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THE WELL OF INVENTIONS – LEARNING, INTERACTION AND PARTICIPATORY DESIGN IN MUSEUM INSTALLATIONS

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Abstract

This paper is concerned with how research on interaction principles, participatory design and museum learning can come together to inform the design of technology-intensive mixed-media museum installations. The paper has two main contributions. First, it presents a novel collaborative interaction technique and illustrates how it can be applied in a museum setting. Second, a new exhibition evaluation methodology adopted from participatory design is presented and assessed. The paper also describes how these contributions have been applied in the production and design of The Well of Inventions, a mixed reality installation co-developed by the Centre for User Oriented IT Design and the Museum of Science and Technology in Stockholm, Sweden.

Keywords: Collaborative Interaction Techniques, Evaluation Methodologies, Museum Learning Research

1. Introduction

Recent research on museum learning suggests that knowledge acquired by visitors during their visit can be highly subjective: personal motivation and previous knowledge interact with socio-cultural and physical factors to determine the learning outcome. We are not in a position to claim that such an epistemology is necessarily correct. However, we argue that it can provide inspiration for novel museum exhibition designs, and shall describe the design and implementation of a museum installation, The Well of Inventions, where a novel collaborative interaction technique we have developed has been combined with an open-ended socio-cultural educational goal.

We evaluated our installation in two different ways. We began by carrying out a standard summative evaluation using behavioural observation and interviews, but although this form of evaluation provided useful information, we felt that it did not capture a wide enough range of improvement suggestions from our visitors. Therefore, we decided to adopt an evaluation/brainstorming workshop methodology from participatory design research. The data provided by the methodology turned out to be largely consistent with the other evaluation methods and it also provided us with a large number of design suggestions.

The rest of the paper is organized as follows. Section two contains a brief overview of human-computer interaction research and provides a selection of relevant previous work in that area. It also contains a review of some recent museum learning research and describes how this has influenced the design of The Well of Inventions. The installation itself is described in detail in section three. Section four deals with the evaluation of the installation and introduces our workshop evaluation methodology. Finally, section five contains a discussion of our results.

2. Previous Work

Human-computer interaction (HCI) research can be defined as the study of human factors in the human-computer interaction process, including research, design, development, and evaluation of interactive computing systems. Its focus is on human communication and interaction with computer systems, and typically combines contributions from computer science, behavioural and cognitive research and systems design. During the last few decades, contributions from end users have also become increasingly important. Much of the research within HCI has traditionally been focused on ergonomic aspects and cognitive psychology, with the aim of providing an understanding of basic principles of interaction (Schneiderman, 1998). This work has resulted in a number of models that relate different human psychological functions to aspects of the interaction with the computer and a wide range of guidelines for user interface design.

During the early 1980s, usability developed as a major topic in HCI research. The development of usability as a new research area can be seen the result of an increasing concern for factors such as social aspects, work processes and the relations between computer applications, users and workplace (Bannon, 1991). Usability research thus deals with interaction in specific contexts and as a result, the focus is typically on experienced users and their work processes they encounter professionally rather than on novice users and general settings. Usability research also has a strong tradition of involving users in the design of new tools to support their work, the rationale being that the experienced end user is the person likely to know most about the challenges and problems that appear in his/her work. This has resulted in a range of new design methodologies that involve users to varying degrees.

The development of usability research in HCI can be seen as the direct result of a number of action-oriented research projects initiated in Scandinavia in the 1970s, often collectively referred to as cooperative design or the Scandinavian tradition in systems design (Greenbaum and Kyng, 1991; Iivari and Lyytinen, 1998). The first cooperative design projects were conceived of as a way to allow workers to influence how new technology should be designed and introduced into their workplace organization. However, after cooperative design was introduced in the United States as participatory design in the early 1980s, the research has focused less on workplace organization issues and more on the development of methodologies for involving users in systems specification and design (e.g., Muller et al., 1993; Beyer and Holtzblatt, 1998; Druin, 1999; Taxén et al., 2001; Bødker et al., 2000). Many of the methodologies from cooperative and participatory design tend to produce a large range of design ideas and suggestions from users and therefore, we believe that the adoption of such methodologies for the museum domain might provide new opportunities for dialogue between museums and their audiences. In section four, we describe how such a participatory methodology was used to assist in the evaluation of The Well of Inventions.

Contemporary HCI research is also often concerned with how different kinds of technology and devices can provide novel, alternative ways of interacting with computers. Examples of topic areas that have grown out of such research include ubiquitous computing (e.g., Weisner 1991) and augmented environments (e.g., Wellner et al. 1993). The SHAPE project (http://www.shape-dc.org/), of which the authors are participating members, belongs to this general area of HCI research. SHAPE is a part of the European Union's IST/Disappearing Computer initiative and is devoted to understanding, developing and evaluating room-sized assemblies of hybrid, mixed reality artefacts in museums. The project has produced a number of exhibitions and installations that combine interactive visual and sonic material with physically present manipulable devices

(Bowers, 2001; Stanton et al., 2003; Fraser et al., 2003). The Well of Inventions is part of SHAPE's second year project deliverables and is a direct continuation of ToneTable, a smaller installation that was produced during the project's first year.

ToneTable

ToneTable is a room-sized installation that consists of a rectangular table in its centre with a surrounding multi-speaker array. Activities at the table influences both computer graphics projected onto the table surface and the mixing and spatialisation of sound emitted from the loudspeakers (Bowers, 2001). Thus, the display surface and the sound environment are the main ways in which participants encounter the installation: the supporting computer technology (workstations, keyboards, monitors) is hidden. For reasons of simplicity, we decided to use trackball devices for the user/surface interaction rather than to attempt to follow the users' gestures through video-based tracking or through a touch-screen interface. The trackballs are positioned at the centre of each side of the table, which allows for up to four users to interact with the application simultaneously.

The users interact with ToneTable by manipulating a watery virtual medium projected onto the table (figure 1). Because we wanted to encourage collaboration between several users interacting simultaneously, we attempted to design the dynamics of this medium in such a way that individuals acting alone would gain some benefit from their activity, but that combined collaborative efforts of two or more users would enable features that would otherwise be difficult to obtain. Moving within the virtual medium produces ripples radiating out from a position given by each trackball. The superposition of two trackball positions yields ripples with a summed magnitude. Following elementary wave mechanics, sometimes these ripples cancel and sometimes they reinforce, producing a combined wave of greater magnitude than either participant alone can produce.

Fig 1: ToneTable.

In addition, a number of star-like objects are floating on the watery surface, each of which is associated with a sound. The visual position of the object is mapped to a spatial location in the audio speaker array (four surrounding the table and four beneath the table), so that the sound "follows" the object around the room. The behaviours of the floating objects are influenced by the amount of virtual force they experience: smaller amounts of force move the objects away from the trackball positions, while a large amount of force (as produced by two or more ripples) sends the objects into a circular orbit. Apart from producing a new visual feature, the orbiting also strengthens the impression of spatial movement of the corresponding object sound.

The ToneTable approach to interaction, co-present collaboration through a shared virtual medium, thus avoids switching interaction medium or mode to support collaboration, i.e., the users do not have to do different things or use new technical features in order to collaborate. With ToneTable, the interaction mechanism remains the same whether collaboration takes place or not (for an alternative approach, see Benford et al., 2000).

In spite of its simplicity, ToneTable provided us with a number of interesting areas for further exploration. It introduced a novel concept of collaboration and it successfully integrated an interactive graphical display with spatialised sound. The trackballs turned out to be a much more expressive device than we had anticipated: our visitors used at least six different types of gestures to interact with the watery surface, including flicking, circular rubbings and careful positioning using the index finger. We also observed a number of different kinds of verbal and non-verbal collaboration, including coordinated efforts to push the sound objects into orbit and "cursor chasing". ToneTable also turned out to be very straightforward to use: no special instruction or descriptive text was necessary to begin using it. These were features we wanted to retain in The Well of Inventions. However, we felt that a less abstract content would be more appropriate for the museum setting and as a result, we turned to current museum learning research in an attempt to identify a suitable approach to introducing such content.

Museum Learning Research

It seems that the educational design of many museum exhibitions is inspired by communication theory and different adaptations of Shannon's (1948) mathematical model of transmission of written messages. Shannon's model was first introduced to the museum domain in the 1960s, and appear to have influenced exhibition design to various degrees ever since (Hooper-Greenhill, 1994). Typically, it is assumed that the museum staff conveys messages or concepts to visitors through an exhibition design, and that different factors may enhance or interfere with the process (e.g., Dean, 1994; Lord and Lord, 2002). However, there seems to be a growing body of recent museum learning research that argues that the adoptions of Shannon's model are too simplistic. The main criticism appears to be that these models tend to neglect that learning may be dependent on the previous knowledge and interests of individual visitors, and on different sociocultural relations between visitors, staff and the set of communities to which the museum's activities are related (e.g., Hein, 1994; Hein 1998; Hooper-Greenhill, 1994).

This critique has resulted in the development of a number of alternative models of museum communication and learning. These are typically more holistic in nature and attempt to tie together issues such as the visitor's encounter with specific artefacts with how the museum contributes to the general knowledge of different communities (e.g., Hooper-Greenhill, 1994; Falk and Dierking, 2000). Thus, the challenge for any exhibition that is designed in accordance with these alternative models appears to be to provide for visitors with a wide range of backgrounds, previous knowledge, motivation and interests, taking part in a variety of social circumstances. It is perhaps not surprising, then, that many authors seems to emphasize aspects such as multiple learning modalities, opportunities for visitors to compare and contrast familiar concepts with new information and the presentation of novel perspectives on familiar objects (e.g., Caulton, 1996; Csikszentmihalyi and Hermanson, 1994).

Our approach to the educational design of The Well of Inventions was to attempt to avoid enforcing any specific didactical methodology. Instead, our installation is designed to provide a foundation from which different learning activities can be built. The design attempts to do this by leaving the choice of how to take advantage of the educational possibilities it offers to the visitors and museum staff. Thus, the educational goal of The Well of Inventions can be characterized as to attempt to encourage discussions on a particular topic relevant to the Museum of Science and Technology. We have attempted to introduce content into The Well of Inventions in such a way that that the opportunities for collaboration offered by the interaction principles developed in our ToneTable work encourages discussions of the content as well. We wanted our installation to be "hands-on" in the sense that it could be accessed directly without the need for written instruction, and we felt that it was important to preserve the sense of natural engagement that visitors often show when they encounter an interesting or mysterious object. Thus, we chose to display the written information in an area adjacent to but separate from the main installation room – the installation itself contains no written text or instruction whatsoever.

3. The Well of Inventions

The content and design of The Well of Inventions was developed in cooperation with the staff of the Museum of Science and Technology. A museum representative was part of the design team throughout the duration of the production and took part in continuous discussions on pedagogy, design and implementation. The topic selected for the installation was chosen with the help of a survey that was sent to all members of the museum staff. The survey asked the staff to identify important artefacts in the collection and many answers indicated objects in the museum's Machine Hall. This hall is a large hangar-like gallery containing steam engines, bicycles, airplanes and cars. Many of the objects and machines in the gallery share a common trait: they make use of propellers and/or turbines in different ways. Furthermore, the gallery also contains a number of historically important turbine and propeller specimens. Thus, the installation was designed to indicate, as a starting point for discussions, that there is a relationship between turbines and propellers and the medium in which they are used (c.f. figure 2), and that the Machine Hall is a resource for further information on the subject. Although the target audience for the installation is high-school students, the topic of dynamics has the advantage of being communicable to a larger range of age groups: with younger children the discussion could be about the usage of turbines and propellers in different forms of machinery, while for adolescents and adults the discussion might be about mechanics or the conversion between different types of energy. It could also readily serve as an introduction into more advanced topics such as that of sustainable energy sources.

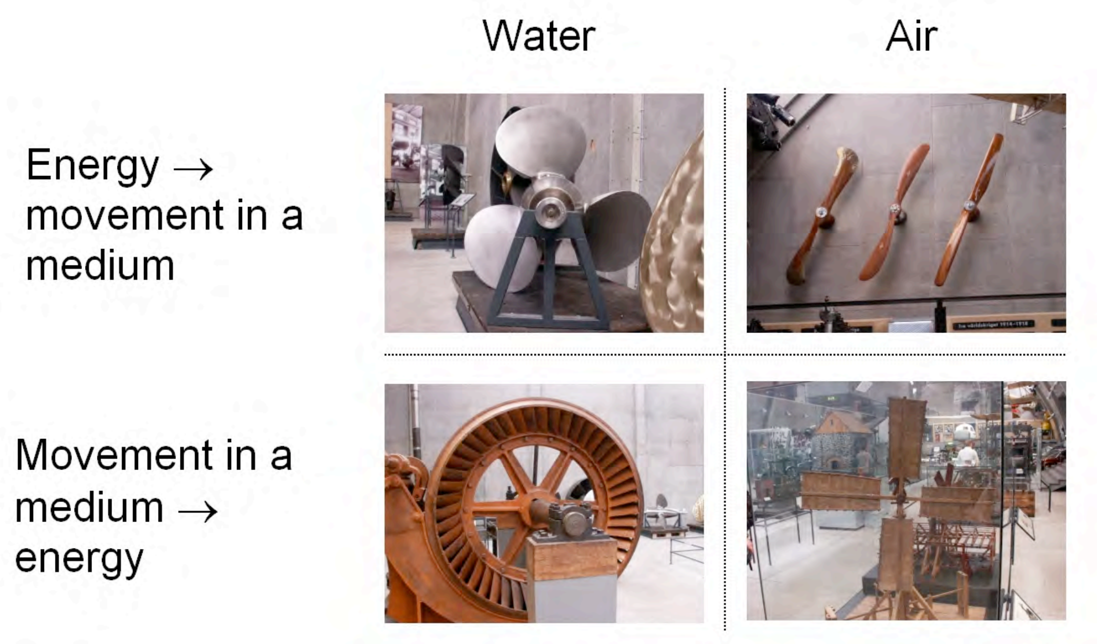

Fig 2: Relationships between propellers and turbines. Fundamentally, a propeller represents a way of converting energy into movement in a certain medium. Conversely, a turbine converts movement in a certain medium into energy.

Before entering the installation room, visitors walk through an antechamber that contains four computer monitors. Each monitor displays a copy of a slideshow with information about the installation and the SHAPE project. Similar to ToneTable, the main installation area is a room with a rectangular trackball-fitted table in its centre and a surrounding speaker array (figure 3). Projected onto the table is a virtual environment depicting an animated, water-filled well. A number of boat propellers and turbines are floating beneath the water surface, moving with the velocity of the fluid (figure 4). These objects are virtual representations of real specimens on display in the Machine Hall. When the velocity of the objects increase, so does their buoyancy, which makes them appear to move towards the water surface. When an object breaks through, it is visually transformed into its corresponding object for air (i.e., a boat propeller is transformed into an airplane propeller, while a turbine is transformed into a set of windmill wings). Above the water surface, the objects move with the velocity of the airflow. Here, their buoyancy is also connected to velocity, so that when an object slows down, it sinks towards the water surface and may again break through. When this happens, it is transformed back to its original appearance.

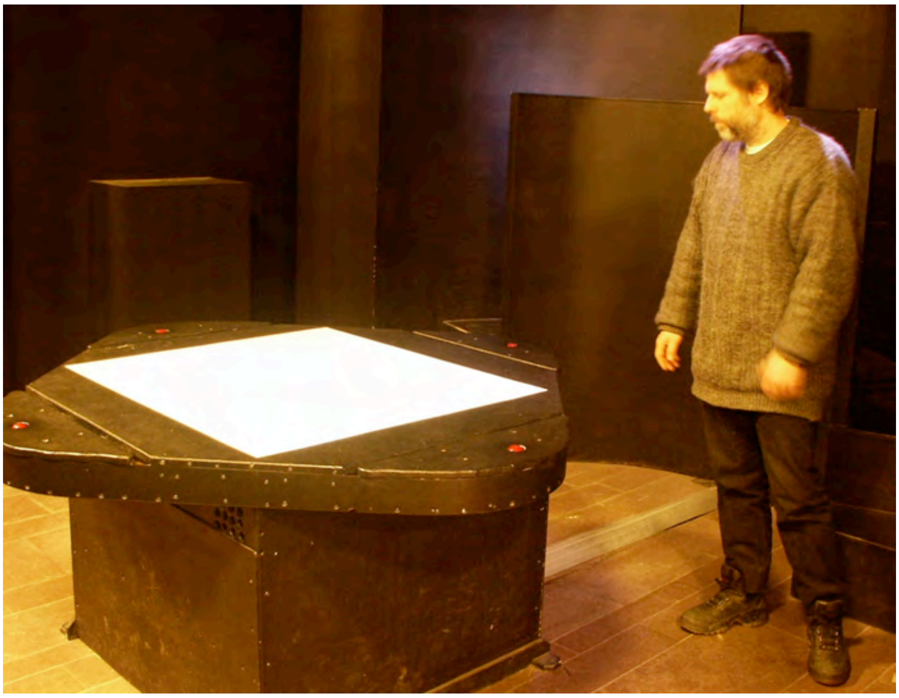

Fig 3: Table and trackballs in The Well of Inventions.

Fig 4: The animated graphical projection in The Well of Inventions.

As with ToneTable, the visitors influence the movement of the objects indirectly through the manipulation of a shared virtual medium (or, to be precise, through two superimposed virtual media: water and air). Each trackball has an associated cursor that follows the trackball movement. As the cursors move, they inject force into the simulations and thus, visitors can more easily push the objects through the water surface if they coordinate their activities at the table. As with ToneTable, each object has an associated sound that is spatialised in correspondence to the object's position in the graphical display. The velocity fields of the water and air are indicated indirectly through underwater weeds and leaves, respectively. In order to provide additional encouragement of higher-level subject discussions, we also decided to include a number of images of machinery where propellers and turbines are used. These images are subtly reflected by the simulated water surface and constitute the inventions referred to in the title of the installation.

Technology

Four trackballs have been fitted into the table and connected to a PC through a standard USB hub. The cursor positions of the trackballs are sent to an Apple G4 that produces the sound (see below) and a Silicon Graphics 330 workstation that renders the graphics. The graphics workstation also runs three simulations that is used to model water wave dispersion, turbulent fluid flow and airflow.

The wave dispersion algorithm is based on (Kass and Miller, 1990) and produces animated water surface waves. We modified the algorithm so that its viscosity parameter can assume different values across the surface, which allows the water surface to appear "sticky" in one part of the display at the same time as having a "flowing" feel in a different part. This feature was used to provide an additional opportunity for collaboration: when two or more trackball cursors are brought together for an extended amount of time, the surface area immediately surrounding them becomes increasingly sticky. An independent two-dimensional simulation approximates the turbulent fluid beneath the surface and is based a Navier-Stokes equation solver (Stam, 2001). When a trackball cursor is moved in a certain direction, a force proportional to the speed of the movement and with the same direction is added to the fluid along the cursor's path, which makes it possible to "stir" the water. The airflow simulation is based on (Wejchert and Haumann, 1991). An air vortex is positioned at the position of each trackball cursor and thus, the airflow is also reconfigured by trackball movement.

The motion of the propeller and turbine objects is governed by rigid body dynamics (Baraff, 1997). The force exerted on the objects is proportional to the underwater velocity field (beneath the surface) and the airflow (above the surface). In addition, a non-penetration constraint is enforced for the objects in order to avoid inter-object intersection (Dingliana and O'Sullivan, 2000). The data from the trackballs and the three simulations produces an image through the superposition of a number of graphical layers, which simulates effects like refraction (Vlachos and Mitchell, 2000) and reflection.

The sound of installation is produced in a similar manner to ToneTable. Applications written in MAX/msp (http://www.cycling74.com) manage the mixing and diffusion of sounds and also calculate appropriate measures of trackball activity and surface perturbation for sonification purposes. We use Pulkki's (1997) VBAP algorithm to spatially locate the object sounds. The sound representing the surface is synthesised using several chaotic oscillators (with each oscillator being a sinusoidal generator that frequency modulates itself via a short delay line) and the moving objects were sonified using looped sound samples. In addition, a sampled transition sound is played when objects cross the water surface. Initially, all the sounds in The Well of Inventions were synthesised using networks of chaotic oscillators, as this has a greater potential for interactivity than replaying sampled sound files. Unfortunately, a fully synthesised solution was beyond the processing capabilities of the computers at our disposal, which made it necessary to introduce recordings of the behaviour of a network of chaotic oscillators. These recordings are played back alongside live synthesised components.

4. Evaluation

The Well of Inventions was evaluated in two different ways. We began with a standard summative evaluation combining behavioural observation and staff/visitor interviews. This provided us with a general impression of the strengths and weaknesses of the installation. However, we felt that the summative evaluation did not provide enough information about the kinds of improvements the visitors themselves would like to see. Therefore, we decided to host a number of workshops whose goal was twofold. First, we wanted to allow a large number of visitors to provide their thoughts and opinions about the installation. Second, we wanted the workshop participants to build from these to develop suggestions for improving its design. In order to ascertain that the workshops generated relevant evaluation information, we triangulated the workshop data with the data from the summative evaluation.

Summative Evaluation

Two researchers observed visitors interacting with The Well of Inventions during approximately 12 hours, spread across 2 days. During this time, about 130 visitors approached the installation. The dwell times varied widely from a few seconds to more than 10 minutes (the longest dwell time we observed was about 30 minutes). Typically, visitors would stay for at least a minute if they "got hooked". A large majority of the visitors that entered the exhibition area also interacted with the exhibition, although a few groups seemed to be unable to spot the trackballs. Of those that interacted with the exhibition, about 20% discovered that it is possible to push the underwater objects through the water surface. It is unclear whether any visitor observed that the objects in the installation are virtual replicas of objects in the Museum's Machine Hall.

It was common for one visitor to discover a feature and demonstrate to other visitors how to use it. On several occasions, children would run off to fetch peers or parents from other parts of the museum, to whom they would then show the feature they had discovered. Children in the ages 10-13 seemed to be more interested in the exhibition than other age groups. These children typically viewed the exhibition as a game: they often (quite enthusiastically) referred to the transformation of objects moving through the water surface as "a kill". Adults showed the least amount of interest, and would often encourage their children to leave the exhibition while the children were still engaged at the table. Many young children were often fascinated by the graphical animation of the water surface and attempted to dip their fingers onto the display to "feel" the water. Older children typically focused on the movement of the objects and attempted to discover the underlying hidden rules of the animation.

Many of the visitors that entered the space as a group discussed the purpose of the installation and the nature of the interaction. They also verbally negotiated the meaning and underlying rules of the motion of the objects. However, the discussions rarely focused on dynamics and the relation between propellers and turbines. Furthermore, few visitors read the text on the computer screens in the antechamber. Occasionally, adult visitors would go back to the antechamber to read the texts after having tried interacting with the installation, but this happened very rarely. Some groups also spent extended amounts of time exploring the physical features of the room, such as climbing the platform or search for the hidden control room.

Two staff members of the Museum of Science and Technology and three visitors were interviewed. The interview data largely confirms the information we obtained through observation. The museum staff members we talked to observed that installation has a strong ability to attract people, even children that would otherwise be hard to encourage to stay and concentrate. Most visitors express a curiosity and want to know more. However, because of the lack of written information, many visitors also leave quickly. Thus, from the point of view of the museum staff, the installation does not really have a specific educational outcome. Its value is more as an indication of the possibilities of technology than as a way of presenting content. The visitors we talked to expressed an interest in the design and implementation of the installation, but also clearly struggled with how to interpret the educational purpose of the installation and how to make use of the opportunities for discussion we attempted to incorporate into its design.

Workshops

Three workshops were held at the Museum of Science and Technology on November 20 and 26, and December 3, 2002. The first of these was organized as an open seminar and had about 15 adult participants. We invited two high-school classes (with about 15 and 30 students, respectively) together with their teachers to participate in the two remaining workshops.

Our workshop procedure is adopted from the future workshop, an evaluation/brainstorming methodology developed within the cooperative design movement for assessing workplace organisations (Kensing and Halskov Madsen, 1991; Bødker et al., 1993). Each workshop begun by allowing 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 installation, we moved to a quiet conference room (containing tables, chairs and a whiteboard) 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 the whiteboard. This stage took roughly fifteen minutes to complete. 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. After about fifteen minutes, all notes had been accounted for. At this point, we took a fifteen-minute 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 keeping the positive aspects. Each group was shown to a quiet, private area and were given about thirty minutes to discuss. When the groups had reconvened in the conference room, we spent about thirty minutes talking about what the groups had discussed and what design suggestions they had thought of. A more detailed account of these discussions and the content of the Post-It notes are provided in (Taxén, 2003).

In our interpretation, the data acquired from the observations, interviews and workshops share five common themes. The first theme is that the educational purpose of the installation is perceived as problematic or non-existing. During our observations, visitors would frequently express a sense of puzzlement and curiosity. We also observed visitors discussing the purpose of the installation, and the purpose of the installation is also mentioned in all interviews. 44% of the workshop Post-It notes on negative aspects mentions lack of purpose or difficulty in comprehending the purpose and all brainstorming/discussion groups (in each of the three workshops) raised pedagogical issues.

The second theme is that the audiovisual design of the installation is largely perceived to be successful. During the observations, visitors and especially children were fascinated by the graphics and a majority of the interviewees mentioned sound and/or graphics as positive aspects of the installation. 51% of the workshop Post-It statements related to positive aspects are concerned with design, graphics and sound.

The third theme is that many visitors perceive the installation as engaging and fun. During the observations, we saw that pre-teen children were especially enthusiastic about the graphics and sound, and many visitors spent a large amount of time in the installation area. In the interviews, the museum staff told us that the installation has a strong ability to attract people, including children that would otherwise be hard to encourage to stay and concentrate. 26% of the workshop Post-It notes on positive aspects were related to fun and excitement. The subject was also raised during the brainstorming discussions.

The fourth theme is that the installation has the ability to encourage collaboration. We observed visitors that coordinated their trackball gestures in order to increase the velocity of the water simulation, thus pushing objects through the water surface. Some visitors also cooperated to reproduce the "stickiness" effect. During one visitor interview, the interviewees described how they coordinated their activity by chasing their respective cursor around the display. The workshop statements also mention collaboration (4% as a positive aspect and 3% as a negative aspect). Collaboration was also brought up as a topic during the brainstorming phase of the first workshop.

The fifth theme is that the physical design of the installation environment made the interaction devices hard to spot for some visitors. During the observations, we observed that several visitors left the main installation area without interacting with the installation, quite possibly because they had not seen the trackballs. The issue is also present in the interview data, and 7% of the workshop Post-It notes mentions darkness, difficulty of spotting the trackballs, or difficulty of relating trackballs to cursors as negative aspects. Darkness and/or difficulty of spotting the trackballs were also brought up as issues during the brainstorming phases in all the workshops.

5. Discussion

We would argue that the emergence of common themes in all three types of evaluation data (observations, interviews and workshops) suggest that the workshops did provide relevant evaluation information, and that they might be useful to evaluate other forms of exhibitions as well. Indeed, the Museum of Science and Technology are now independently adopting the methodology for evaluating their science centre exhibits.

However, an important difference between the workshops and the observations/interviews is the broad range of design suggestions we obtained through the workshops. Some of these suggestions were mentioned in all three workshops (e.g., improving the visibility of the trackballs, presenting the background information in a clearer way). This suggests that many visitors share these concerns, which makes them important to act upon. Interviews or questionnaires are good ways of obtaining suggestions from visitors, but we would argue that the workshop format could be used as a complementary method to assist in efficiently acquiring a broad range of detailed such suggestions from large groups of visitor representatives. For The Well of Inventions, the workshops and the summative evaluation demanded similar amounts of resources, but the workshops also provided us with opinions from roughly sixty visitors and the opportunity to engage these visitors in a fruitful dialogue about design and content.

Our evaluation data suggests that The Well of Inventions has the ability to encourage reflection, collaboration and dialogue. For many visitors, it provides a sense of mystery and is perceived to be fun, attractive and aesthetic. Furthermore, it gradually reveals new features as visitors are interacting with it and in many cases the result is long dwell times. We believe that this suggests that the interaction principle of collaboration through a shared virtual medium can be fruitful in museum settings.

On the negative side, our installation fails to communicate its purpose and background and it is perceived to have a questionable (or even non-existent) educational goal. Visitors very rarely perceive the important connection between the contents of the installation and the Museum's Machine Hall. The educational goal of The Well of Inventions was to provide an experience that could serve as a foundation for communication (verbal or non-verbal) between visitors (or visitors and museum staff) on the subject of dynamics. We believe the evaluation data indicates that this goal has been partially met. While the installation does encourage visitors to interact, think and reflect, the focus of the reflection process is typically the installation itself rather than the topic its design is intended to represent. Thus, some form of modification of the installation's design is necessary to guide discussions towards dynamics and machinery. The workshop data provided us with a large number of suggestions of how this could be done, ranging from replacing the computer screens in the antechamber with properly highlighted posters to introducing a narrative into the installation.

We believe that a museum, like any other institution, affords a certain set of socio-cultural conventions. These conventions include visitor expectations about different pedagogical and audiovisual aspects of exhibition design. When experimental installations like The Well of Inventions break these conventions, in this case by allowing information to be portrayed implicitly rather than explicitly in the design, visitors may become confused. Thus, it may be necessary to scaffold the visitor's expectations in such situations so that they know how to approach and understand the exhibition. At the time of writing, we are planning a re-design of The Well of Inventions to this end and a subsequent number of workshops to evaluate the outcome.

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