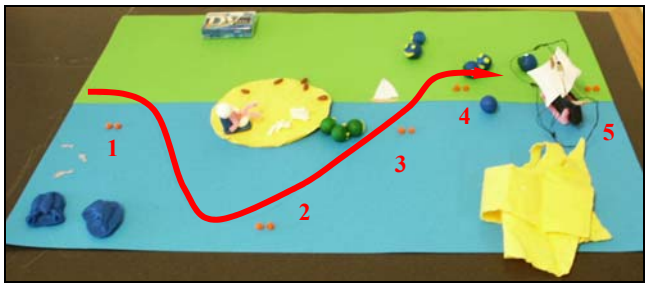

Figure 4. A mechanical model that illustrates the origins of the sulphuric acid problem. The lower half of the wall represents water. The arrow illustrates the motion of the Vasa model. The numbers indicate where "binoculars" containing information can be found: 1) Vasa sinks, 2) the wood absorbs sulphur from waste in the water, 3) salvage, 4) conservation –

sulphuric acid is formed in contact with oxygen, 5) different alternatives for solving the acid problem (the "cage" surrounding the Vasa model at the far right is the Vasa museum).

5.3 Session 3

The goal of the last design session was to refine the concepts and to focus on possible implementation alternatives. Two of the groups from session two participated (groups 2 and 3), together with two of the museum educators. Again, CID hosted the session. Before the session, CID researchers had analysed the concepts and chosen one interesting aspect for each concept. The choices were based on current trends in museum technology and learning research. The researchers had also developed one "what if" scenario for each concept that highlighted issues that were raised in the participants' own evaluation from session two.

The groups were encouraged to continue to refine their concept, while focusing on the highlighted aspects and scenarios. Each group was also presented with a video camera, and were encouraged to record a usage scenario that illustrated their concept. As in the previous session, the groups worked for roughly one and a half hours (including a coffee break). During the last twenty minutes, the groups watched each other's videos and discussed the result.

5.3.1 Refinement: Group 2

Group two had been asked to think about what the interactive stations would contain, and about what would happen if a larger group of visitors wanted the same information simultaneously. The resulting video shows an interested tourist that is given a selection of multiple languages for the voice commentary for an "experiment" at one of the exhibits. It also shows a child that cannot reach the upper part of the exhibit, only to discover "child menus" at a more appropriate height. When these menus are used, the exhibit reconfigures itself to display a content developed specifically for children. The group came up with a simple solution for the problem of large visitor groups: they are given access to one of the museum's tour guides!

5.3.2 Refinement: Group 3

Group three had been asked to elaborate on the content on the wall, and about what would happen if a larger group of multilingual visitors approached the wall at the same time. The result was a number of clarifications to the concept, e.g., the contents of each of the "binoculars", and an "icon-based" chemical formula (figure 5). The video illustrates how the Vasa model moves across the wall, and indicates how each of the individual model parts will move and work.

Figure 5. Sulphur + oxygen = "wicked" sulphuric acid.

5.4 Session 4

The students' school hosted the final session, which was devoted to feedback. Eight of the ten students that participated in the previous workshops were in attendance, together with two of their teachers and a member of the museum staff. During the first half of the session, a CID researcher described how the students' work fit into current research on participatory design, museum technology and learning. The KidStory project was also described, together with the main results from [37] and [38]. The presentation also explained how the concepts from sessions 2 and 3 had been analysed (see next section). The second half of the session was devoted to feedback from the students. They were encouraged to evaluate the work method in the same way as they evaluated their own concepts at the end of session 2. This feedback also included a short general discussion on work methods and research in general.

5.5 Concept Analysis

The fact that the groups chose to focus so differently in their concept development was an expected outcome of the work method: it is well-documented that low-tech prototyping methods often result in a wide range of design ideas (e.g., [1][12][36]). In this case, the first group chose to target communication aspects, the second group visual aspects, while the third group chose to focus on context. These three aspects are vital to consider in any museum exhibition [17][29]. It is interesting to note that the groups were not assigned to different topics by the session facilitator (although the topics the groups did address are largely part of the set of "basic requirements" from the first session). The division of topics among the groups was probably largely coincidental.

The first group focused on communication aspects and how to communicate with different audience groups. Their main idea was that different kinds of information databases would provide part of the support for such a communication process – in different languages, and for different age groups. The robot the group describes is something in between an information database and a museum guide, in that it provides an opportunity for individual, private dialogue about the exhibition at the same time as it has access to very detailed information. It is seldom possible for "ordinary" museum tour guides to engage in longer conversations with individual visitors during the tour. Within the museum technology research field, similar kinds of ideas are currently being explored (e.g., [8][30][32]). The group also provided a number of thoughts on technical details. The idea of projecting

images directly onto the ship to "illustrate what is going to happen" is particularly interesting, and is reminiscent of recent research within the ubiquitous computing field, research that is just now being introduced into the museum domain (e.g., [2][33][19][28]).

The second group focused on visual aspects and different kinds of participation. The large-scale 3D-animation of the ship serves both as a means for drawing audiences into the exhibition, but also provides visitors with a sort of "compensation" for not being able to walk onto the real ship. The display also presents the focus of the exhibition by illustrating how sulphuric acid is produced in the wood. The smaller exhibits are designed to allow their content to be seen from any direction, which highlight the issue of how museum visitors constantly shift between contemplation and being active, roles that are afforded by all interactive exhibits. One current trend in museum research is to examine how technology can be used to support different forms of participation, and how such participation can be made visible to observing visitors (e.g., [23][21]).

The third group focused on context and temporal aspects. A particularly interesting result of their work is that it questions and extends the originally intended scope of the exhibition. To illustrate, as the group has done in their concept, the entire history of the ship, naturally raises waste recycling and ecology issues, something that is not part of the original exhibition scope. The third group also took a somewhat more pedagogical approach than the other groups. One example is the "formula" where the physical "icons" from their model representing oxygen, sulphur and sulphuric acid are being used both to illustrate the chemical process, and to explain what the icons are (figure 5).

Thus, the groups were able to provide a number of concepts that embody ideas from current trends in museum research. In addition, some of the general ideas (such as projection onto artefacts and 3D displays) are just beginning to emerge and receive attention within museum research. Therefore, our participatory concept development was able to (at least in this case) produce design ideas that are both relevant and extend the initial scope of the exhibition in question.

The amount of resources required was modest: CID spent roughly 24 man-hours preparing and hosting the four sessions. The participants spent approximately nine hours each (excluding travel and the students' initial teaching session at the museum). Approximately $100 was spent on low-tech material.

6. METHOD EVALUATION

The students' written comments on the work method itself (acquired during session 4) can be grouped into the following categories:

The work environment: It is clear that the students felt that the sessions were positive and easy-going: the most frequent positive comment is "coffee breaks"! That a majority of the students feel strongly about the coffee breaks suggests that the breaks do not merely constitute a pleasant opportunity for socialising; they are extremely important for the work method itself (a similar conclusion is drawn in [1]).

Work material and planning: A number of the positive comments were related to working with low-tech material and video camera. However, some of the students also felt that the amount of time available for working was too short.

School issues: Quite a large number of comments deal with the students' relationship to their school. The fact that the students feel that it is positive to "work freely" and "not having to go to lessons" raises some interesting questions concerning the pedagogical methods currently being used in the school. Are the students too constrained in their day-to-day work, and if so, can aspects of the participatory methods described in this paper help? Another interesting issue is that the students who participated in our sessions received notes of absence in their report cards, something that potentially may have a negative impact on their future grades. Thus, in effect, even though the school endorsed the students' participation in the sessions, it also indirectly punished them (albeit in a limited way) for taking part in the activities.

Viewing things differently and contacts with "the outside": Swedish high school curricula rarely allow students to come in direct contact with adults' workplaces. Several of the students that participated in our sessions have mentioned that direct contact with researchers and the museum's personnel have been positive and have led to new ways of thinking about different issues. Thus, at least for these students, our work method has had positive pedagogical side effects (see [31] for a more detailed, similar argument).

Opportunity for influence: The foremost goal of cooperative and participatory design is to empower users so that they are able to influence the design process. Among users, this is – not surprisingly – seen as a mostly positive aspect. In this regard, our findings are not different: we received a number of positive comments from the students with respect to the ability to shape and influence a real museum exhibition.

Our documentation of the work process has also identified a number of challenges and aspects that could be improved:

Including a member of the museum's educational staff in each group had both positive and negative outcomes. The main benefits were that the work of the groups became an amalgamation of ideas from both students and educational staff, and that the adults were able to resurrect the discussion when it dwindled. The main drawback was that the adults sometimes tended to exert too much control over the general direction of the work. The difficulty of establishing roles in participatory processes seems to be rather common and appears to become less significant as the participants gain experience in working together (see, e.g., [35][18]). Allowing the museum personnel to partake in preparatory educational activities regarding their expected roles in the design activities might help.

Sometimes, the researchers influenced the work of the groups unintentionally. For example, in session 2 the low-tech material had been positioned at one end of the table around which the participants gathered. As a result, the students tended to work with the material that happened to be closest to them. An interesting area for further research is to attempt establish to what extent the available material (and how it is being introduced) shapes the outcome of the work.

It was hard for our participants to avoid reasoning about how "implementable" their designs were. For example, a number of the negative aspects from the students' concept evaluation (at the end of session 2) are related to the implied cost of the scenarios, even though they were explicitly asked to disregard such issues.

During the low-tech sessions, each group divided the construction work among its members after a short initial discussion. As a result, some of the students were "marginalized" in the sense that they focused solely on construction and did not take part in any of the ensuing design discussions. Thus, our low-tech approach has the ability to both focus the work for some participants, and to draw the attention away from the discussion for others.

The groups were given too many tasks to solve in session 3 (video recording, scenarios, and the evaluation data). This caused some confusion, and the groups had difficulties focusing on their work from time to time.

7. FUTURE WORK

Our partner museums are, so far, very pleased with our new participatory concept development and evaluation methodologies. At the time of writing, the Museum of Science and Technology is preparing to use our evaluation method to assess the rest of the exhibits in its Science Centre gallery, while the Vasa Museum has decided to work with CID to produce an exhibit prototype based on the students' concepts. If the evaluation of the prototype is favourable, it will be finalized and included in the large-scale exhibition. Also, the students' school has expressed an interest in learning more about participatory methodologies. The next step is to determine whether visitors can be involved even further in the design process, for example, during content development or exhibit design.

The fact that participatory design is able to produce high-quality user-oriented information technology does not necessarily mean that it can support design processes within other domains. Thus, there is a need for evaluating and validating the outcome of such attempts, not only with respect to the products of the design process, but also with respect to how the different stakeholders and participants feel about their participation. This is especially important within the museum domain, where current design practices have been developed and established over a long time period. It is our belief that the project described in this paper has taken the first steps towards such an introduction and evaluation.

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