Envisioning & Evaluating "Out-of- Storage" Solutions

Luigina Ciolfi, Liam Bannon, Mikael Fernström
Interaction Design Centre
University of Limerick, Ireland.
[Luigina.Ciolfi; Liam.Bannon; Mikael.Fernstrom]@ul.ie

ABSTRACT

The successful introduction of technology into museums and exhibitions is a complex and difficult process. It requires detailed study of both visitor expectations and experiences and a sensitivity to curator and exhibition designer concerns, together with the concerns of architects and interior designers, in the case of newly built spaces. It also requires an understanding of the ergonomics of the spatial environment and the way that objects are located within the exhibition area, as these features affect the users' behaviour, and their communication and collaboration strategies. This paper provides some information on the process of introducing certain new multimedia artefacts into a new decorative arts museum - the National Museum of Ireland at Collins Barracks, Dublin. It includes a discussion of a usability evaluation of the resultant interactive media installations, noting several difficulties with the implemented solutions.

KEYWORDS: Museum technology, interactive media, visitor experience, usability.

INTRODUCTION

In this paper we present some reflections on the process of developing the specifications for interactive multimedia installations at a new museum – The National Museum of Ireland at Collins Barracks, Dublin, and examine the final implementation, noting certain problematic features of the achieved result. Our major goal here is not to criticise specific stakeholders or parties, as to the process or result, but to learn both from the process, and from our subsequent final evaluation of the achieved result.

The National Museum of Ireland was established by the Science and Art Museums Act, 1877. From its foundation it incorporated the scientific collections of the Royal Dublin Society (the basis of the present Natural History Museum) and in the 1890s the Royal Irish Academy's collection of antiquities was transferred to the state. The collections are displayed at a number of locations[1]. The National Museum at Collins Barracks, which opened in 1997, includes exhibitions of decorative arts, history and folklore. There are a number of special thematic exhibitions – i.e. "Curator's Choice", "Out of Storage", "The Museum at Work" and "Museum Development".

Other displays trace the development of the country through the ages. The

---

[1] The archaeological and historical collections are displayed at the National Museum in Kildare Street, Dublin. The Natural History Museum in Merrion Street, Dublin, holds an extensive collection of Irish and world zoology.

ichim 01

various collections chronicle the development of a vast range of arts and crafts including ceramics, silver, glassware, period furniture and weaponry[2].

The Collins Barracks building has been chosen as the venue for the collections as it offers good accommodation for the collections in its large rooms, and it is an interesting historical building itself, being a part of the longest continually-occupied military barracks in the world.
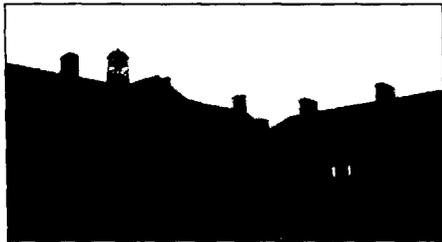

Fig. 1. Collins Barracks, Dublin.

One of the intentions of the curators in arranging the collections in the new venue was to provide visitors with an understanding of the quality and quantity of the Museum holdings. For, as is the case in many Museums, only a fraction of the Museum's holdings are on show at any one time. Consequently, another intention of the curators was to provide the visitors with the possibility of accessing a large body of information related to the collections, by means of introducing computer-based interactive applications in the exhibition rooms.

Our motivation in conducting the usability survey at Collins Barracks was to understand the visitors' experience of the interactive spaces. In particular, we were interested in how people approach, perceive and use the physical space, and

how they relate to the artefacts on display and shape their behaviour according to the affordances offered by this context. The specific space referred to in the title of this paper is very interesting as it is designed to encourage exploration of the many objects on display and to allow the development of one's own path through the space. The visitors are immersed in the space, surrounded by objects and closets they can actively explore. They thus need tools that encourage sharing, collaboration and communication and go beyond conventional 'desktop' applications, which do not involve the visitors in an engaging and rewarding museum experience (Falk and Dierking, 1992).

DESIGNING TECHNOLOGY FOR THE MUSEUM: THE IDC WORK AT COLLINS BARRACKS.

In 1996 the Interaction Design Centre at the University of Limerick was asked by the museum's curators to conduct consultancy work on the specifications for audio-visual and multimedia support, user requirements and design solutions for the multimedia installation to be introduced in the entire exhibition area at Collins Barracks, and in the assessment of tenders for the work (Fernström & Bannon, 1997).

The IDC was included, with a certain reluctance, in the Design Group for the project, which consisted principally of architects and planners. Surprisingly, this group did not contain any curators, and so, in effect, the IDC became a spokesperson for the concerns of the curators at these design meetings. As our own work is based on the importance of user involvement in the whole design process, this arrangement was very problematic for us, and one which, in hindsight, we would not

[2] http://www.heritageireland.ie/scripts/en/VenueP age.cfm?VenueID=32.

accept under any circumstances. However, at the time, we were keen to assist the curators in getting their concerns across to the design group, and given our involvement with the curators and the design team, we felt that perhaps we could act as agents for change.

From the IDC's perspective, the major design issue in this case was how to provide an engaging visitor experience of the quantity of material in the collection, and information on these items using new technologies, without overloading the visitor at a sensory or cognitive level with too much physical detail about the items.

The authors conducted an initial survey of the site, where physical renovations were underway, and had numerous contacts with the Office for Public Works, architects, specialists in lighting and A/V equipment in order to explore the availability and/or feasibility (in terms of costs and requirements) of different design solutions. We also engaged in extensive discussions with the curators, concerning the Museum material available, and the major narratives being developed for the artefacts.

The curators were then involved in discussions and focus groups and they were encouraged to express clearly any ideas they had about the possible uses of interactive multimedia in the galleries. There were other management committees overseeing the work on the new Museum, representing Government Departments, external Museum experts, etc., that handled overall financial matters and the public side of the development.

The museum management selected a user-group (art experts, other curators, academics in the field of Art History) that was involved in the discussions, but the general visitor perspective was not strongly covered. Consequently, an extremely important stakeholders group for the museum had a minimal impact on the design process.

The IDC group believe that this decision has affected the design process and its outcome, as it is vitally important to include the major group of end-users in the design of any system. This is required in order to analyse their features, preferences and behaviour so as to adapt the artefacts to the users and their activities (Preece, 1993; Hix & Hartson, 1993). The design solutions must be assessed on their effectiveness in responding to people's needs and behaviour strategies; in other words, in responding to the real *situations of use* (Bannon & Bødker, 1991).

Despite these practical limitations, we proceeded with the development of scenarios focused on a series of spaces within the museum, envisioning possible situations of use involving different artefacts and interaction styles (Carroll, 1995). One area was of particular interest in this regard: the "Out of Storage" gallery.

THE "OUT OF STORAGE" SPACE: SUPPORTING DISCOVERY AND LEARNING

The "Out of Storage" gallery provides an extensive view (two storeys) of museum artefacts from storage, not arranged in a structured exhibit, but rather exhibited as being exemplars of vast collections of material still in storage. The intention behind the room was also to chronicle certain major historical events in the life of the Museum, particularly those that affected its collections policy over its lifetime.

According to the ideas expressed by the curators, the room needed to give an impression to the visitor of both a

597

warehouse and a treasure trove, without being cluttered or indecipherable. Large window cabinets and open drawers encourage the exploration of the materials stored in the room: the users have to open up drawers to discover what they contain and to approach the cabinets at two different levels of the room. This allows the visitors to comfortably observe the objects displayed both in the lower and in the upper shelves of the cabinets.

The large variety of objects on display, their different sizes, origin and historical period make the "Out of Storage" space very different from a traditional museum gallery, as the visitor is allowed to browse the artefacts without any form of sequencing information, normally provided in traditional galleries.

On the contrary, this particular space encourages the visitors to develop their own paths and discovery strategies during the visit. The disposition of the room itself supports the sense of involvement and immersion, as the visitors find themselves surrounded by the glass cabinets and the open drawers that contain the art pieces. The conception is a striking one, and its realisation visually arresting. The challenge was then how to support visitors in understanding this physical space and array of exhibits without affecting the overall experience of the space as a "cornucopia of delights" (Fernström & Bannon, 1997).

We believe that technology in museums should support the comprehension and enjoyment of complex and meaningful artefacts (the artworks), and adapt itself to a structured environment (museum or exhibition), extremely rich in information resources and perceptible clues. Media applications should overlap in a seamless way with the objects they provide information about, and involve the visitors in a pleasant and rewarding experience by means of flexibility and personalisation of information.

It is clear that a technology to be introduced into the "Out of Storage" space must respond to its very particular nature and it must support adequately the activities that can be performed by the visitors within the space. In particular, the educational potential of the room has to be supported and amplified; in fact, the process of learning in museums seems to be more likely related to the possibility of directly interacting with objects, instead of, for example, reading labels or guides (Caulton, 1998). It is unlikely to find in traditional museums (differently from hands-on exhibitions or exploratoria), spaces where the exploration by the visitors and the direct interaction with the objects on display is allowed (Hooper-Greenhill, 1992). Through the active exploration of cabinets and drawers the "Out of Storage" allows the users to experience discovery and freedom to structure a unique path in the visit.

The visitors' direct engagement with the exhibit encourages the development of their curiosity and interest towards what they are observing, and this precipitates to the experience of a condition of what has been called *flow*: the involvement happens at the sensory, intellectual and emotional levels and the visitor is highly motivated and consequently stimulated to further exploration (Csikszentmihalyi & Hermanson, 1994).

Our approach to interaction design is committed to the support of visitors experience in this respect, particularly, envisioning possible devices (input-output) and systems architectures that could suit the museums context and allow the users to fully engaged while visiting the environment as a whole.

We envisioned a variety of possible

598

interactive applications (prototypes) based on different devices, but all focused on the main goal to enrich the visit experience and to highlight the value of artistic heritage, without distracting the users and interfering with their comprehension and enjoyment of the artworks.

Our proposed solution for the "Out of Storage" gallery was essentially driven by the requirement of supporting human perception and physical response within the context, as the space's physical and perceptible features, or *affordances* (Gibson, 1979; Norman, 1993; Norman, 1999), naturally call for behavioural responses by the visitors. The style for interaction should be designed to be flexible, without physical constraints and responsive to the visitors behaviour. Our proposed solution for the "Out of Storage" gallery was essentially driven by the requirement of supporting human perception and physical response within the context, as the space's physical and perceptible features, or *affordances* (Gibson, 1979; Norman, 1993, 1999), naturally call for behavioural responses by the visitors. The style for interaction should be designed to be flexible, without physical constraints and responsive to the visitors behaviour. Our initial recommendations were for a wireless tool to ensure the visitors were free to move in the room as they preferred, and the use of a "pointing" interaction style: just pointing at the object of interest would have allowed the users to listen to a 3D auditory comment. This tool would support unobtrusively the exploration and enjoyment of the space and would allow the users to be close to the objects, and to observe them carefully while being provided with a comment or a description. The development of multisensory interfaces, wireless or

'invisible' appliances, grounded on the physical space and unobtrusively supporting human physical behaviour are core issues of this perspective.

Our suggestions for the use of interactive media focussed on the nature and amount of documentation on the artefacts available (in many cases documentation was quite sparse), the possibilities for interactivity, and the general ecology of the museum space where the artefacts would be located. In a number of cases, we recommended that simple still images or audio/film strips would be sufficient. Only in a relatively small number of cases could we make powerful arguments for computer-based media. (One such example concerned the silver collection, were many visitors had a strong interest in determining the provenance of specific items, and so there was an obvious need for a database of information, and an image collection.) Our approach created some problems within the design group - at the level of policy concerning procurement of audio-visual and interactive multimedia installations, as others wished to allocate the technology budget *en bloc* as a single specific budget allocation for 'multimedia'. In our view, this separation of the technology provision at an early stage was problematic.

Ultimately, interactive media were installed in the "Out of Storage" gallery, but the implementation differed in fundamental ways from the outline scenarios we had devised. While the original plan was for the IDC to be involved in evaluating the implementation by the contractor, this did not happen, for complex organizational reasons, and our consultancy ended at this point. Nevertheless, we were keen to discover

what was ultimately provided, and over a year later, with the addition of new staff, we were able to carry out a brief evaluation on the interactive multimedia that had been installed, concentrating on two areas, including the "Out of Storage" gallery.

EVALUATION

An informal evaluation of the new technology in the Museum had been conducted by the IDC researchers involved in the original specification work described above, which noted some difficulties. Subsequently, a more extensive evaluation was conducted by a new member of the IDC staff that was not involved in the earlier work. Certain problematic areas of the site were noted and a further review of the site was conducted by the new researcher. It is principally the report of the latter researcher that is provided below. In the later phases, all the researchers involved spent some time in assessing the relation between the original design concepts and the final implementation.

Initially we performed a survey of the museum in order to clarify the exhibition's structure and organisation, conducting a preliminary heuristic evaluation of the main multimedia installations and collecting some data on their effectiveness (Preece, 1993; Nielsen and Mack, 1994). The main goals of the survey were to focus on the organisation of the museum, the intended and the actual role of the several multimedia applications and, in particular, the way these installations fit the exhibition's physical space.

Consideration of the findings coming from the first survey at the Museum and the discussion of data followed at one of the IDC research meetings. From that

several evaluation issues have emerged. In particular:

1. the problem of the integration between the technological installations and the museum's physical environment. This required further observations of how users interact with the applications and the way they behave towards them;
2. the problem of the exploration and enjoyment of the space itself in order to design more effective information resources. This required further observation of how the visitors move through the space and how they behave towards the objects that are exhibited.

We thus planned and performed two observation sessions, conducted during different days of the week, so that we could include different groups of visitors (e.g. art students, school classes, foreign tourists during weekdays; art *amateurs*, tourists from Ireland and Dubliners and families during the weekend).

The observational study focused on specific aspects of the visitors' behaviour within the space, as well as their interaction with the computers and, specifically, the graphical user interfaces. A number of specific visitor behaviours were noted:

- physical path of the visitor in the room
- pauses in front of the cabinets
- use of the free space (windows, benches, aisles, etc.)
- use of the information resources (labels, panels, descriptions, guards

or guides, books, multimedia[3])
- possible breakdowns and/or problems with artefacts
- total time of the visit and time of stops.

We applied various evaluation methodologies such as observation, usability analysis, heuristic evaluation and cognitive walkthrough (Preece, 1993; Nielsen and Mack, 1994; Hix and Hartson,1993). We observed 30 visitors during the first observation session (weekday), and 70 visitors during the second session (weekend). In the following section we present in detail the outcome of the sessions conducted in two specific galleries of the museum, where there is a significant use of computer-based installations.

TECHNOLOGY IN THE GALLERIES: SOME RELEVANT CASES
The Cloyne Harp

The "Exhibition Development" gallery (located on the 2nd floor, West block) is intended to present the development of the Collins Barracks collection and its forthcoming acquisitions and rearrangements.

In the gallery, there are two multimedia installations. By means of the first one, the users have the possibility to consult other museums' websites offline.

The second application focuses on a single object, the ancient "Cloyne Harp". As the main purpose of our survey was analysing how the technical appliances and installations fit the physical space and the artworks' locations, this specific part of the "Exhibition Development" room is particularly interesting, because the A/V

presentation is related to a specific artefact and its display, and it is located in the immediate surroundings of the object itself (see fig. 2).


Fig. 2. The Cloyne Harp exhibit inside the wall (left) and the interactive installations (right).

The PC screens lean out of an upright wall that surrounds the cabinets where the reconstructed Cloyne Harp and the fragments of the original instrument are located. This round wall is placed in between the harp's cabinet and the aisle along the windows.

The PCs stations are endowed with headphones and chairs. The screens are placed at different heights to respond to the physical features of different users. The monitors are settled inside metal shells that are supposed to shelter them but, actually, it is extremely easy to turn them off.

The natural light entering the room by two windows might have been used to good effect in lighting the harp exhibit, but the upright wall covers the light as well as the objects on display. Problems in the physical location of the installation and of the harp itself are noticeable: the users cannot see the harp while sitting in front of the PCs.

---

[3] We then proceeded to further specific observations regarding the interaction with multimedia applications.
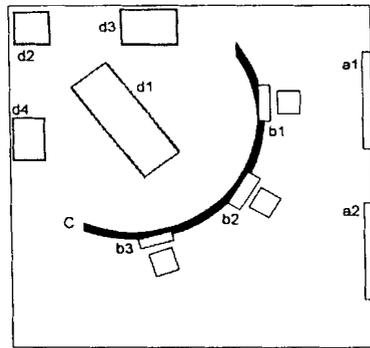
a1, a2: windows;
b1, b2, b3: computers and chairs;
C: wall;
d1, d2, d3, d4: glass cabinets containing the reconstructed
harp and the original fragments.

Fig. 3. The Cloyne Harp exhibit: outline.

The wall has some openings between every two screens, but they are too far from the user's location to allow the visitor to look at the harp. Moreover, given the location of the wall, people who are sitting on the benches under the windows cannot see the harp either (see figure below).

Almost all the visitors we observed sat down in front of the computers, but, as soon as they started reading information about the harp, they realised they couldn't look at it and they abandoned the interaction with the machine to move back to the surroundings of the artwork. The installation clearly prevents the visitors observing the art piece and to access the information, not only in a seamless way, but overall. The structure of the informative medium does not support the affordances of the space and the behaviour the visitors perform within the physical environment.

As well as analysing these aspects of the physical and contextual relations between the presentation and the harp,

we conducted a thorough heuristic evaluation of the interface by means of an extensive walkthrough of the system and focused observations on the users, aiming to asses the effectiveness of:
- user interface and interaction styles
- role of sound
- information organisation and delivery.

The devices consist of touch screens and headphones.

After 30 seconds without any interaction, the system returns back to the first page.

A set of basic commands is available on the interface:
- touch anywhere to continue,
- touch a button to choose a section,
- click on a word to learn more.

A general problem the user encountered was that there is no way to go back while browsing the presentation (it is possible just to touch the screen to go forward): in order to browse another section the user has to exit the current one, then to choose another. The use of sound is limited to the "Hear the Harp" section only, while it could be effectively used for providing other information, such as brief description, comments, music clips. Eventually, all the icons that introduce the sections are graphically represented by the same picture and this did not help the users to have an immediate idea of the different topics available.

The sections available in the presentation are:
- harp
- original
- reconstruction
- hear the harp

In the case of the "Cloyne Harp" exhibit, even though the system is sufficiently

602

well designed and the interface simple and quite straightforward, the choice of a kiosk as interaction device and its placement do not fit the space and do not respond to the visitors behavioural strategies within the space.

Even if the presentation is relatively good, the design choice is not effective because the context structure and the patterns of action within it are not taken into account to develop the solution. The users tend to interact with the system only for a few minutes, then they prefer to move back to the surroundings of the object to observe it.

A shortcoming of the information body was also pointed out by means of the observation of users interacting with the system. There are some other ancient harps in the Museum and this gives the possibility to create cross-references between similar pieces of the exhibition, located in different sections or rooms. The verbal account from the observations revealed that a good number of visitors were able to remember some of the other harps displayed at Collins Barrack; they mentioned similarities with the Cloyne Harp and expressed their interest in learning more about this topic: unfortunately, the information available on the interactive presentation does not cover this subject, missing the opportunity to create links with other objects of the collection and stimulate correlations and further reflections in the visitors.

Out of Storage

As said in advance, the "Out of Storage" gallery (1st and 2nd floor, West block) is a very impressive physical space: the lighting is excellent, and the double entrance at two levels allows for the possibility of having two different views on the exhibit, as well as increasing the visitor space.
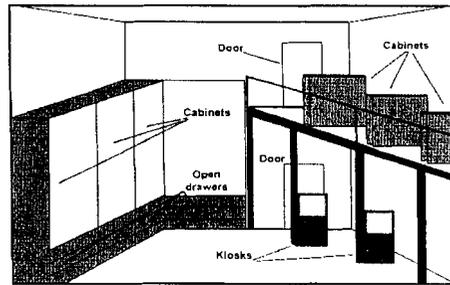

Fig. 4. Outline of the exhibit in the "Out of Storage" Gallery.

The underlying idea of object "storage" is extremely interesting and it can be an effective way of displaying a series of pieces that otherwise would not been on display due to limited space and resources. In particular, the possibility for "discovery" of the drawers' contents is potentially very interesting and involving for the visitors, and the visibility of the objects in the glass cabinets is very good.

The room does, however, have some drawbacks. One problem in the room's organisation is the weak mapping between the cabinets and the related descriptive labels put on the walls some distance away (see figure 5). Sometimes the panel on the wall does not correspond to the nearest cabinet and the user can easily mismatch the object and its description. The users we observed had difficulties in understanding what description was related to a certain shelf, drawer and object. They complained that there were a lot of interesting objects to observe but they could not find out what they were. Moreover, the series of numbers used to identify the objects in the cabinet's shelves is repeated very similarly for any cabinet in the hall, which can cause confusion as well.
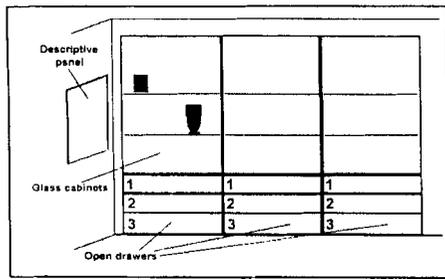
603

Fig. 5. Outline of the main exhibition cabinets in the "Out of Storage" Gallery.

The iconic representation of the objects beside their descriptions in the label (see figure 6) does not help, as there are a lot of similarly shaped pieces in the shelves (vases, glasses, containers) and they can be easily confused.
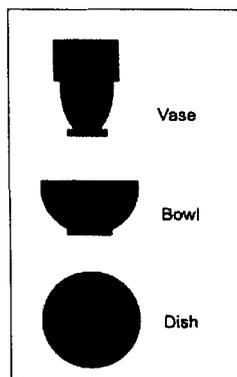

Fig. 6. Iconic representation of the objects in the descriptive panels.

Concerning the multimedia presentation, we previously described the IDC recommendations for this room that included the encouragement of the user to remain in the surroundings of the objects and to explore the drawers, as the browsing and understanding of information should to overlap with the

activity of discovery and observation of the pieces (Shuh, 1994).

The computers are located beside the windows, along the only wall where no objects are displayed: they are endowed with a touch-screen and installed into kiosks at different heights. They are very distant from the glass cabinets, and some of the visitors we observed did not even notice them, as they were attracted by the variety of objects in the room and by the drawers. The users who approached the computers interacted with them only briefly, then moved away. From the informal data collected during our observations, the average duration of the users' interaction with the system is very low: out of 100 visitors observed, over half of them used the system for a time between 5 and 10 minutes.

If we consider that accessing and reading the description of a single object can take some minutes, this data makes clear that the presentation is not being used appropriately by the majority of visitors. In other words, it does not achieve its purposes.

A problem in the multimedia presentation structure is that it requires as many as 8 screens to reach a single description, and it is not easy for the user (being at the deepest level in the menu structure) to be aware of the current location and to return back quickly either to the main menu or to the upper level. In this respect, there is a lack of an effective "home" button, as the back button works as "history" and it keeps track of all the pages previously displayed, rather than of the different levels of information structure. The main introductory page of the presentation is problematic in terms of the layout used, as it presents a very large blank space that might be better

used for a "welcome" or a more appealing introduction to the system. The presentation is quite rich in information resources, even if they are problematically arranged. Some other specific problems identified in the observational study: first of all, in the interactive system there are no indications about the cabinets' and drawers' identification numbers. For this reason, the references to the real locations of the objects are not clear. The mapping between the information space and the real space is thus not effective and this creates problems for the users in associating an object to the related information and vice versa. The interaction style is based on a touch screen, which causes some problems as users cannot easily operate on some interactive portions of the device: in fact, some of the "hot spots" are located near the edge of the screen and the users do not have enough room to touch the surface with their finger. We observed numerous visitors showing frustration at being unable to designate the part on the screen. In the case of this gallery, the interactive presentation itself has problems in its structure and interface. More importantly (as we saw for the Cloyne Harp), it seems the technology does not respond to the environmental conditions in which it is located and the visitors prefer not to use the tool as this distracts them from observing the objects and exploring the exhibition space.

CONCLUSIONS

Collins Barracks is a very interesting museum in a number of respects. The building itself is architecturally impressive, and the renovation work has been done in a tasteful fashion. Inside, the development work has been done with the utmost sensitivity, creating a number of superb exhibition spaces within the confines of the original physical structure. Also, the Museum exhibits have been thoughtfully displayed within the spaces. Our focus here has been to examine some of the successes and failures of the new technology being used within the museum with a view to gaining a better understanding of technology in museums. We have noted how visitors do not engage with a number of the interactive media installations – a common finding in many museums and exploratoria around the world. Our analysis has attempted to show how an understanding of the physical setting, together with an understanding of visitor behaviours can allow us to understand why certain of the technological installations were problematic in terms of user acceptance and use. The kind of appliances that have been introduced are not suitable in supporting the users' behaviour. In certain instances the kiosks interpose themselves between the visitors and the objects, preventing the visitors from maintaining their physical proximity to the exhibit. Approaching the computers thus breaks a condition of flow (Csikszentmihalyi, 1990) and engagement they are experiencing during the visit. In other cases the computers are not interposed, but then they suffer from too distant a linkage with the actual exhibit, both physically and semantically, and users are unable to make the link between the artefacts and the installations.

Our observation and analysis of the spaces and interactive media exhibits in Collins Barracks are part of a range of studies of museum spaces and exhibits that we are conducting at the IDC as part of our work on the EU SHAPE

project (Situating Hybrid Assemblies in Public Environments). This study shows how important it is that in the design process of SHAPE we incorporate important topics such as visitor studies, analysis of human interaction within public places, analysis of the physical space that accommodates the exhibit together with the objects on display, and the way they are perceived and experienced by the visitors. The process of technology exploration must also take into account these aspects.

ACKNOWLEDGMENTS

REFERENCES

1. Bannon, L. Use Design and Evaluation: Steps towards an integration, in Shapiro, D. and Tauber, M., Traunmueller, R., Eds. *The Design of Computer-Supported cooperative Work and Groupware Systems* (series "Human Factors in Information Systems", vol. 12). Amsterdam: North-Holland.

2. Bannon, L. and Bødker, S. Beyond the Interface: Encountering Artifacts in Use, in Carroll, J.M., Ed. *Designing Interaction: Psychology at the Human-Computer Interface.* New York: Cambridge U. P. 1991.

3. Carroll, J.M., Ed. *Scenario-Based Design*, New York: Wiley & Sons 1995.

4. Caulton, T. *Hands-on Exhibitions*, London: Routledge 1998.

5. Csikszentmihalyi, M. *Flow. The Psychology of Optimal Experience*, New York: Harper Perennial 1990.

6. Csikszentmihalyi, M. and Hermanson, K. Intrinsic motivation in museums: why does one want to learn?, in Hooper-Greenhill, E., Ed. *The Educational role of the Museum*, London: Routledge 1994.

7. Fernström, M. and Bannon, L. Enabling Technology for Museum Visitors: Issues and Experiences, in *Proceedings of the International Conference on Museums and the Web 1997*, Los Angeles 1997.

8. Gibson, J.J. *The ecological approach to visual perception*, Boston: Houghton-Mifflin 1979.

9. Hix, D. and Hartson, R.H. *Developing User Interfaces. Ensuring Usability Through Product and Process*, New York: Wiley 1993.

10. Hooper-Greenhill, E. *Museums and the Shaping of Knowledge (The Heritage Care Preservation Management)*, London: Routledge 1992.

11. Nielsen, J. and Mack, R., Eds. *Usability Inspection Methods*, New York: Wiley & Sons 1994.

12. Norman, D.A. and Draper, S.W. *User centered system design: new perspectives on human-computer interaction*, Hillsdale, NY: Lawrence Erlbaum 1986.

13. Norman, D.A. *Things That Make Us Smart. Defending Human Attributes in the Age of the Machine*, Reading, Mass.: Addison-Wesley 1993.

14. Norman, D.A. Affordance, Conventions, and Design, in

«Interactions» vol.VI-3 May/June, New York: ACM 1999.

15. Preece, J., Ed. *A Guide To Usability. Human Factors in Computing*, Reading, Mass.: Addison-Wesley 1993.

16. Roy, D.M. and Panayi, M., Eds. *Proceedings of the International Workshop on Physicality and Tangibility in Interaction: Towards New Paradigms for Interaction Beyond the Desktop*, 1³ Annual Conference-Siena 20th October 1999.

17. Shuh, R.H. Teaching yourself to teach with objects, in Hooper-Greenhill, E., Ed. *The Educational role of the Museum*, London: Routledge 1994.

ABOUT THE AUTHORS

Luigina Ciolfi is a research officer at the Interaction Design Centre, University of Limerick. Her research interests include HCI, interaction design, usability practice, information design, and particularly the development of technology for museums and artistic environments. Her current doctoral research focuses on user activity analysis and interaction design for public and social spaces.
E-mail: *Luigina.Ciolfi@ul.ie.*

Liam Bannon is Professor of Computer Science and Director of the Interaction Design Centre in the Dept. of Computer Science and Information Systems at the University of Limerick, Ireland. He has been involved for many years in the fields of human-computer interaction, information systems, and computer-supported cooperative work. He is currently involved in several EU projects concerned with ubiquitous computing and interaction design.
E-mail: *Liam.Bannon@ul.ie*

Mikael Fernström M.Sc., is lecturer in the CSIS department at the University of Limerick. Mikael is co-designer of the LiteFoot interactive floor. His research interests cover Computer Science, HCI, Electronics, Sound, Music, Multimedia, History, Archaeology and the Performing Arts. He is currently working on his doctoral research in Ecological Sound Design in the context of Human-Computer Interaction.
E-mail:*Mikael.Fernstrom@ul.ie.*