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Evaluating the Social Context of ICT Applications in Museum Exhibitions

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Abstract

The spreading of Information and Communication Technologies (ICT) in exhibitions is, among other reasons, due to the wish of curators to find new ways to improve visitors' experiences in museums. This has lead to an interest to understand if and how they really work as a museological and museographical element and assess their effectiveness. However, systematic studies in this field remain very limited or are not of sufficient depth. Although the technological field has a long tradition of assessment, this usually concentrates on technological, attitudinal or cognitive issues and does not take into account the specific features of the visit in a museum or cultural heritage site and the importance of the social context. This paper stresses the need to carry out and take into account the results of a systematic body of analyses dealing with how technological displays are really used. It also discusses the need to concentrate on the social dimension of the visit and use of ICT and to develop the methodological aspects. Based on previous studies and on our own research, the contribution of this paper is twofold: firstly, it provides an overview of empirical results concerning the use of different kinds of ICT exhibits and secondly, it discusses some preliminary ideas aimed at the construction of a methodology for evaluation. The aim is to establish the basic guidelines for the effective integration of ICT applications in museums and cultural heritage.

Categories and Subject Descriptors (according to ACM CCS): J.5 [Arts and Humanities]: Cultural Heritage, Museums, evaluation, qualitative studies

1. Introduction

The spreading of new technologies as communication tools in exhibitions is not only due to fashion and socio- economic pressures, but corresponds also to the most recent stage of a museological renovation trend which started in the last third of the 20^{th} century and aims at improving the visitors' experience. As ICT applications have proven to be effective for learning and communication in other contexts, museums adopted them for their exhibitions hoping to introduce better ways of communicating with their visitors and to encourage their participation. This interest in their integration in exhibitions has now led to an interest in verifying if they really are effective in the museum environment and understanding how they operate in that context.

Three fields have undertaken research evaluating ICT applications in cultural heritage. The first of them is technology/engineering: this has a long tradition of studies, for example inside the specific branch of Human-Computer Interaction, but mainly focused on technological issues related to usability of the interface. As the field evolves, research studies have recently been concerned with some aspects closer to museum interests, like multi-user environments and interfaces, but they still do not question the traditional linear and sequential computer interaction paradigm. The second field is formal learning environment, which is concerned with cognitive issues arising from the use of technology for learning, but their results can only be extrapolated to some extent to museum settings because the contextual conditions of the classroom and the exhibition are different. The last field where evaluation studies have taken place is museums, where the spreading of ICT displays has recently led to an interest in evaluating their effectiveness from a communicative/learning point of view. In this direction, cultural organizations have often collaborated with external bodies or commissioned related studies. However, these studies are either mainly aimed at studying visitors' attitudes and perceptions [e.g. VKT*01, OBP05] or they are undertaken by organi-

zations and researchers working in the previous two fields and for this reason they are more concerned with their interests, rather than taking into account museological issues, and especially the social dimension of the visit, which has been demonstrated to be paramount in the informal learning environment.

According to recent museological thinking, the museum experience can be conceptualized as the dialectical relationship each person establishes with space and time [MW05], that is, with all the components constituting this physical, emotional and cognitive environment. ICT applications seem to fit perfectly this experiential perspective because they necessarily entail an interaction, a dialogue, between the machine and the user. The problem is that until recently this dialectical concept has been understood as an individual experience -an idea shared and reinforced by the technological interaction paradigm- while, the education and later the museum field [McM88, FD00, HG94, FD92] have shifted their attention to the social experience, taking into account how people interact with each other. In situ observations have shown that even in the case of individual visits [Gal03, vLHH05, vLHH02, HvLO05], people always explore exhibits through direct or indirect interaction with all the visitors that are sharing the same space: the importance of this "social dimension" as a crucial element of the museum experience has been demonstrated by the fact that even diametrically opposite approaches to the experience of art in museums reach the same results when the construction of meaning is achieved through social interaction [Pie05].

Thus, there is a need to carry out evaluation studies which take into account the specific features of both exhibition visit and technological applications, and develop the data collection and analytical methodology accordingly, because as some authors have pointed out [HvLO05, Rou04, Man01], the traditional quantitative methods (e.g. timings, learning tests) have proven to be insufficient for offering a real understanding of what really happens with high-tech exhibits in museum galleries and study the complex set of parameters which affect the visitors' experience.

2. Building an integrated methodology for ICT evaluation in museums

Evaluation should be developed in two complementary directions: from an empirical point of view, focusing more on the way people behave at and around ICT applications, including the qualitative aspects, and not only on usability or cognitive results; and from a methodological point of view, trying to identify standard indicators of the analyzed phenomenon and then look for the factors which determined its existence. This might seem to some extent contradictory -as typified indicators are associated with the behavioural model of evaluation, examining mainly external, measurable indicators of learning- but we have to bear in mind that observable does not necessarily have to be associated with quantitative methods and learning. In order to understand the impact of technological exhibits in any of its perspectives (knowledge acquisition, emotional aspects, social interaction, etc.) we need elements of analysis which have to be necessarily external (when the researcher's point of view is used) or externalized (when the visitor's point of view is used).

Starting from this fact, different evaluation methods can be used (observation, questionnaires, interviews, focus groups, etc), each of which can be aimed either at qualitative or quantitative factors because these features are not exclusively inherent to any specific evaluation category but depend on the goals established by the underlying museological/learning theory. In our research we are concerned with the development of an observational methodology because it is one of the most powerful means to describe or verify fundamental hypothesis about what happens during interaction with exhibits -namely, the process of constructing meaning through social interaction in the social-constructivist model of learning. In conclusion, we propose the development of an integrative methodology because, as other authors have pointed out, the dichotomy between quantitative and qualitative approaches is erroneous [HG94, Hei82, Mac93], while in most cases a combination of methodologies might be more effective to obtain the whole picture of the element under analysis [vLHH02].

Some recent evaluation studies of technological displays have used observation in order to study different aspects of visitors' engagement and learning. They are relevant because not only they deal with qualitative evaluation but they are also explicitly aimed at building a specific methodology. The first one was intended to design and implement a 3D projection about Astronomy for a Science museum in order to analyze its relationship with engagement [Pod04]. To that end, the researcher conducted observations of 14 sessions and interviewed 10 of these groups. The first observations helped to identify a range of behaviours indicating engagement or the lack of it and were classified along two axes: physical/verbal and active/passive. Afterwards, he made hypotheses about which factors could influence engagement and verified them through interviews.

The second study tried to verify if technology allowed group interaction and learning in a temporary mixed reality exhibition organized at the Nottingham Castle in the UK [NG02]. The Storytent was composed of two screens forming a tent and allowing the projected images to be seen both by the visitors who controlled the navigation from inside and by those who were outside. Again, the researcher conducted direct observation in order to identify and verify if the learning indicators foreseen by socio-constructivist theory were present. She observed different activities belonging to collaborative exploration of exhibits, such as turn-taking for interaction, pointing at objects; verbal communication, and the adoption of a leader's role when interacting with the exhibit while the rest of the group observed. Starting from that,

four kinds of behaviour were observed, which indicated indirectly that a learning process was taking place: storytelling, often from mothers to their children; asking questions about the castle; relating the information presented at the exhibition with previous knowledge of historical facts; and relating digital artefacts with real objects.

The relationship between interaction and learning has also been analyzed in experimental situations with virtual environments by authors who follow a constructivist model, supporting the idea that learning is a process of meaning construction which is carried out through interaction with the environment, the contents and the partners [Rou04]. Accordingly, they put the emphasis on the development of the task rather than on its results. Through observations, interviews, questionnaires and task resolution tests, it has been deduced that learning can be tracked, from an individual point of view, through conceptual change, additional knowledge and changes in behaviour; and from the social perspective, through verbal interaction (asking questions, explaining the contents, connecting with previous knowledge or the surroundings), collective decision making, conflict resolution and peer teaching.

We applied some of the lessons learned in these studies to the evaluation carried out at an exhibition organised at the Trajan Markets of Rome by the Istituto per le Tecnologie Applicate ai Beni Culturali (ITABC) from September 15 to November 20, 2005. The exhibition was called "Immaginare Roma Antica" and presented a selection of the different applications related with the ancient city of Rome, the Roman Empire or innovative research implementations submitted to an international call for technological applications (VR, MM, audiovisuals, etc.) inside the Virtual Heritage Centre project promoted by the Rome City Council, the Imperial Roman Forum Museum, UNESCO, Region of Lazion Funding Group, the Italian National Research Centre and LUISS University. This exhibition, in which audiences were able to interact with different high-tech exhibits, offered the invaluable opportunity to undertake a survey aimed at assessing the visitors' perception about the use of ICT in the Cultural Heritage field and the way different kinds of technological displays are used in the informal learning context. The project is presented in more detail, together with the preliminary results of the evaluation, in the Projects and Short papers volume [FPP06]. The social and qualitative aims of the evaluation were reinforced by the fact that the content of the ICT applications were also different and therefore the comparison of the effectiveness of different interfaces could not be as conclusive as it would have been if it had been in an experimentally controlled situation in which the same content would be tested using different software and hardware.

The evaluation included interviews and observations, which we undertook in order to gather qualitative information about real situations and compare it with the visitors' answers in order to clarify or explain them. We carried out two different kinds of observations: staying for forty minutes at each exhibit, and tracking one example of each visitor category along the visit. In both cases, we wrote down in a standardized sheet all comments and behaviours in relation to four different groups of variables: individual, social, technological interaction and learning. In relation to the first three categories, we distinguished between social exchange and interaction with the exhibits because, as we mentioned above, this research is based on the premise that the experience of the visit comprises of the mutual influence of three different elements: the exhibits, the visitors' personality and previous experience and their behaviour. The indicators related to the visitors alone were divided into social and individual behaviours and organized following a gradation. Individual behaviour included: just take a look, read/look at it, observe what others do, talk to other visitors, and individual interaction with technology. Social behaviour included: just take a look, read/look at it, observe what others out of the group do, interaction within the group, talk to other visitors, individual interaction with technology while the rest just look, turn-taking, collaborative interaction with the technology (one uses and the rest help), collaborative interaction with the technology (all use at the same time).

These indicators have been used in the substantial body of research concerned with visitors' behaviour analysis which follows the ethnomethodological approach [vLHH05, HvLO05, AGBPM93, APM96, APM01, APM02] but have been simplified for this project because the data collection was carried out through field observation by only one observer. The technological interaction was also analyzed through a simplified range of indicators, aimed mainly at testifying the presence of major actions related to usability: examine/understand the interface, examine/understand the contents (navigation), problems with the interface, problems with the contents, ask help from other visitors, ask help from exhibition staff, look at written instructions, interaction through guide. The last general category of analysis was learning. Some of the widely accepted external indicators for learning include: from an individual point of view, conceptual change, additive knowledge and changes in behaviour; while from the social perspective, verbal interaction (asking questions, explaining the contents, connecting with previous knowledge or the surroundings), collective decision making, conflict resolution, and peer teaching. However, some of them can only be observed either in an experimental or formal learning environment context or through video recording, which allows a more detailed analysis [vLHH02, Pie05]. This is why we chose again a simplified version, adapted to the conditions of the data collection: make comments about the contents, ask/explain contents, connect with previous knowledge, link with surroundings. In any case, the interest of this research was not focused strictly on learning, because the situation did not allow it (goal of the exhibition, conditions of the survey) but on how the different interfaces are used by different kinds of visitors, and it only tried to

verify if the most evident indicators of learning were present and why.

3. Qualitative evaluation of ICT applications in Cultural Heritage settings

Having referred to the basic foundations of a methodology for qualitative evaluations of ICT applications in Cultural Heritage settings, we will now discuss some empirical results concerning the use of technological exhibits and how they affect visitors' experience, with particular regard to the social dimension, learning and usability. These come from published findings of related research projects and also from the aforementioned visitors' survey that we participated in at the "Immaginare Roma Antica" exhibition. The statistical analysis remained mainly descriptive because the sample was not big enough to produce reliable results in the non parametric tests and the correspondence analysis. Nevertheless, the findings offer, along with the results of the previous studies, an invaluable repertory of the audience's opinions, attitudes and behaviours in front of different kinds of interfaces and contents, which constitutes a useful basis for future research.

3.1. Social use of exhibits

Even in the case of single visitors, the experience of the exhibition visit consists of a permanent renegotiation between people and objects sharing the same space, in which the resources available in the room, those generated by people through body and verbal language, and visitors' previous experiences are combined. Galani and Chalmers [Gal03, GC03], followed Falk and Dierking's contextual model of the museum visit in their analysis of the influence of the interaction between group members in the relationship established with exhibits in a mixed reality visiting model (one visitor in the gallery and one off-site) at The Lighthouse and the House of an Art Lover in Glasgow. They found out that a shared visit through Hybrid Reality presents some fundamental differences when compared to normal ones: as visual clues cannot be totally activated, visitors organize their visit using the map and, above all, verbal communication, which is primarily devoted to spatial positioning and, secondarily, to talk about the contents, when the latter is usually the main function. This confirms the role played by visual and verbal communication in exhibition visits. With regard to the use of ICT as a museographical tool, the absence of visual clues and the fact of having three different points of view were considered by the authors both as an advantage and a disadvantage: it is an inconvenience because visitors invest a lot of time in agreeing about what they are seeing; but this is also forcing them to pay explicit attention -through description- to the exhibits and explore them in greater depth, as was demonstrated by the fact of linking them to previous knowledge. The conclusion we can derive from this study is that the design of museum experiences has to take intro serious consideration the social dimension because it is so fundamental that visitors will use any available resources to serve it optimally and this might be different than the way it had been originally designed.

Dirk vom Lehn and Christian Heath have also investigated the effect of technology on the social dimension of the visit [vLHH05, vLHH02]. Their main conclusion is that technological exhibits are based on the traditional computer paradigm, which establishes a one-to-one sequential interaction between the user and the machine in order to complete a task and therefore do not allow co-participation and collaboration: there is only one visitor who can use them at a time, while the rest become mere spectators (if they do not know the user) or have to interact through him/her (assisting, requesting navigation paths) if they are visiting together. This was also observed in Rome and was more accentuated in the case of particular interfaces, like a tactile device which forced turn-taking. In the rest of the cases, the size of the screen and the fact that each exhibit was alone in each room, allowed the presence of more visitors and when one user had problems to operate correctly the interface, the other visitors abandoned their passive role and ventured to give advice (this was easier when the user was a child than when he/she was an adult). The same was observed in VR exhibits when they were busy or the observers did not want to use the interface probably due to a lack of skills: then, the visitors did not wait for serious problems to appear but cooperated with the user telling him or her, for example, where to go or what to press in order to carry out certain tasks. Summing up, it appears that cooperation between different groups of visitors was evident in three circumstances: when there were problems with the interface, when the exhibits were busy and when there was a skilled user and the observers did not want to operate the applications themselves. In the case of families or couples, when problems with the navigation appeared, it was not uncommon to see another member of the group abandoning his/her spectator role and trying to help by using the devices at the same time, especially if the first user was a child.

Several studies report that in many cases, when visitors in exhibitions which include ICT applications arrive when the activity has already begun, they get a partial and fragmented experience or the surprise effect intended by designers disappears [vLHH05, HvLO05]. This was also observed in Rome: visitors limited themselves to continuing the exploration where the previous user had left it and missed part of the contents, did not understand how to start the exploration (even having technological skills, like in the case of two skilled teenagers at one multimedia application) and/or repeated what they had seen and did not take the maximum advantage of the interface possibilities (this was more evident in two VR applications, probably because, contrary to other applications, there were no visible instructions). On the other hand, watching what other visitors did, helped those

who had little experience with technology to know what to do.

Experimenting with the integration of ICT in exhibitions, many museums initially introduced kiosks and later PDAs as a complementary non-pervasive way of providing supplementary information. However, it has been observed [vLHH05, vLH03] that they both monopolize the visitors' attention, instead of fermenting an egalitarian communication between the different elements involved (user, mobile device, environment, objects and other visitors) as they are designed for a single user. The same was reported by Hsi in the evaluation of the use of PDAs at the Exploratorium in San Francisco [Hsi03]. This obtained results related to ambient, cognitive and attitudinal fields. In the first case, users emphasized a feeling of isolation either with regard to other visitors or with regard to the rest of the exhibition. In the cognitive domain, the researcher discovered that visitors had problems to establish transferences between the real and the virtual world when there were no reference points to allow the superposition of the two kinds of explanation. In all cases, the presence of a virtual guide was a source of motivation and inspiration to try new ways of interaction with the exhibition and to pay more attention to the exhibition discourse. With regard to the attitudinal field, visitors expressed a wide range of interests and preferences concerning contents and presentation format: while some people expected to find exactly the same in the real exhibition and the virtual support, others wanted it to be different or complementary, and this depended on the category of visitor which they belonged to.

Trying to go a step further, some museums have tried to introduce multi-user interfaces, as is the example of a game at the Science Museum in London. But even in this case the system seems to fail because it was designed as a competitive game in which each visitor has to give his/her own opinion instead of coordinating to built shared meanings or complete tasks [vLHH02]: more than collaboration, this supported rather common access to information. On the other hand, if the visitors did not follow all the sequence, they lost track of how their actions were affecting the activity and they augmented their body gestures in order to supply the communication that should be done by the system. It appears that in most cases multi-user interfaces are not yet able to deal with the richness of multi-user collaboration: instead, they either treat different users as a group, that is, again as a single user; or they coordinate internally the inputs preventing the users to understand what was the effect of their intervention. As it was observed in one experimental situation with interactive low-tech displays in which visitors had to collaborate to understand them because the functional parts were physically separated, social interaction and collaboration (through verbal explanations complemented with gestures) were critical for the understanding of the exhibits [vLHH05]: this is why groups had good results while individual visitors had a lot of problems to reach the goal, which indicates that social participation will only exist if it is integrated from early on in the design of the exhibit.

Although the applications at the Rome exhibition were not purposely designed to support group interaction, this does not mean that this did not actually take place. In fact, it was detected in all cases but in some this was the result of problems with the interface. This acted at the same time as problem and as a stimulus. A stimulus because visitors, even strangers, collaborated to understand the operation of the system; but also a problem because this cooperation was focused on the interface and not on the content. This was true even for audiovisuals: in a 3D audiovisual, visitors merely observed the images and only talked when they had problems with the glasses, while in the other exhibit sharing the room (an audiovisual with virtual reconstructions), maybe because there was a voice explaining a story, visitors talked to each other about it. These observations show that the screen paradigm did not help to promote the construction of meaning because it had a "TV effect": activity and people's attention were limited to the observation of the screen, everything was purely visual and thus, in the case of interactive exhibits and as other experimental studies have shown [JRL*98], only the direct user was really involved in the task. This has also a methodological corollary and it is that we would have had the wrong impression if we had only taken into account the timings in each room: as it has also been contrasted in other situations [HvLO05], visitors spend a lot more time in computer-based exhibits than, for example, reading texts, but this is often not due to the fact that the former improve collaborative learning but that in most of the cases they are spending a lot of time to understand -sometimes without success- the interface operation.

Coming again to the Rome exhibition, although in some of the exhibits visitors tried to operate the devices synchronously (in exhibits with two input devices), the only case in which true co-participation was possible was in an Artificial Reality exhibit, because it allowed an interaction not only based on an input device but on the body projected onto a screen. This could be completely demonstrated in the case of a group of elders who had kept a passive attitude in all the rest of the exhibits but here they felt free and comfortable and even found it funny to interact with the e-beings. One of them (a female visitor in her sixties) even took the microphone and explained to her partners the aims of the application. In the rest of the exhibits, as in previous studies [vLHH05], collaboration was limited to assistance in the understanding of the interface operation except in those cases in which they had experience with this kind of environments and they could really concentrate on the exploration of the content.

3.2. Learning

Different studies agree that there cannot be any learning if users do not understand well first the interface operation

[vLHH05, Rou04, AGBPM93, SMI03, ASLA*05, EP06, Jov03, XMM05]. In the Rome exhibition this was confirmed in all the cases, even with the audiovisuals: for example, in the aforementioned 3D audiovisual, the only comments made by the observed visitors concerned problems with the glasses. On the other hand, a young couple at a navigable VR application only talked about the content because they did not even need to explore the interface operation, as they were able to navigate automatically. And the same happened in those cases in which a member of the staff acted as a human guide: then people seemed to really enjoy the exhibit and made comments or asked questions about the content. However, in some exhibits, due to their novelty, the technology overshadowed the content: at the tactile device, social exchange was mainly done with the human guide who showed how to manipulate the device but all the comments were about the interface and its utility. Most of the conversations about the content were observed with the multimedia applications, especially if the interface did not pose any operation problems, while in VR it was again comments about navigation, even if it was done through a human guide (people asked what the environment could do and show).

However, when considering learning, we need to take into account the type of visitor and the social interaction that this determines. Because of the learning indicators we had chosen, groups (especially families) gave the impression they learned more because the social interaction between them (e.g. the explanations -sometimes wrong- that, as it has been reported by other studies [FD00, HG94], parents often give to children) provokes more external evidence of learning. In the Rome exhibition, the groups distributed the tasks according to each person's skills: one navigated, the rest looked at the screen or explained the contents. In the case of groups with little knowledge about technology (for example elders), the roles were adopted depending on the personality of each member: usually the one who was more courageous adopted a leading role and explained the contents or even tried to use the application. One group of elders also demonstrated, confirming the constructivist theory, that learning is not only a matter of facility with the interface but also of familiarity with the content: to interest them and/or maintain their attention, the content must appeal to users' previous knowledge and then it is likely that they will try to approach the exhibit, even if they are "afraid" of the technology. In the two cases in which this happened at the Rome exhibition -with two VR applications-, visitors said they wanted to buy the CD-ROM, if it was available, to be able to explore it more carefully at home.

3.3. Interaction with exhibits

After conducting field observations and interviews about operation and learning in several exhibitions, Viviane Jovet [Jov03], who was interested in the study of VR integration in the exhibition as a communicative tool, reached the conclusion that high-tech exhibits have problems of integration in the exhibition because they are a very specific tool; an autonomous and very particular communication system located inside a bigger one that, contrary to the foregoing, is contextual and already owns other completely integrated resources. Furthermore, the visitor has to face two problems: decipher the message and the operation of the intermediary, which usually is not natural or intuitive. This could be seen at Rome exhibition, where, for example a young woman had problems to use the trackball although it might seem very easy. On the contrary, no child had problems to navigate with a Playstation device.

In relation to software interface, it appeared that some people had difficulties exploring one multimedia exhibit when they wanted to find specific objects: this offered too many options and did not have clear "instructions" or a direct way to know how to operate them. On the other hand, another multimedia program, was more intuitive because it had a simpler interface, with only one screen and few buttons. Visitors could navigate this without problems despite the barriers to basic comprehension posed by the language (it was in Spanish). It is also interesting to note what happened with several adult visitors at two different multimedia applications: their first impulse, without having read the instructions, was to click on the visual symbols in the screen because they thought this would get the program started (the application was in English, so they were interpreting the icons); they had not understood that those were the instructions. Seemingly, some of them did not understand that they had to wait for the computer to render the model and kept clicking the buttons again and again thinking it did not work. Finally, as we mentioned above, the fact of starting the exploration at the point were the previous visitor had left it caused problems even to those who had experience with computers. It is important to bear this natural impulses in mind when designing multimedia environments, for example by clearly indicating that the machine is processing, by introducing an automatic "restart" after a time of inactivity and by creating more universally intuitive navigation symbols.

The same applies to VR environments: in one case, the moving books, abstract guides and doors to change level were not evident to the users, so visitors were not using them and consequently were not making good use of all the environment's capacities. VR designers have to remember that not all users will naturally have the impulse to explore in detail a virtual environment to discover its possibilities, especially in the exhibition context; visitors need instructions or, even better, signs clearly indicating their function. Another issue is how to display knowledge uncertainty in virtual models: one of the most frequently used conventions is to leave the corresponding element with a uniform color. However, this is not always understood by non-specialists. One family wanting to see the appearance of one artistic monument at a specific date was surprised to see that "it

was all white!", not having realized that this colour was indicating the lack of knowledge for that specific period. VR has also problems of navigation, especially with avatars: the problems some visitors encountered in one avatar-navigable application (not knowing how to make the avatar approach specific elements, or what it was looking at and what actions it had unchained) showed that, as other authors have demonstrated [Sch97], it is more intuitive to navigate in first than in third person. Even the most intuitive interfaces have the problem of not being natural enough. The Artificial Reality application allowed corporal direct interaction with the e-beings but still required the use of a microphone: in general, people had not understood that the beings learned words and were getting disappointed when they were asking them questions and did not get any answers back; in another case, one old lady was talking very quietly close to the screen without using the microphone. In other cases, as visitors could only see the microphone, they thought the only interaction they were allowed was talking and did not try to move in front of the screen. This shows that intuitiveness demands, as an essential feature, visibility because most of the times people will not read written instructions and will interact directly with the exhibit; therefore, it has to make all its capabilities evident at first sight.

Heath and vom Lehn demonstrated that even the most evident and basic levels of interactive exhibits can cause problems, for example, depending on the way visitors are approaching the resource [HvL02]. This applies also to high-tech displays, as the case of one young couple in the Rome exhibition demonstrates. Even though there was a rope clearly separating the two spaces corresponding to each of the two screens, and the two images were different, users tried to watch the second application while sitting on the first and made comments about the bad quality of the visualization, as they had not understood that each screen was a different application and that the polarized glasses could only be used in the 3D hyper-realistic audiovisual. Similar findings were recorded by a group of Spanish sociologists [ASLA*05] who conducted a study about the coexistence of technological and traditional exhibits in a temporary exhibition about the Iron industry in the Basque Country specifically designed for research purposes. This demonstrated that people had problems establishing a relationship between the real object and its virtual reconstruction despite the obvious association created by the fact that they were in the same exhibit, a combination of virtual workbench and showcase. The results also showed problems of integration of this Virtual Showcase inside the exhibition context: it became the main attraction of the exhibition, and this generated great expectations which, in most of the cases, could not be satisfied.

From the observation at the Rome exhibition it has been possible to group visitors' interaction in four large categories. The first category is that of passive exploration of the exhibition. In several cases, visitors seemed to expect to see audiovisuals and were not looking for direct interaction with the exhibits. Some people preferred to see, to receive or be given (visual) information, than to interact; or if they did use the application, they only looked for (navigable) images/reconstructions or audiovisuals and skipped any textual explanations. This is why instead of concentrating on the content, they often asked the guide to show them the visualization possibilities of the environment. In fact, as the general evaluation showed [FPP06], most of the visitors came to see reconstructions of Rome and associated VR with computer-modeled images of buildings. The second type of visitors were couples. In most cases, especially if the couple was not young, it was the man who controlled the interface while the woman adopted a passive role. In the case of young couples, the girl also tried to use the application but her boyfriend would finally take the control of the interface because he usually seemed to have more facility using it. This was a good example to compare the differences in navigation style between adults and children: the first look at the interface and try to infer how it works before starting, while children are more impulsive and have a more hazardous pattern, clicking at different points or pressing all the buttons at the same time in order to get the system to respond.

The third type of visitors were families (parents or grandparents with children). Adults would usually let the children interact with the exhibit directly, even if they belonged to different groups of visitors, and they would always act as guides for the navigation and/or the understanding of the content. Consequently, they always filtered the experience through their own perceptions and, in the worse case, gave wrong information about the interface and/or the content. However, sometimes the situation was inverted: twice at the tactile exhibit and once at the VR avatar-navigable application, the father tried first, then the children and finally the mother; when it was her turn, the children explained to her how it worked. If adults did not know how to operate the interface they would ask other visitors or the museum staff (in the case of women) or read the instructions. The observation showed that in order to be able to correctly manipulate the interface and enjoy/learn the content of the various applications, users needed to have a certain age and/or a high level of experience with computers. The last type were older visitors. These showed limited interaction with interfaces, usually adopted a passive role, observing what others did, even when there was opportunity to interact with the application with the help of a guide. In the Rome exhibition older visitors felt comfortable with two exhibits. The first of them was the Artificial Reality application, probably because they perceived it as a game and also because it allowed the possibility of a direct interaction. The second was a touch screen, which had a very easy interface. Despite this grouping into types, there was never a single pattern of navigation, but as other authors have shown [HvLO05] each category might have been different at the same time and could change diachronically according to the composition of the group, the problems en-

countered during interaction with the exhibit and personal skills or interests.

An interesting conclusion from the observation was that people like realism and are willing to feel immersed in the virtual reconstruction. This is why visitors were making very positive comments about the virtual reconstruction of "Domus Aurea". In one case a young man using a multimedia application with virtual reconstructions was following a navigation path and was moving his body exactly the same way he would in the real environment: gazing at the room/view from the entrance, from left to write and from the eyes' level to the ceiling/sky. In another case, a child had problems with the tactile interface but when he tried the polarized glasses, he immediately extended his arms to touch the three-dimensional virtual image that had suddenly appeared in front of his eyes. Another lesson learned from the observation is that, in general, people seemed to appreciate and prefer a human guide to show them the interface -and then they were able to concentrate on the contents- or assist them in case of problems with the navigation because it was easy for them to reproduce the actions they had already seen or been told. In some cases they did not even try the interface on their own: if there was a member of staff present, they asked him or her directly and then followed the instructions. This is linked with the fact that visitors did not spend a long time exploring the interface operation -as it has generally been reported by different authors [AGBPM93, Alc92]. If they had problems with it, they would in some cases read the instructions (if available) or ask for help but in most of the cases, they explored it at random until they could see some content and abandon the exhibit without having fully exploited its capacities. This behavior was observed especially in multimedia applications, while in VR ones users spent more time because they had one immediate result: the "physical" motion inside the environment.

4. Conclusions

Constructivist theories support the idea that learning is produced through interaction with the content inside a socially dynamic environment in which physical activities and later language is fundamental in order to build shared meanings and integrate knowledge. As this is especially true in the informal learning environments, it should be taken into consideration by curators and designers when introducing ICT exhibits in museums. The problem is that they often overlook the fact that ICT's interaction model is individual, oriented to the achievement of a goal through a sequence of strictly defined actions and responses [HvLO05]. This is what makes them so effective for individual learning but also so different from the processes that arise in the social and rich in resources exhibition context, where their integration as a communication tool is often problematic [Puj05, EP06].

However, several ways are opened that can offer different solutions. One possibility is to keep the interaction paradigm and then to use ICT to complement the experience of the visit. As the major evaluation of the permanent exhibition of the Holocaust Memorial Museum in the United States has shown, this can be done in four ways [Swi05]: by adding the interactive, personalized layer in travelling exhibits, which are necessarily "flat"; through the Internet, by preparing or complementing the visit and creating a forum of debate or even a community of people related to the museum; by promoting long term learning thanks to reiterate remote access; and finally, in all cases, by offering the possibility of personalization which, contrary to traditional mass media, ICT are able to provide. The other possibility is to change the interaction paradigm. If even the multi-user environments isolate the users and/or create problems for them coping with non-sequential collaboration, we can try to use real objects as interface. This is exactly the goal of "Tangible User Interfaces", which are starting to be tested in several projects [XMM05, SFD03, PPW05] and offer the advantage of requiring little time from the user to learn how to use them because they rely on our way of interacting with the physical world and they support the complexity of the multi-layered collaboration between several users [XMM05].

All cases and situations demonstrate that visitors coming in groups adopt a social modality of visit which predisposes them to interact simultaneously with the exhibits. But in most cases the interfaces do not allow it and therefore they have to adapt their behavior depending on three major categories of factors: the exhibit (kind of interface and interest of contents), the environment (if busy or not) and visitors (composition of the group, personality and skills). In order to discriminate and understand the significance of each factor, we need more integrated evaluations conducted in optimal conditions, moving beyond attitude and usability to include more complex phenomena such as learning and social use of exhibits. We also need to continue developing specific tools for observational analysis of technological displays in museums: detect observational indicators, make hypothesis about causal factors, and then test them experimentally and on site. To that end, video recording could be specially useful [vLHH02, Pie05]. This can be completed with other traditional evaluation systems (interviews, concept mapping, interaction logging, focus group discussions) in order to obtain a deeper and wider insight.

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